

**EFFECT OF 'OM MEDITATION ON BRAINSTEM AUDITORY
EVOKED POTENTIALS, AUTONOMIC AND RESPIRATORY
VARIABLES' AND SELECTIVE ATTENTION**

Thesis submitted by

SANJAY KUMAR

Towards the partial fulfillment of

DOCTOR OF PHILOSOPHY (YOGA)

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SWAMI VIVEKANANDA YOGA ANUSANDHANA SAMSTHANA
(declared as Deemed University under Section 3 of the UGC Act, 1956)
BANGALORE - 560 019
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**CONCEPT OF OM MEDITATION AND ITS COMPONENTS
(CAÑCALATĀ, EKĀGRATA, DHĀRAṆĀ & DHYĀNA) ACCORDING TO
ANCIENT YOGIC TEXTS AND SPIRITUAL LORE**

Thesis Submitted for the Award of
DOCTOR OF PHILOSOPHY (YOGA)

By
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Under the Guidance of
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C E R T I F I C A T E

This is to certify that Sanjay Kumar who has been given Ph.D. registration with effect from September 11, 2004 by Swami Vivekananda Yoga Anusandhana Samsthana, Deemed University under the Division of Yoga and Life Sciences has successfully completed the required 'training' in acquiring the relevant background knowledge in physiology, neurology and psychology related to Yoga He has completed the required 'course of research' for not less than two years to submit this thesis as per the rules and regulations of the University.

We also declare that the subject matter of this thesis entitled EFFECT OF 'OM MEDITATION ON BRAINSTEM AUDITORY EVOKED POTENTIALS, AUTONOMIC AND RESPIRATORY VARIABLES AND SELECTIVE ATTENTION' has not previously formed the basis of the award of any degree, diploma, associate-ship, fellowship or similar titles.

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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), Bangalore, under the guidance of Dr. H.R. Nagendra, Vice-chancellor and Dr. Shirley Telles, Prof. & Head, Dept. of Biosciences, Swami Vivekananda Yoga Anusandhana Samsthana, Deemed University, Bengaluru.

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Bangalore

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Date:

STANDARD INTERNATIONAL TRANSLITERATION CODE USED TO
TRANSLITERATE SANSKRIT WORDS

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| 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 |
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| e | = | ए | ḍa | = | ड | va | = | व |
| ai | = | ऐ | ḍha | = | ढ | śa | = | श |
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| 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 |
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ABSTRACT

Background

Research on meditation in volunteers who were previous naïve to meditation began with studies on transcendental meditation (TM) in the early 1970 (Wallace 1970, Wallace, et al. 1971). Subsequently, there have been several studies on widely differing meditation techniques and practitioners for e.g., study done by Hirai (1960) on Japanese Zazen meditation showed that during the practice, meditators showed an increase in heart rate and increase in beta activity in EEG. However, another study on Zen meditators showed that this meditation was associated with decrease in breath rate (Kasamatsu & Hirai 1966). Hence the two studies on Zen meditation showed different trends. The study by Hirai (1960) suggested that Zen meditation is activating which was in contrast to study done by Kamatsu and Hirai (1970), which suggested that Zen meditation is physiologically relaxing. Another study done on a meditation technique called *Ānanda Mārga* meditation (based on principles from *tāntric* yoga text) showed that the practitioners of this meditation had an increase in heart rate from a mean of 69.4 to 72.8 and an increased skin conductance (Corby, et al. 1978). In contrast, a study by another group showed that *Ānanda Mārga* meditators had reduced breath rate (Elson, et al. 1977). Here again like the two studies on Zen meditation, two studies on *Ānanda Mārga* meditation also had conflicting implication. While the study by Corby et al (1978) and others suggested that *Ānanda Mārga* meditation is physiologically activating. The study by Elson et al (1970) suggested that *Ānanda Mārga* meditation decreased physiological activation. All these studies compared meditators with non-meditators. A different

research design was attempted to assess whether this would reduce inter-subject variability. This is a self-as-control design, which required the same person to be assessed in yoga session and in a non-yoga session (Telles, et al. 1992). This approach also involved assessing each yoga practitioners in repeated yoga and non-yoga sessions and it was found that there was definite inter-subject variability as well as intra-subject variability (i.e., where each practitioners differed in their trends of results of different days).

Hence no clear picture emerged about the effect of meditation on autonomic and respiratory variables given the considerable intra and inter individual variability (Telles, & Desiraju, 1993^a; Telles, & Desiraju, 1993^b; Telles, et al. 1995; Telles, et al. 1998). Hence it was considered that practitioners may be showing different results because they practice meditation in different ways i.e., meditation on *OM* was found to be practiced by visualizing the syllable *OM* as it is written in Sanskrit while few other practitioners practiced by mentally repeating *OM* (Telles, et al. 1994). Thus an attempt was made to teach all practitioners to practice meditation in the same way and this resulted in group significant results (Telles, et al. 1994). However this may limit the individual's experience and sense of fulfillment derived from meditation.

This gave rise to the idea of examining description of meditation from traditional yoga texts may give, common results across different subjects. Hence, the present study intended to examine the effects of meditation as described in Patañjali's yoga *Sūtras* as well as two more mental states described in the *Bhagavad Gītā*.

These mental states are *Dhāraṇā* (Patañjali's Yoga *Sūtras*, Chapter 3: Verse 1) and

Dhyāna (Patañjali's *Yoga Sūtras*, Chapter 3: Verse 2) and two other states, these are random thinking *Cañcalatā* (*Bhagavad Gītā* Chapter 6: Verse 34), and single pointed *ekāgratā* (*Bhagavad Gītā* Chapter 6: Verse 12).

In order to understand the psychophysiological effects the assessments comprised an attention task, autonomic and respiratory variables as well as brain stem auditory evoked potential. The last variable was selected to assess whether these practices influence sensory information processing as assessed by evoked potentials.

Aim

The present study aimed to assess the psycho-physiological changes during *cañcalatā* (random thinking), *ekāgratā* (focusing), *dhāraṇā* (meditative focusing), and *dhyāna* (meditation without focusing) on: (1) brainstem and auditory evoked potentials (2) autonomic and Respiratory variables (3) performance in a six letter cancellation task.

Methods

Thirty subjects from *Svāmī* Vivekānanda Yoga Research Foundation, Bangalore, South India were selected with ages ranging from 20 to 45 years ($M = 29.1 \pm SD = 6.5$ years) who had a minimum of 6 months experience in 'OM' meditation.

Design

Each subject was assessed in four sessions i.e., two meditation (*dhāraṇā* and *dhyāna*) and two control sessions (*cañcalatā* and *ekāgratā*) to record brainstem auditory evoked potentials, autonomic and respiratory variables separately. And for performance in a cancellation task, assessments were made immediately before and after each session. The two control sessions were: (i) *Ekāgratā*, i.e., single topic lecture and (ii) *Cañcalatā*, i.e., non-targeted thinking. The two meditation sessions were (i) *Dhāraṇā*, i.e., focusing on the symbol 'OM' and (ii) *Dhyāna*, i.e., meditation with effortless focusing on *OM*, the object of meditation. All four sessions consisted of three states, i.e., 'pre' (5 minutes), 'during' (20 minutes), and 'post' (5 minutes).

The assessments were made on four different days, but at the same time of the day (i.e., the self-as-control design). The allocation of the subjects to the four sessions was randomized using a standard random number table. This was done to prevent the influence of being exposed to the laboratory for the first time, from influencing the results.

Assessments

- I. BAEP were recorded using the Nicolet Bravo system (Nicolet Biomedicals, U.S.A.).
- II. Autonomic and respiratory variables using 4-channel polygraph (Polyrite D, Recorders & Medicare Systems, Chandigarh, India)
 - a) Galvanic Skin Resistance (GSR)
 - b) Finger Plethysmogram Amplitude (FPA)

- c) Electrocardiogram (EKG)
- d) Respirogram
- (i) Six letter cancellation task (SLCT)

Intervention

Throughout all sessions subjects kept their eyes closed and followed pre recorded instructions. The instructions emphasized carrying out the practice slowly, with awareness and relaxation. The meditators who participated in the study underwent a month of orientation sessions where they practiced two phases which formed a continuum in meditation (*dhāraṇā* and *dhyāna*) as two separate sessions and two control sessions, i.e., *cañcalatā* or non-target thinking and *ekāgratā* (by ‘listening to a lecture on meditation, with multiple, yet associated thoughts’).

These states are described in the traditional texts i.e., the Patañjali’s *Yoga Sūtras* and *Bhagavad Gītā*, (*Bhagavad Gītā* Chapter 6: Verse 34, Chapter 6: Verse 12; Patañjali’s *Yoga Sūtras*, Chapter 3: Verses 1-2) stating that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of ‘streamlining the thoughts’ (concentration or *ekāgratā*), before moving on to the stage of meditation. These are: one-pointed concentration, non-analytical focusing or *dhāraṇā* and a defocused, effortless single thought state or *dhyāna*.

During *cañcalatā* session (non-targeted thinking) the participants were directed to allow their thoughts to wander freely as they listened to a pre recorded general

conversation of a local radio station transmission. During *ekāgratā* practice participants were listening to a lecture on meditation. The *dhāraṇā* session consisted of meditative focusing on the meaning of the Sanskrit syllable, 'OM', where *OM* is used as a symbol for the entire universe, representing that which sustains everything (*Māṇḍukya Upaniṣat*; Cinmayānanda, 1984). The *dhyāna* session consisted of meditation with effortless absorption with the object of meditation. For the two meditation sessions (*dhāraṇā* and *dhyāna*) and the other two control sessions (*cañcalatā* & *ekāgratā*) participants were given guided instructions with a compiled audio CD relevant to the respective sessions. All sessions (*dhāraṇā*, *dhyāna*, *cañcalatā*, and *ekāgratā*) constituted a practice of 20 minutes duration.

Data analysis

Statistical analysis was done for all variables using SPSS (Version 10.0). The peak latencies and peak amplitudes of all seven waves and all autonomic variables were analyzed using repeated-measures analyses of variance (ANOVAs), and *post-hoc* analyses with Bonferroni adjustment was to compare 'pre' data with 'during' and 'post'. Also six letter cancellation task scores were analyzed using repeated-measures analyses of variance (ANOVAs), and *post-hoc* analyses with Bonferroni adjustment was to compare 'pre' with 'post' scores.

The repeated measures analyses of variance (ANOVAs) were performed with two 'Within Subjects' factors, i.e., Factor 1: Sessions; with four levels, viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; with six levels, viz., Pre,

During (D1 to D4), and Post. These repeated measures ANOVAs were carried out for the peak latency and peak amplitude of all levels as well as autonomic and respiratory variables. For letter cancellation task the repeated measures analyses of variance (ANOVAs) were performed with two ‘Within subjects’ factors, i.e., Factor 1: Sessions; with four levels, viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; with two levels Pre and post. This was followed by a *post-hoc* analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre, During 1 to During 4 and Post) and pre and post data analysis was done for letter cancellation task.

Results and Discussion

(i). Brainstem auditory evoked potential –There was a significant increase in the latency of Wave V during the *cañcalatā* session (Pre versus During), *ekāgratā* session (Pre versus During & post) and following the *dhāraṇā* session (Pre versus Post).

Hence irrespective of whether meditators were in a state of random thinking (*cañcalatā*) or channelized thought in concentration (*ekāgratā*) there was a delay in sensory information processing, as mentioned above at the mid-brain, (possibly the inferior colliculus) level. The mental state was characterized by a lack of effort during *dhyāna* session, where as there was effort involved during *dhāraṇā* session; in both the sessions, the latency of wave V did not show any significant delay in sensory information processing. In contrast, there was a significant delay

seen post *dhāraṇā* session while no such changes was observed post *dhyāna* session.

ii) Autonomic and respiratory variables-

- Galvanic Skin Resistance (GSR): There was a significant increase in the galvanic skin resistance during and after the *dhyāna* session in comparison to *cañcalatā*, *ekāgratā*, and *dhāraṇā* sessions.
- Finger Plethysmogram Amplitude (FPA): There was a significant increase in the digit pulse volume in *dhyāna* session (pre versus during).
- Electrocardiogram (EKG): There was a significant decrease in the heart rate in *dhyāna* session (pre versus during & post).
- Respiratory rate: There was a significant increase in the respiratory rate in *cañcalatā* sessions (pre versus during & post). But in session *dhyāna* there was significant decrease in respiratory rate (pre versus during & post).
- HRV LF: There was a significant increase in low frequency in *cañcalatā* and *ekāgratā* sessions (*cañcalatā* (pre versus during & post), *ekāgratā* (pre versus during & post)). But there was significant decrease in low frequency in *dhyāna* session (pre versus during & post).
- HF: There was a significant decrease in high frequency in *ekāgratā* session (pre versus during & post), while there was significant increase in high frequency in *dhyāna* session (pre versus during & post).

- LF/HF: There was a significant increase in low and high frequency ratio in *ekāgratā* session (pre versus during & post).

In the present study the LF power was higher during *cañcalatā*, *ekāgratā* and lower in *dhyāna* sessions. The HF power was lower during the *ekāgratā* practice and higher during the *dhyāna* practice. The LF/HF ratio was higher during the *ekāgratā* practice. The changes in LF and HF power suggest that there was a shift towards the increased sympathetic activity during *cañcalatā* and *ekāgratā*, where as increased parasympathetic activity was observed during *dhyāna* sessions. Hence *dhāraṇā* did not influence the HRV.

In the present study there was a significantly higher increase in skin resistance during *dhyāna* session in compare to other sessions. The rate of breathing is known to vary directly with the level of anxiety (Srinivas & Telles, 1999). A decreased breath rate is a well recognized correlate of reduced psychophysiological arousal. Hence for this variable also there were difference between *dhāraṇā* and *dhyāna*. The heart rate was also lower during *dhyāna* in the present study there was a lowering of both breathing rate and heart rate during *dhyāna* suggestive of physiological relaxation.

- Six letter cancellation task (SLCT): Total and net scores were significantly higher after the *dhāraṇā* session compared to the pre scores, whereas after

the *cañcalatā* session they were significantly lower. No significant change was observed in other sessions for the letter cancellation task.

Conclusions

These results showed that information transmission along the auditory pathway is delayed during *cañcalatā* and *ekāgratā* with no change during *dhāraṇā* and *dhyāna*. In *dhyāna* there was a relative increase in wave V amplitude (relative to wave III) suggesting recruitment of more neurons at the inferior collicular level compared to before. This suggests that during *dhyāna* auditory information transmission was delayed at the inferior collicular level (the tectum) as the wave V corresponds to the tectum. Also the autonomic and respiratory variables suggested a higher magnitude of psycho-physiological relaxation during *dhyāna* as compared to other sessions. Performance in the six letter cancellation task also suggested that meditative focusing (*dhāraṇā*) may improve attention.

1.1 BACKGROUND

Meditation has become popular throughout the globe since 1960 while it has been in vogue for centuries. It is a systematic approach for an individual to become one with the object of meditation and ultimately the highest level of consciousness of which man is capable (Taimni, 1961). During meditation a state of mind is reached which is characterized by deep relaxation as well as increased internalized attention (Murata, et al. 1979).

Meditation as part of yoga in general has been described as a training in awareness which produces definite changes in perception, attention and cognition (Brown, 1977). Based on changes in oxygen consumption, carbon dioxide elimination, breath rate and the electroencephalogram (EEG), the practice of Transcendental meditation (TM) has reported to induce a 'wakeful hypo-metabolic physiologic state' (Wallace & Benson, et al.1971). Similarly, a decrease in oxygen consumption occurred following meditation on a meaningful syllable, 'OM' which was accompanied by decrease in cutaneous blood flow suggesting an increase in sympathetic vasomotor tone. This suggested that meditation on 'OM' produces a state of alertful rest (Telles, et al. 1998). The relationship between the mental state and body physiology; emotional and cognitive processing and the biological correlates of religious experience are being studied (Newberg & Iverson, 2003). The verbal definition of different phases of meditation do not merely serve to label sections of a meditation sequence which, are basically similar but they actually refer to evidently different physiological brain states (Lehmann, 2001).

Studies were conducted on meditators using the self-as-control design in both meditation and non-meditation sessions in *Brahmakumārī Rāja* yoga meditation suggested that both autonomic activation and relaxation occurred simultaneously in different sub-divisions of the autonomic nervous system in a subject; hence a single model of sympathetic activation or overall relaxation was considered inadequate to describe the physiological effects of a *Brahmakumārī Rāja* yoga meditation technique (Telles & Desiraju, 1993b).

1.2 TRANSCENDENTAL MEDITATION (TM) - ALERTFUL REST

Popularity of meditation started throughout the globe by TM movement started by *Mahaṛṣi Mahesh Yogi*. Extensive scientific exploration proved the usefulness of TM. TM opened up a new dimension of a state of mind in which the meditator can be in deep rest, but totally alert. This become open the earlier concept that mind is resting indicative of inertia and laziness or should be active and dynamic without rest; a new vision of alertful rest emerged.

The practice of TM was reported to cause reductions in heart rate, respiratory rate, and oxygen consumption and to increase the level or stability of the electrodermal response (Wallace, 1970; Wallace, et al. 1971). TM was hence described as a ‘wakeful hypometabolic physiologic state’. A later report (Heide, 1986), noted a difference in the heart rate response but not in the electrodermal response evoked by 80 dB tones, when TM meditators and non-meditators were compared. More recently, the practice of TM has shown to reduce cardiovascular sympathetic activity both at rest and during a simulated car driving stressor in adolescents at

risk for hypertension (Barnes, et al. 2001). These reports suggest that the practice of TM reduces sympathetic activity. This concept of predominant parasympathetic activity during TM was mentioned in a recent review (Newberg & Iverson, 2003).

1.3 CONTROVERSY ABOUT DIFFERENT TYPES OF MEDITATION

However, contradictory results were observed in *Zen* and *Tāntric* meditations. One set of studies reported changes suggestive of autonomic activation (Hirai, 1974; Corby & Roth, et al. 1978), while another set of studies reported changes suggestive of autonomic relaxation (Kasamatsu & Hirai, 1966; Sugi & Akutçu, 1968; Elson & Hauri, et al. 1977).

The autonomic and respiratory variables were studied in *OM* meditators (Telles, et al. 1995). In seven experienced meditators (with experience ranging from 5 to 20 years). Each subject was studied in two types of sessions-meditation (with a period of mental chanting of *OM*) and control (with a period of non-targeted thinking). The meditators showed a statistically significant reduction in heart rate during meditation compared to the control period. During both types of sessions, there was a comparable increase in the cutaneous peripheral vascular resistance. This was interpreted as a sign of increased mental alertness even while being physiologically relaxed (as shown by the reduced heart rate). When repetition of ‘*OM*’ was compared with the repetition of ‘*ONE*’ in twelve meditators, there was a difference in the autonomic and respiratory responses (Telles, et al. 1998). Both types of sessions resulted in a decrease in the heart and breath rates, but repetition of *OM* alone reduced the skin resistance indicative of alertness, suggesting a subtle change in the mental state, related to the significance of the syllable. It was

interesting to note in a single case study that an accomplished meditator was able to switch between 'single thought' and 'no thought' states at will, with significant differences in the breath rate and pattern between the states (Telles & Desiraju, 1992). Meditation has a noticeable influence on blood pressure, which dropped much lower than normal. Also there was a reduction in heart rate and skin conductance after meditation (Vemapati & Telles, 2002). A recent study showed an increase in sympathetic activation in the yoga posture phases of Cyclic Meditation (where 'CM' is a combination of yoga postures and relaxation techniques) while parasympathetic dominance increased after Cyclic Meditation (Sarang & Telles, 2006). With several types of meditation techniques having been identified it is more difficult and confusing to understand what meditation involves.

A similar trend of variability between meditation techniques, between meditators, and in the same meditators assessed on different days was found in middle latency auditory evoked potentials (Telles & Desiraju, 1993^a). The fact that subjects had evolved individual methods of meditation, which was taken to explain the inter-individual variability. In a subsequent study (Telles, et al. 1994) senior meditators with comparable experience of meditation attended a ten-day meditation camp where they were given common instructions on meditation i.e., to focus attention on the visual image of *OM* while mentally chanting it. This resulted in group significant changes in mid latency evoked potentials.

1.4 NEW RESEARCH DESIGN

An early study on meditation (Telles & Desiraju, 1993^a) used for the first time, two important modifications in the research design for yoga research. Here subjects were studied using the 'self-as-control' design and the two types of sessions, meditation and non-meditation, were repeated thrice in each subject. This study highlighted two points, (i) meditation is best described as a physiological state of 'alertful rest', and (ii) considerable physiological variations are seen both intra- and inter-individually. This study assessed the effects of meditation on the syllable 'OM' on mid-latency auditory evoked potentials, it was found that in seven experienced meditators during meditation there was a significant decrease in the peak latency of the Nb wave (the maximum negativity occurring between 35 and 65 ms.) In another study on the effects of meditation on 'OM' on mid-latency auditory evoked potentials were studied in experienced meditators and novices (Telles, et al. 1994). There were two types of sessions before, during and after (i) mental repetition of 'OM' (meditation session) and (ii) mental repetition of 'ONE' (control session). The experienced meditators showed a significant increase in the peak amplitude of the Na wave (the maximum negative peak between 14 and 18 msec.) during the meditation with a significant decrease in the Na wave peak amplitude during the control session. Hence during mental repetition of a meaningful syllable ('OM') and of a neutral syllable ('ONE') neural changes occurred at the same level (possibly diencephalic) though in opposite directions. Studies on short latency auditory evoked potentials have not shown such clear changes (McEvoy, et al. 1980) In that study brainstem auditory evoked potentials (BAEP) were measured in five advanced practitioners of TM to determine whether

such responses would reflect an increase in perceptual acuity to auditory stimuli following meditation. The BAEP provide an objective physiological index of auditory function at a subcortical level. Repeated measures of the BAEP of TM practitioners were taken before and after a period of meditation and were compared with those of age-matched controls. Peak latencies as well as interwave latencies between major BAEP components were evaluated. No pre-post meditation differences for experimental subjects were observed at low stimulus intensities (0—35 dB). At moderate intensities (40—50 dB), the latency of the inferior collicular wave (wave V) increased following meditation. However at higher stimulus intensities (55—70 dB), the latency of this wave was slightly decreased. Comparison of slopes and intercepts of stimulus intensity-latency functions indicate a possible effect of meditation on brainstem activity (McEvoy, et al. 1980). This study on short latency auditory evoked potentials in TM meditation practitioners demonstrated that short latency auditory evoked potentials vary with stimulus characteristics.

1.5 STUDIES ON PHASES & TYPES OF MEDITATION

Naveen and Telles (2005) found during meditation on ‘OM’ the changes during the *dhāraṇā* and *dhyāna* phases were different and distinct. In the *dhāraṇā* phase the change suggested reduced physiological arousal whereas in *dhyāna* phase the changes were suggestive of ‘alertful rest’. Also, the evoked potential changes suggested facilitated neural transmission and better cortical neural synchrony. In the two phases of BK meditation the changes were almost directly opposite to those during meditation on ‘OM’. During the *dhāraṇā* phase there was a state of

‘alertful rest’ with facilitated cortical neural transmission and greater cortical neural synchrony. However, in the *dhyāna* phase the changes were suggestive of ‘alertful rest’.

There were also marked differences between the two meditation techniques when subjects were actively attending to or ignoring external stimuli. During the practice of ‘OM’ meditation when subjects actively attended to the external auditory stimuli, there was a decrease in arousal whereas in the case of BK meditators there was no change. When the meditators were actively ignoring the external stimuli ‘OM’ meditators showed ‘a state of alertful rest’ and delay in cortical neural transmission while on BK meditators it actually produces ‘a state of physiological arousal along with a delay in cortical neural transmission’.

The findings have shown that the changes during the phases are different and also differ **between meditational techniques**. Also, the differences appear to fit in to the fairly well recognized descriptions of meditations of largely of two types i.e., ‘Concentrative’ and ‘Mindfulness’.

1.6 THE PRESENT STUDY

Based on the above studies, it appears that there are differences in types of meditation as also in different phases of meditation. So the present study deals with studying different phases of meditation based on descriptions in traditional yoga texts. In the traditional texts [the Patañjali’s *Yoga Sūtras* (Taimni, 1961) and *Bhagavad Gītā (Bhaktivedānta Svāmī Prabhupāda, 1998)*] it has been described that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of ‘streamlining the thoughts’

(concentration or *ekāgratā*), and one-pointed concentration (focusing or *dhāraṇā*), before reaching the meditative state (defocused, effortless single thought state or *dhyāna*).

Thus' the present study was carried out to evaluate one of the effects of meditation practice which aimed at assessing the psycho-physiological correlates (brainstem auditory evoked potentials and autonomic with respiratory variables and performance in a letter cancellation task which assess selective attention) in four different states of consciousness detailed above, namely (i) *cañcalatā*, (ii) *ekāgratā*, (iii) *dhāraṇā*, (iv) *dhyāna*. We present in the next chapter the details about their form phases described in texts of yoga and spiritual lore. Later in chapter 3 a thorough review of scientific literature is presented leading to the Aim and objectives of this study in chapter 4 followed by Methods, Results, and Discussions in chapters 5, 6 & 7 respectively ending with an Appraisal in chapter 8.

2.1 BACKGROUND

There are large numbers of techniques of meditation which are being used by many yoga masters all over the globe. For examples, *zazen*, *Tai Chi Chuan meditation*, *Yoga nidrā*, *Prekṣā Meditation*, *Vipassanā Meditation*. However a few of them have been scientifically reviewed such as TM, CM, *OM Vipassanā*, Mindfulness etc. Other do not have proper research data and conclusions.

In the traditional texts [the Patañjali's *Yoga Sūtras* (Taimni, 1961) and *Bhagavad Gītā* (Bhaktivedānta Svāmī Prabhupāda, 1998)] it has been described that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of 'streamlining the thoughts' (concentration or *ekāgratā*), and one-pointed concentration (focusing or *dhāraṇā*), before reaching the meditative state (defocused, effortless single thought state or *dhyāna*). Symbolism has a place in spirituality. In shamanic traditions "perceptual-cognitive-symbolic" characteristic of ordinary states of consciousness and another source of information processing, called "direct-intuitive-nonlocal," characteristic of nonordinary states of consciousness is required to be introduced for interpretation. The first one is capable of modeling via symbolism and is more culturally bound due to its psycholinguistic features. The second one lacks symbolism; therefore, the first one has more transcultural similarity, though culture-specific transliteration may occur.

Among many symbols used, *OM* is one of the fundamental symbols used in the yoga tradition. *OM* is the name or symbol of God (*Īśvara, Brahman*) *Kaṭha Upaniṣat* (Cinmayānanda *Svāmī*, 2002). *OM* covers the whole threefold experience of man. It is the combination of three letters, namely, A, U, and M. *Japa Yoga A comprehensive treatise on Mantra-Śāstra* (*Śivānanda Svāmī*, 2005). “A” represents the physical plain. “U” represents the mental and astral plain, 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 *Svāmī*, 1984). This concept has been well described in various Indian scriptures. In *Māṇḍūkya Upaniṣat*, it has been described that *OM* is the syllable of the past, the present and the future. From the original sound, *OM*, all things become manifest as its extension embodiments *Māṇḍūkya Upaniṣat* (Cinmayānanda *Svāmī*, 1984). The analogy in *Muṇḍaka Upaniṣad* describes that *OM* is the bow; the soul is the arrow; and *Brahman* is the target. The target is attained by an unerring man. One should become one with the target just like an arrow. This is to become one with the imperishable by eliminating the ideas of the body, ego, *prāṇa*, hence being the self with nothing less than union with the Absolute *Muṇḍaka Upaniṣad* (Gambhirānanda *Svāmī*, 1995).

Śvetāśvatara Upaniṣat describes that *OM* is like the fire which though potentially present in firewood is not seen until two sticks are rubbed against each other. The self is like that fire; it is realized by constant awareness of the sacred syllable *OM*. Let the body be the stick that is rubbed and *OM* be the stick that is rubbed against. Then the real nature is

realized which is hidden within, just as fire in a sense hidden in the wood. *Śvetāśvatara Upaniṣat* with the commentary of Śaṅkarācārya (Gambhirānanda *Svāmī*, 1986).

Patañjali's *Yoga Sūtras* (PYS) is one of the classical yoga texts in which the explanation about *OM* is well defined: Patañjali's *Yoga Sūtras* (Taimni, 1961) In PYS there is a single direct mention about *Prāṇava (OM)*. *Prāṇava* is virtually *Īśvara* or *OM*, where *Īśvara* is the word denoting God. Even though there is only one mention about *OM* in PYS, the definition of *Īśvara* and the attributes are given in PYS Chapter I, Verses 24-26.

Bhagavad Gītā describes Kṛṣṇa's instructions to Arjuna just before the great war on the battlefield of *Kurukṣetra* (*Bhagavad Gītā* Madhusudhan *Sarasvatī*, Gambhirānanda *Svāmī*, 1998).

OM is the central element in Kṛṣṇa's exposition of spiritual life and practice, speaking from his perspective as the infinite being, enumerating his major manifestations and embodiments. The meaning is that *OM* is nothing less than the supreme consciousness; so there can be nothing greater or a subject more important than *OM*. This is illustrated as "One who is engaged in the practice of concentration, uttering the monosyllable *OM* (the *Brahman* or consciousness) who remembers it always, he attains the supreme goal (*Bhagavad Gītā* Madhusudhan *Sarasvatī*, Gambhirānanda *Svāmī*, 1998).

In Summary: the sacred syllable *OM* is the primordial sound from which all other sounds and creation emerge. It underlies all phonetic creations. The utterance of *OM*, consisting of the three letters *A*, *U*, and *M*, covers the whole process of articulation. It is like the

sound of a gong that gradually tapers to a point and merges in silence. One, who attains *OM*, merges with the Absolute.

OTHER MEDIATIONS

Transcendental Meditation (TM)

Transcendental meditation (TM) is based on the traditional yogic principles. In TM the meditator sits in a comfortable position silently closing the eyes and repeats a specific *mantra* mentally from time to time to go beyond thought level. This technique is preached and practiced by *Mahaṛṣi* Mahesh Yogi. This is less rigorous and demanding discipline, apparently easily learned, and hence widely practiced. The TM is defined as ‘turning the attention inwards towards the subtler levels of a thought until the mind transcends the experience of the subtle state of thought and arrives at the source of the thought’.

Tāntric 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.

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.

Vipassanā Meditation

Vipassanā, which means to see things as they really are, is one of the ancient techniques of meditation. It was rediscovered by Gautama Buddha more than 2500 years ago. 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.

Prekṣā Meditation

This is also an ancient meditation technique practiced in Jainism. *Prekṣā* means to perceive and realize the subtlest aspects of ones 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.

Cyclic Meditation

Cyclic meditation (CM) is a ‘moving’ meditation technique devised to address the needs and problems of modern man (Nagendra, Nagrathana, 2001). Many people find it difficult to relax and get into a meditative state if asked to sit with their eyes closed while others feel drowsy and even fall asleep. Cyclic meditation involves a combination of gentle yogic stretching and relaxation. It is based on the principles culled from classical yogic texts like *Māṇḍūkya Upaniṣat* (Chinmayānanda, 1984) and *Yoga Sūtras* of Patañjali. This technique is developed and propagated by *Svāmī Vivekānanda Yoga Anusandhāna Samsthāna* and is widely used as an effective therapeutic measure and technique of stress management. It is called so, because it consist the measures of ‘relaxation’ and ‘stimulation’ in cyclic order. This technique includes the practice of certain yoga postures interspersed with relaxation while supine, thus achieving a combination of both ‘stimulating’ and ‘relaxation’ practices.

Yoga teachings consider the syllable *OM* to be the force behind all thoughts. Either chanting or thinking about *OM* is anecdotally reported to cause a quiet mental state. The word ‘meditation’ is more associated with healing and relaxation (Adhīśwarānanda, 2004). It was believed earlier that meditation was meant for spiritual aspirants alone. Now, with the availability of simple methods and with the better understanding of deeper meaning, meditation has become very popular among all categories of people. Scientific and medical evidence has proved its benefits, but still there remains a need to further explore it.

SCOPE FOR THE STUDY: Meditation has been of mystic importance since its discovery. Subjective experiences of various meditators have shown to uplift the

practitioner from a lower state of physical existence to the realms of reality and absolute consciousness. Since then meditation has been a subject of higher interest for various researchers. Every study carried out to discover the effects of meditation gives a new direction and unveils a novel question. What is the effect of meditation? What are the mechanisms occurring during meditation? There continues to be a constant quest for understanding meditation as it reveals varied facts based on the type, duration and depth of its practice. These variations in its effects keep the constant need for studying it in all its aspects.

2. 2 AIM AND OBJECTIVES

- i) To summarize the work already done on mediation from text of ancient Indian lore.
- ii) To compile authentic information on *Cañcalatā*, *Ekāgratā*, *Dhāraṇā* and *Dhyāna* from classical *yogīc* and spiritual literature.
- ii) To explore the concept of *OM* meditation from different classical & *yogīc* texts and the usefulness of above aspects in *OM* meditation

2.3 SOURCES AND METHODS

2.3.1 Sources

This literary research was based on the information collected from the following ancient Indian traditional scriptures and *yogīc* literature which includes:

- A. Classical yoga text: (i) *Patañjali yoga sūtras*, *Vyāsa bhāṣya on Patañjali yoga sūtras* (ii) *Yoga Vāsiṣṭha* (iii) *Bhagavad gītā*, (iv) *Haṭha yoga pradīpikā*, (v) *Gheraṇḍa saṁhītā* and (vi) *Śiva saṁhītā*.
- B. Major Upaniṣads: (i) *Īśāvāsya Upaniṣat* (ii) *Kena Upaniṣat* (iii) *Kaṭha Upaniṣat* (iv) *Muṇḍaka Upaniṣat* (v) *Māṇḍūkya Upaniṣat* (vi) *Aitareya Upaniṣat* (vii) *Taittirīya Upaniṣat* (viii) *Praśna Upaniṣat* (ix) *Chāndogya Upaniṣat* (x) *Bṛhadāraṇyaka Upaniṣat* (xi) *Śvetāśvatara upaniṣat*.
- C. *Brahmasūtras*.
- D. *Prakaraṇa Granthas* like *Ātmabodha* and *Vivekacūḍāmaṇi*.
- E. Texts written by persons recognized as spiritual leaders and visionaries like *Śri Rāmakṛṣṇa Paramahansa*, *Svāmī Vivekānanda* and *Svāmī Adhīśvarānanda*.

2.3.2 Methods

The classical and authentic information was derived from the verses and the commentaries and descriptions about concept of *OM* meditation and its components (*cañcalatā*, *ekāgratā*, *dhāraṇā* & *dhyāna*) and its usefulness from the above mentioned sources. The information was first systematically compiled and then sorted out according to the defined structure of the sections. The original *ślokas* in *samskṛta* transliteration in the standard international codes and meaning will be presented first. Then the special features of the *ślokas* will be explained

based on the relevant commentaries on them. The relevant references are cited in the body of the text as well as in the reference section.

2.4. CONCEPT OF MEDITATION

The English word meditation comes from the Latin root word *meditari*, which derives from the same root as the word meaning 'to heal'. Its *Sanskṛta* derivation '*medhā*' means wisdom. The practice of meditation sets in motion, a process that leads to the restoration of one's - physical, mental, and spiritual well-being. The English connotation of the word 'meditation' is therefore more associated with healing and relaxation (*Adhīśvarānanda*, 2004). It was believed earlier that meditation was meant for spiritual aspirants alone. Now, with the availability of simple methods and with the better understanding of deeper meaning, it has become very popular among all categories of people. Published scientific and medical evidence has proved its benefits, but it still needs to be much understood.

Meditation is the freedom from thought, a state of no-mind. It is a state of pure consciousness with no contents. It is the activation of natural 'seeing' activity, of the 'Self' or Consciousness. It is the finest way to increase one's personal energy by getting connected to the Source.

It is a surprise for the scientist, doctors as well as in the common group that meditation can cure different types of diseases as well as it is becoming a tool for healthy living. Different types of research have been done in this subject and it is continuing. Since west shows the mystic powers of different *yogīs* who went there to serve this world the research in yoga and meditation becoming a major point of

study. Even many *yogīs* and scientist came together to form a common ground to propagate yoga and meditation.

Difference among the *Dhyāna*, *Upāsana*, *Tapas* and *Niddhyāsana*.

Dhyāna is uninterrupted, spontaneous flow of the mind towards the chosen object. *Upāsana* is a prescribed method for approaching a Deity or God or getting close to a deity/deities. *Upāsana* can be described as a systematic practice of a prescribed method of worship for pleasing and winning the attention of the deity. A devotee would consult the scriptures, or a person who knows them thoroughly, to get a prescribed form of worship (*Upāsana*) for his/her deity of choice (*Īṣṭa Devatā*) and follow it faithfully to the best of his/her abilities. *Tapas* referring to a focused effort leading towards bodily purification and spiritual enlightenment. Through *tapas*, a yogi or spiritual seeker can "burn off" or prevent accumulation of negative energies, clearing a path toward spiritual evolution. *Tapas* may be the striving for nirvana, or mokṣa. It may also be striving for perfection in a particular sport, field of knowledge or work. *Tapasyā* may also be undertaken as penance, to liberate oneself from the consequences of a sin or sinful activities, or karma. In other words 'tapas' is the act of burning-through the fire of direct cognition of the knowledge that *Brahman* is the truth and the universe, a myth the seed of the deep-rooted desire to attain the powers of *Brahmā* etc (*Nirālamba Upaniṣat-Narayana Svāmī*, 2003). As Patañjali defined, *tapah* is to reach to the perfection of the

sense-organs and body after destruction of impurity. *Niddhyāsana* is Fixing the mind firmly on Brahman, the point of Contemplation, restraining the sense organs in their respective centre's, holding the body steady and giving up all thoughts of maintenance, identifying with Brahman, and being tuned to it, continuously drink the bliss of Brahman in your Self. Of what use are other things? They are entirely false, empty. Contemplation is Enquiry into Self, Leading to experience of non duality, Transcending Man's creation, the discovery of freedom to devalue thoughts, a process of re-absorption into the Self, Disappearance of small self in Self (Like waves in a ocean, Transcending Man's creation) Contemplation is the discovery of freedom to devalue thoughts.

In a scientific point of view the general concept defines:

Meditation offers a fascinating window into human consciousness, psychology and experience; the relationship between the mental state and body physiology; emotional and cognitive processing and the biological correlates of religious experience (Newberg & Iverson, 2003). In the last thirty-five years there have been scientific studies examining physiological changes induced by the process. However, it has been mentioned that even detailed reports were not complete as they did not define the method of meditation or they presented a general definition, often inaccurate and inadequate (Cardoso, de Souza, Camano, & Leite, 2004).

Occidental context, the word meditation is used to describe practices that self-regulate the body and mind thereby affecting mental events by engaging a specific attentional set. Regulation of attention is the central and common factor across many divergent methods (Davidson & Gollman, 1977).

2.4.1 OBJECTS OF MEDITATION

Meditation involves three factors (*tripuṭi*) i.e., meditator, the object of meditation and the process of meditation. The object of focus is generally sacred and can be personal or neutral, concrete or abstract, a word or an idea, an image or a symbol, a divine form or personality.

The Yoga *Sūtras* of Patañjali mention the following as the possible objects of meditation: (i) the effulgent or radiant light which is beyond all sorrow (*jyotiṣmati*), (ii) the heart of an illuminated being (*vītarāgī*) who is free from all passion and attachment (iii) the subtler dimensions and knowledge of sleep and dream state or (iv) anything (*yathābhimata*) that is spiritually uplifting. Such a thing may be a place, some scenery, an idea or any other thing that would evoke concentration of mind (Adhīśwarānanda, 2004).

The texts on *Haṭha* yoga say the object of concentration can be outside the body like a *jyoti* or *bindu* in case of *trāṭaka*, sun (*sūrya*) and moon (*candra*) or can be inside the body like breath, movement of *prāṇa*, sensations of processes in the body, various *cakras* or even the mind (genesis of thoughts) itself (Muktibodhānanda, 2003).

According to the tradition of *Vedānta* following objects are preferred for meditation:

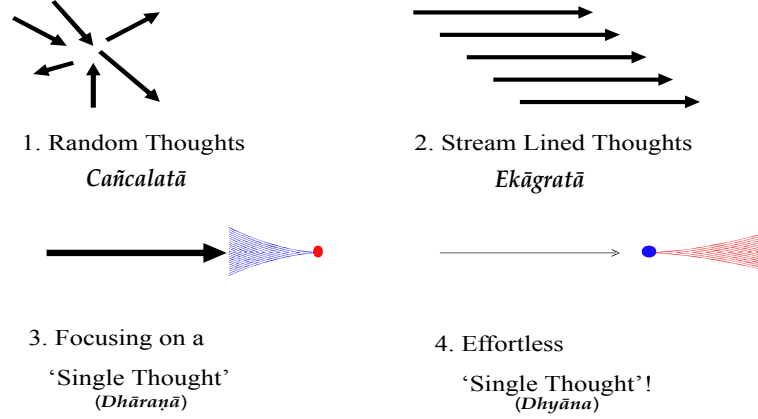
(i) a divine form, (ii) an Incarnation of God, (iii) the divine Lord as inmost Self of Supreme Teacher, (iv) *Virāṭa Puruṣa* or the Cosmic Personality, (v) the sacred word *AUM*, (vi) *Gāyatrī mantra*, or the sacred prayer of the Vedas (vii) the meaning of any of the four *mahāvākyas*, or great Vedic saying or (Viii) the meaning of a sacred text, word or mystic syllable (Adhīśvarānanda, 2004).

2.4.2 FOUR COMPONENTS IN THE WAKING STATE OF CONSCIOUSNESS

Fig. 1 Schematic representation of phases of wakeful consciousness

(Cañcalatā, Ekāgratā, Dhāraṇā and Dhyāna)

Illustrated phases and general concept of 'OM' meditation



2.4.2A *Cañcalatā* (Random thoughts):

Specific to meditation, it has been described that in the absence of a specific task the mind is very distractible (*cañcalatā*) with an outward attention (*paraṅga-cetanā*). Another classical text on yoga (The *holy Bhagavad Gītā*, *Bhaktivedānta*, 1998) describes the characteristics of *cañcalatā* state of the mind (one of the four states in the waking state of consciousness) and the continuous practice (of yoga) (*abhyāsa*) and non-attachment (*vairāgya*) as the solution.

The *Bhagavad Gītā* is presented the hurdles and its solution for meditation, in the form of a conversation between Arjuna and Lord *Kṛṣṇa*.

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 obstinate.
I deem it as hard to control as the wind.

Lord *Kṛṣṇa* answers:

असंशयं महाबाहो मनो दुर्निग्रहं चलम् ।

अभ्यासेन तु कौन्तेय वैराग्येण च गृह्यते ॥

Asaṁśayaṁ mahābāho mano durnigrahaṁ calam'

Abhyāseṇa tu kaunteya vairāgyeṇa ca gṛhyate.

(*Bhagavad Gītā*, Ch: 6 V: 35)

Doubtless, O mighty-armed, the mind is restless and hard to control; but by practice and non-attachment, O son of Kunti! It can be controlled.

The mind in the *cañcalatā* state has to be taken through the stages of 'streamlining the thoughts' (*ekāgratā*), and one-pointed concentration (*dhāraṇā*), before reaching the meditative state: a defocused, effortless, single-thought state (*dhyāna*) (Cinmayānanda, 1984).

ध्यायतो विषयान् पुंसः सङ्गस्तेषूपजायते । सङ्गात् सञ्जायते कामः कामात् क्रोधोऽभिजायते ॥२.६२॥

क्रोधाद् भवति संमोहः संमोहात् स्मृतिविभ्रमः । स्मृतिभ्रंशाद् बुद्धिनाशो बुद्धिनाशात्

प्रणश्यति ॥२.६३॥

Dhyāyato viṣayān puṁsaḥ saṅgasteṣūpajāyate. Saṅgāt sañjāyate kāmaḥ kāmāt krodho'bhiajāyate. Krodhād bhavati sammohaḥ sammohāt smṛtivyibhramaḥ.

Smṛtibhramśād buddhināśo buddhināśāt pranaśyati.

(Cinmayānanda, 2001, Ch: 2 V: 62, 63)

Desire leads to generation of more thoughts; repetition of thoughts and experience makes deeper impressions converting them into emotions. Punishing the mind through self-torture and mortification would merely repress the desires, driving them underground (subconscious). Trying to transform the mind by changing our environment would be futile because wherever we go, our mind with all its habitual tendencies goes with us. Thus mind never becomes controlled automatically; it must be controlled consciously. The only alternative, according to the yoga is to slowdown the mind and face it by control and regulation

Meditation provides the systematic method to control and regulate the *cañcala* mind.

अविश्रान्तमनाः स्थित्वा पप्रच्छ पितरं तदा ।

संसाराडम्बरमिदं कथमभ्युदितिं मुने ॥५॥

Aviśrāntamanāḥ sthitvā papraccha piatarāṁ tadā

Saṁsārāḍambaramidaṁ kaṭhamabhyuditiāṁ mune ॥5॥

(*Yoga Vāsiṣṭha* Ch: II. 5. E.Y.V)

With a restless mind, he then asked his father, “Sage ! How did this show of wordly existence arise?”

भवताऽप्येष एवार्थ उक्तः शास्त्रेषु यः श्रुतः ।

त्वत्तो विश्राममाप्नोति कथं चेतो वद प्रभो ॥१६॥

Bhavatā’pyeṣa evārtha uktaḥ śāstreṣu yaḥ śrutaḥ ।

Tvatto viśrāmamāpnoti kaṭham cetō vada prabho ॥16॥

“The same fact which is heard of in the scriptures has been uttered by you also. How does the mind attain tranquillity? Tell that yourself.”

Janaka said: अव्युच्छिन्नचिदात्मैकः पुमानस्तीह नेतरत् ।

स्वसंकल्पवशात् बद्धो निःसङ्कल्पश्च मुच्यते ॥१७॥

Avyucchinnaçidātmaikāḥ pumānastīha netarat ।

Svasaṅkalpavaśāt baddho niḥsaṅkalpaśca mucyate ॥17॥

“There is here but one Self who is of the nature of undivided Consciousness. There is nothing else. He is bound by his own thoughts; free ideation, he is liberated.

Note: The word used for ‘thought’ and ‘ideation’ in this verse is ‘*Saṅkalpa*’. It also

means: will, intention, wish and imagination. All these terms indicate the functions of the internal instrument of perception, designated by the common word ‘mind’.

2.4.2B *Ekāgratā* (Concentration)

Meditation is generally understood as deep concentration on any object. In that sense, everyone meditates, because concentration is indispensable not only for survival but also for success in any walk of life. It is through concentration one can see, hear, work or understand anything. Concentration is the way to gain knowledge about any subject. Through concentration the mind acquires the quality of a lens and can penetrate deeply

into an object, external or internal, and perceive its' real nature. However, practically it is observed and experienced that concentration is tiring, it drains the energy. One cannot concentrate for long. After some time spent in concentration one feels fatigue and stressed because concentration involves intense effort.

In *Saṁskṛta*, *ekāgratā* (moving in one direction) means concentration (Apte 1992), the channelizing of all the mental energies in a single direction. Normally our mind exists in the state of *cañcalatā* (continuously moving) wherein it moves in all directions, jumps (as it were) from one object to another object randomly. The mind in this phase is unstable, turbulent and restless (Cinmayānanda, 2001, Ch: 6 V: 34). It flows in all directions according to its likes and dislikes and its patterns. The haphazard flow of thoughts is called as *cañcalatā*. Streamlining these scattered energies of the mind in one direction is *ekāgratā*. However' this process requires voluntary control and effort. For example, reading a book, watching a movie, driving a car all require different degrees of effort. Thus' in concentration mind is directed on a single subject or direction, but there exist multiple thoughts. All these thoughts are interconnected to one another to form a meaningful or logical chain.

तत्रैकाग्रं मनः कृत्वा यतचित्तेन्द्रियक्रियः ।

उपविश्यासने युञ्ज्यात् योगमात्मविशुद्धये ॥६ १२ ॥

Tatraikāgram manaḥ kṛtvā yatacittendriyakriyaḥ
Upaviśyāsane yunjyāt yogamātma viśuddhaye.

(*Bhagavad Gītā*, Ch: 6 V: 12)

Seating in one place, making the mind one-pointed and restraining the thinking faculty and the senses, one should practice yoga for self-purification.

तं दुर्दर्शं गूढमनुप्रविष्टं गुहाहितं गह्वरेष्ठं पुराणम् ।

अध्यात्मयोगाधिगमेन देवं मत्वा धीरो हर्षशोकौ जहाति ॥

Tam durdarśam gūḍhamanupraviṣṭhaṁ guhāhitaṁ gahvareṣṭhaṁ purāṇam.

Adhyatmayogādhiḡamena devaṁ matvā dhīro harṣaśokau jahāti.

Kaṭha upaniṣat - (Cinmayānanda, 2002, Ch: 1 V: 2.12)

The wise man who, by means of concentration on the Self, realizes that ancient, effulgent One, who is hard to be seen, un-manifest, hidden, and who dwells in the *buddhi* and rests in the body – he, indeed, leaves joy and sorrow far behind.

2.4.2C Dhāraṇā

Dhāraṇā is a continuation of the process of sensory inhibition or withdrawal called as *pratyāhāra*. *Dhāraṇā* is the ‘holding of the mind in a motionless state’, as the *Tri-sikhi-Brahmaṇa-upaniṣat* defines this advanced practice (Feuerstein, 2001).

Dhāraṇā the fifth limb of the Patañjali ’s eightfold path is focusing of attention to a given locus (*deśa*), which may be a particular part of the body (such as *cakra*) or an external object that is internalized (such as the image of a deity).

The *Saṁskṛta* word *dhāraṇā* stems from the verbal root *dhṛ* (Apte, 1992), meaning ‘to hold, to fix’. What is being held is one’s attention, which is fixed on an internalized object and the underlying process is called *dhāraṇā*. According to sage *Patañjali*,

देशबन्धश्चित्तस्य धारणा ॥

Deśabandhaścittasya dhāraṇā.

(PSY- Ch: 3.V: 1; Prabhavānanda , 2002).

‘Fixing of mind on a specific object (or a spot, internal or external) is *dhāraṇā*’
Concentration is the confining of the mind within a limited mental area object of concentration.

Fig.2



The main tasks in the *dhāraṇā* phase are: (i) keeping the mind continuously engaged in consideration of an object and bringing it back as soon as the connection is lost, (ii) reducing the frequency of such interruptions and (ii) complete focusing with sharply defined mental images, by increasing the degree of alertness and power of attention. It is the holding of the mind to some particular object. (When the mind holds on to some object, either in the body or outside the body, and keeps itself in that state, it has attained *dhāraṇā* concentration). An unbroken flow of knowledge about that object is *dhyānā*. When the mind tries to think of one object, to hold itself to one particular spot, such as the top of the head, or the heart, and succeeds in receiving sensations only through that part of the body, and no other part, it has attained *dhāraṇā*: and when the mind succeeds in keeping itself in that state for some time, it has attained *dhyāna*.

अर्धोन्मीलितलोचनः स्थिरमना नासाग्रदत्तेक्षण-

श्चन्द्रार्कावपि लीनतामुपनयत्रि स्पन्दभावेन यः ।

ज्योतीरूपमशेषवीजमखिलं देदीप्यमानं परं

तत्त्वं तत्पदमेति वस्तु परमं वाच्यं किमत्राधिकम् ॥ ४१ ॥

Ardhonmīlitalocanaḥ sthīramanā nāsāgradattekṣaṇa

Ścandrārkāvapi līnatāmupanayatri spandabhāvena yaḥ ।

Jyotīrūpamaśeṣavījamakhilam dedīpyamānam param

Tattvaṁ tatpadameti vastu paramaṁ vācyaṁ kimatrādhikam ॥ 41 ॥

(Muktibodhānanda, *H. Y. P.* Ch: IV, V: 41)

Mind steady, eye semi-open, gaze fixed on the nose tip, the moon (ida) and sun (*piṅgalā*) suspended, without any movement (physical or mental), that one attains the form of light (jyoti) which is endless and is complete, radiant, the Supreme.

Meditation is the spontaneous result of concentration of the mind. *Dhyāna*

or meditation occurs when the mind stops oscillating off the point of

concentration, when the witness, witnessed, and process of witnessing

alone remain. *Dhyāna* is ekāgra or one-pointedness of mind, when the *vṛttis*

or mental movements are confined to the process and the object of

concentration.

देशे नाभिचक्रनासाग्रादौ चित्तस्य बन्धो विषयान्तरपरिहारेण

यत् स्थिरीकरणं सा चित्तस्य धारणा इत्युच्यते ।

Deśe nābhicakranāsāgrādaucittasya bandho viṣayāntaraparihāreṇa

Yat sthīrikaraṇam sā cittasya dhāraṇā ityucyate.

(Sukhānanda natha, 1992).

The mental flux could be halted on navel center, tip of the nose or any place as sanctioned by scriptures. Stabilizing the mental flux without disturbance from any corner is termed as *dhāraṇā*.

मैत्र्यादिचित्तपरिकर्मवासितान्तः करणेन यमनियमवता चितासनेन परिहृतप्राणविक्षेपेण
प्रत्याहृतेन्द्रियग्रामेण निर्वाधे प्रदेशे ऋजुकायेन जितद्वन्देन योगिना नसाग्रादौ सम्यज्ञातस्य समाधेः

अभ्यासाय चेतसः स्थिरीकरणम् कर्तव्यम् इति ॥

यमादिगुणसंयुक्ते मनसः स्थितिरात्मनि । धारणा प्रोच्यते सदिः योगशास्त्रविशारदैः ॥

तस्मात्समस्तशक्तिनाम् आधारे तत्र चेतसः । कुर्वीत संस्थितिं सा तु विज्ञेया शुद्धधारणा ॥

*Maitryādīcittapari karmavāsītāntaḥ karaṇena yamaniyamavātā citāsanena
parihrataprāṇavikṣepeṇa pratyāhratendriyaagrāmeṇa niroādhe pradeśe ṛjukāyena
jīta dvandena yogīnā nasāgrādau samyajñātasya samādheḥ abhyāsāya cetasaḥ
sthirīkaraṇam kartavyam iti. Yamādiguṇasanyukte manasaḥ sthīrātmani.*

*Dhāraṇā procyate sadiḥ yogaśāstraviśāradaīḥ. Tasmātsamastāśaktinām ādhāre
tatra cetasaḥ | Kuroīta sansthitim sā tu vijñeyā śuddhadhāraṇā – Viṣṇupurāṇam.*

(*Viṣṇupurāṇam*, Sukhānanda natha, 1992).

This (*dhāraṇā*) is supposed to be practiced by the *yogī*, who has gone through the previous five limbs, and desirous of attaining *Samādhi*. Hence directing or stabilizing all mental forces on a particular base or object is known as *śuddhadhāraṇā*.

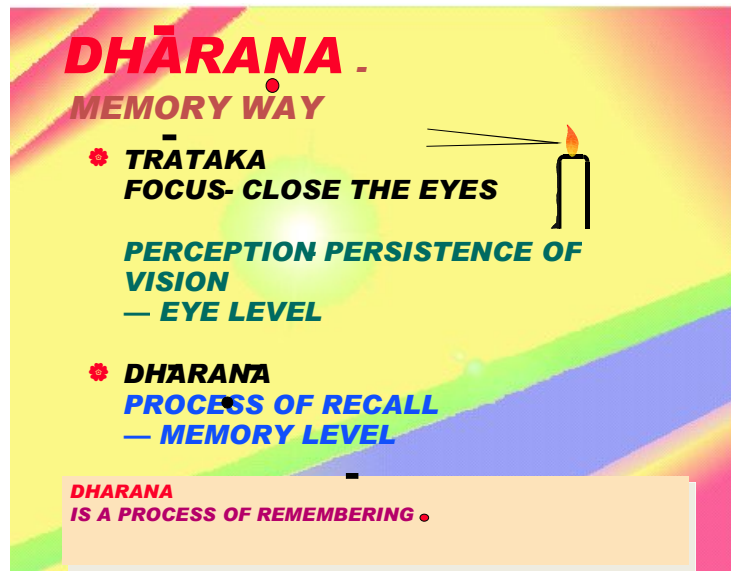
Thus' *dhāraṇā* not only involves concentration but takes to the next step of focused attention. *Dhāraṇā* consists of focusing on a relevant thing and withdrawal from irrelevant. In the process of perception, mind not only aligns with external sense organs (*jñānendriyas*) but also tunes with earlier experiences. *Ekāgratā* is analytical focusing where as *dhāraṇā* is a non-analytical focusing. Hence *dhāraṇā* also involves a component of remembering i.e., repeated continuous recollection of the object and not allowing the mind to get distracted (Nagendra, Svāmy, & Mohan, 2003). Thus' in *dhāraṇā* mind is confined (*bandha*) to a single object with

single thought. Hence *dhāraṇā* requires voluntary control, persistent effort and training (*abhyāsa*).

The *Saṁskṛta* word *dhyāna* means continuous dwelling of mind on a single object.

When *dhāraṇā* becomes effortless and continuous it takes the form of *dhyāna*. Often this is translated as meditation. Nevertheless, the word meditation is also used to denote concentration and *dhāraṇā*. In this thesis, meditation means *dhyāna*.

Fig. 3.





तत्र प्रत्ययैकतानता ध्यानम् ॥

Tatra pratyayaikatānatā dhyānam.

(Taimni, 1961, Ch: 3 V: 2).

‘Meditation is uninterrupted, spontaneous flow of the mind towards the chosen object’.

2. 4.2D *Dhyāna* (meditation)45

Uninterrupted concentration on the object of concentration (*Pratyayaikatānatā*) is the distinguishing feature between the *dhāraṇā* and *dhyāna*. This continuity is regarded as the measure of concentration and the total control over the mind. The attainment of ‘*Dhyāna Avasthā*’ shows that the mind is ready for the last limb (*Aṅga*) (*Samādhi*) and the beginning of the higher states of yoga.

Dhāraṇā naturally leads to the state of meditative absorption, in which the internalized object or locus fills the entire space of consciousness. Just as the one-pointedness of attention is the mechanism of *dhāraṇā*, ‘one-flowing-ness’ (*ekatānatā*) is the underlying process of meditation accompanied by a peaceful, calm disposition. There is no loss of lucidity, but on the contrary, the sense of wakefulness is intensified, even though there is no or little awareness of the external environment.

The psychology of meditation is to cultivate a single thought. A restless mind is like a lake, constantly agitated by the winds of desires, creating thought–waves of diverse intensities. Because of this constant agitation, our true Self at the bottom of the lake cannot be perceived. When, to counter all those many thought–waves, a single thought is consciously cultivated by the repeated and uninterrupted practice of meditation, it develops into a huge wave that swallows up all the diverse ripples and makes the mind transparent and calm. The mind in meditation takes the form of this single thought-wave. The five characteristic features of meditation (*dhyāna*) are (i) single thought, (ii) effortlessness, (iii) awareness, (iv) slowness and (v) expansiveness. This can be called as defocusing. Meditation is a fine method for learning the secrets of the outer and inner worlds. Meditation is a technique of withdrawing the mind so that it receives rest and rejuvenation. The initial purpose of meditation is to intercept the flux of ordinary mental activity (*citta vṛtti*), which is cause for *cañcalatā* (Feuerstein, 2001).

ध्यानहेयास्तद्वृत्तयः ॥

Dhyāaheyāstadvṛtayah.

(Taimni, 1986, Ch: 2 V: 11).

The modifications of the *kleṣas* are reducible through meditation *Sāṅkhya Yoga* (Bahadur, 1988):

Cessation of desire is meditation.

It has been stated that knowledge alone can confer liberation. The author goes on to say how such knowledge can be obtained. When by meditation the mind is untarnished by external objects the impediments in the way of knowledge are removed.

Meditation is perfected by repelling the modifications of the mind. The modifications are real cognition, unreal cognition, imagination, deep sleep and memory. Meditation is accomplished by restraining them. When this is achieved there takes place the immediate intuition of the object of meditation.

Meditation is accomplished by dhāraṇā, āsana and svadharma.

The author mentions how meditation is accomplished. This is by holding the mind in a particular part of the body (*dhāraṇā*), adopting the needful posture (*āsana*), and by performance of the *varṇa* duties (*svadharma*), i.e., duties belonging to the stage of life in which one is placed.

Meditation may be a spiritual practice but its effects on the body are definite and physiologically verified. Alpha waves become intense, respiration becomes minimal, consumption of oxygen decreases, blood pressure and temperature drop (*HYP*, Muktibodhānanda 1985).

प्रत्याहारो धारणा च ध्यानं भ्रूमध्यमे हरिम् ॥२४॥

*Pratyāhāro dhāraṇā ca dhyānaṁ bhrūmadhyame harim |
yogatattoopaniṣat ||24||*

Pratyāhāra, dhāraṇā, Dhyāna the contemplation on Hari in the middle of eyebrows.

अभेददर्शनं ज्ञानं ध्यानं निर्विषयं मनः ।

स्नानं मनोमलत्यागः शौचमिन्द्रियनिग्रहः ॥२॥

Abhedadarśanaṁ jñānaṁ dhyānaṁ nirviṣayaṁ manaḥ |

Snānaṁ manomalatyāgaḥ śaucamindriyanigrahaḥ |2|| (maitreyyupaniṣat)

The cognition of everything as non different from one self of *jñāna*. Abstracting mind from causal object in *dhyāna*. Purifying the mind of its impurities *snāna*. Bathing. The subjugation of *indriyas* is *sauca*. The wise man should observe thus: than he obtains Absolution.

ध्यातृध्याने विहाय निवातस्थितदीपवध्दत्रेयैकगोचरं चित्तं समाधिर्भवति । ।

Dhyātr̥dhyāne vihāya nivāsthitadīpavadhdatreyaikagocaram
cittam samādhirbhavati | (Adhyātmopaniṣat)

That is called *Samādhi* in which the chitta, raising above the conception of the contemplator and contemplation, merges gradually into the contemplated, like a light undisturbed by mind the wind.

ध्यायतेऽध्यासिता तेन तन्यते प्रेयते पुनः ।

सूयते पुरुषार्थं च तेनैवाधिष्ठितं जगत् ॥ ४ ॥

मन्त्रिकोपनिषद्

Dhyāyate' dhyāsitā tena tanyate preryate punaḥ |
Sūyate puruṣārtham ca tenaiṣādhiṣṭhitam jagat || 4||
(Mantrikopaniṣad, V: 4)

Nididhyāsana and Dhyāna

आत्मा वा अरे द्रष्टव्यः श्रोतव्यो मन्तव्यो निदिध्यासितव्यो मैत्रेयि आत्मनो व अरे दशनिन श्रवणेन
मत्या विज्ञानेनेदं सर्वं विदितम् ॥५ ॥

Ātmā vā are draṣṭavyaḥ śrotavyo mantavyo nididhyāsitavyo maitreyi ātmano va
are darśanena śravaṇena matyā vijñānenedam sarvaṁ viditam ||5||.

(*Bṛhadāraṇyaka Upaniṣat II.4.5*)

It should first be heard of from the teacher from the scriptures, then reflected on through and reasoning and then steady firstly meditated upon ' thus only is It realized- when these means, viz hearing, reflection and meditation have been gone through. When these three are combined than only true realization of the unity of Brahman is accomplice, not otherwise - by hearing alone.

श्रवणमनननिर्विकित्सेऽर्थे वस्तुन्येकतानवत्तया चेतःस्थापनं निदिध्यासनं भवति ।

śravaṇamanananirvicikitse'rthe vastunyekatānavattayā cetaḥsthāpanam
nididhyāsanam bhavati | (Adhyātmopaniṣat)

It becomes manana (completion) when such idea are quited (in one) through logical reasoning. When their meaning is conformed through these (two process) the concentration of mind on it alone constitutes *nididhyāsanam*.

Dhyāna has been defined by Maḥarṣi Patañjali but nididhyāsanam comes under the upaniṣadic thoughts or ideas such as mahāvākyas as flows

In nididhyasana there is an inner search to find the root of I thought; to go to the very source from where thoughts arise. Later as we evolve. We search the source from where all deep rooted vasanas and samskars also emerge. While in dhyana we keep the mind on a simple thought effortlessly; there is no search inside. Similarly in nididhyasana there can be a series of different thoughts as concentration but all directed to phathom Reality. As the teacher assess him to see “That you are”.

1. तत्त्वमसि (*tattvamasi*), (Chāndogya Upaniṣat 6.8.7)
2. अयमात्मा ब्रह्म (*ayamātmā brahma*), (Māṇḍūkya Upaniṣat 1.2)
3. अहं ब्रह्मास्मि (*aham brahmāsmi*), (Bṛhadāraṇyaka Upaniṣat 1.4.10)
4. सर्वं खल्विदं ब्रह्म (Sarva khalvidam brahma) (Chāndogya Upaniṣat 3.14)

In the present study, the concept of *Dhyāna* is presented based on the definition given by *Mahaṛṣi Patañjali* .

2.4.3 THE FACETS OF MIND

Generally mind is defined as a flow of thoughts. The conglomeration of thoughts is mind (Nagendra, 2001). This process of thoughts is always ongoing and is related with the information and inputs given by the external organs of perception and the feedback obtained from the earlier memories and impressions. In yogic understanding, the mind has four functional facets i.e., *manas*, *buddhi*, *citta* and *ahaṅkāra* together called as *antaḥkāraṇa* (internal instrument).

निगद्यतेऽन्तःकरणं मनोधीरहंकृतिश्चित्तमिति स्ववृत्तिभिः ।

मनस्तु संकल्पविकल्पनादिर्बुद्धिः पदार्थाध्यवसायधर्मतः ॥१३॥

अत्राभिमानादहमित्यहंकृतिः । स्वार्थानुसन्धानगुणेन चित्तम् ॥१४॥

Nigadyate'ntaḥkaraṇam manodhīrahāṅkṛtiścittamiti svavṛttibhiḥ.
Manastu saṅkalpavikalpanādirbuddhiḥ padārthādhyavasāyadharmataḥ.

Atrābhimānādahamityahaṅkṛtiḥ. Svārthānusandhānaguṇena cittam.

The oscillating nature of thoughts is *manas* (*saṅkalpavikalpatmika*), discriminative ability is *buddhi* (*niścayātmika*), stored impressions and patterns is *citta* (*anusandhānātmika*) and feeling of 'I' ness, the ego is *ahaṅkāra* (Cinmayānanda, 2002a, V: 93, 94). This mind oscillates between any of the following five states:

क्षिप्तं मूढं विक्षिप्तमेकाग्रं निरुद्धमिति चित्तभूमयः ।

Kṣiptam mūḍham vikṣiptamekāgraṁ niruddhamiti cittabhūmayah.

Mind often functions in restless or turbulent way (*kṣipta*), sometimes becomes dull and stupefied (*mūḍha*), sometimes becomes distracted and divided (*vikṣipta*), sometimes becomes concentrated and one pointed (*ekāgra*) and rarely becomes restrained and suspended (*niruddha*). These are different grounds or fields of functioning of the mind (*cittabhūmayah*) (Bangali Baba, 2002). This is presented schematically in **Fig. 4**

2.5 CONCEPT OF OM

2.5.1 UPANIṢADS- ŚRUTI PRASTHĀNA: To describe the ultimate reality or *Brahman* is infinite and difficult to comprehend, so the *upaniṣads* suggest that we take the help of a symbol, *OM*. *Upaniṣads* had taken great credits to explain why *OM* is the most appropriate symbol. It says that *OM* is nothing but so many components put together. For one thing, it comprises three distinct sounds- *A*, *U* and *M*. the whole range of sound is covered by these three sounds, and so *OM* is called *Nāda Brahman*, sound *Brahman*.

सर्वे वेदा यत्पदमामनन्ति तपांसि सर्वाणि च यद्वदन्ति ।

यदिच्छन्तो ब्रह्मचर्यं चरन्ति तत्ते पदं संग्रहेण ब्रवीम्योमित्येतत् ॥

Sarve vedā yatpadamāmananti tapāṅsi sarvāṅi ca yadvadanti |

Yadicchanto Brahmccāryaṅ caranti tatte padaṅ saṅgrahaṅa bravīmyomityetat ||

(*Kaṭha Upaniṣat*, 1. II. 15.)

I tell you briefly of that goal which of all the Vedas with one propound, which all the austerities speak of, and wishing for which people practice *Brahmccarya*: it is this, viz OM.

OM is one of the fundamental symbols used in the yoga tradition. *OM* is the name or symbol of God (*Īśvara*, *Brahman*) *Kaṭha Upaniṣat*

(*Cinmayānanda Svāmī*, 2002). *OM* covers the whole threefold experience of man. It is the combination of three letters, namely, *A*, *U*, and

M. *Japa Yoga* A comprehensive treatise on *Mantra-Śāstra* (*Śivānanda Svāmī*, 2005). “*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 Svāmī, 1984). This concept has been well described in various Indian scriptures.

In *Māṇḍūkya Upaniṣat*

ओमित्येतदक्षरमिदं सर्वं तस्योपव्याख्यानं भूतं

भवद्भविष्यदिति सर्वमोङ्कार एव ।

यच्चान्यत् त्रिकालातीतं तदप्योङ्कार एव ॥

Omityetadākṣaramidaṁ sarvaṁ tasyopavyākhyānaṁ bhūtaṁ

Bhavadbhaviṣyaditi sarvamoṅkāra eva |

Yaccānyat trikālātītaṁ tadapyoṅkāra eva ||

(*Māṇḍūkya Upaniṣat*, V: 1.)

It has been described that *OM* is the syllable of the past, the present and the future. From the original sound, *OM*, all things become manifest as its extended embodiments *Māṇḍūkya Upaniṣat* (Cinmayānanda Svāmī, 1984). The analogy in *Muṇḍaka Upaniṣat* describes that *OM* is the bow; the soul is the arrow; and *Brahman* is the target. The target is attained by an unerring man. One should become one with the target just like an arrow. This is to become one with the imperishable by eliminating the ideas of the body, ego, *prāṇa*, hence being the self with nothing less than union with the Absolute *Muṇḍaka Upaniṣat* (Gambhirānanda Svāmī, 1995).

वह्नेर्यथा योनि गतस्य मूर्तिर्न दृश्यते नैव च लिङ्गनाशः ।

स भूय एवेन्धन योनिगृह्यस्तद्वोभयं वै प्रणवेन देहे ॥१॥१३॥

*Vahneryathā yoni gatasya mūrtirna dṛśyate naiva ca liṅganāśaḥ |
sa bhūya evendhana yonigr̥hyastadvobhayaṁ vai praṇavena dehe
||1| 13|| Śvetāśvatara upaniṣat*

Śvetāśvatara Upaniṣat describes that *OM* is like the fire which though potentially present in firewood is not seen until two sticks are rubbed against each other. The self is like that fire; it is realized by constant awareness of the sacred syllable *OM*. Let the body be the stick that is rubbed and *OM* be the stick that is rubbed against. Then the real nature is realized which is hidden within, just as fire in a sense hidden in the wood. *Śvetāśvatara Upaniṣat* with the comentary of Śaṅkarācārya (Gambhirānanda *Svāmī*, 1986).

2.5.2 BHAGAVAD GĪTĀ-SMṚTI PRASTHĀNA

ॐ तत्सदिति निर्देशो ब्रह्मणस्त्रिविधः स्मृतः ।

ब्राह्मणास्तेन वेदाश्च यज्ञाश्च विहिताः पुरा ॥२३॥

*Om tatsaditi nirdeśo brahmaṇastrividhaḥ smṛtaḥ |
Brāhmaṇāstena vedāśca yajñāśca vihitaḥ purā ||23||*

(Ch: 17; V: 23).

OM' tat and sat this has been declared as the triple appellation of *Brahma*, who is Truth, Conciuousness and Bliss. By that were the *Brahmanas* and the Vedas as well as sacrifices created at the cosmic dawn.

तस्मादोमित्युदाहृत्य यज्ञदानतपःक्रियाः ।

प्रवर्तन्ते विधानोक्ताः सततं ब्रह्मवादिनाम् ॥२४॥

Tasmādomityudāhṛta yajñadānatapaḥkriyāḥ |

Pravartante vidhānoktāḥ satataṁ brahmavādinām ||24||

(Ch: 17; V: 24).

Therefore' with the utterance of the holy syllable "AUM" the acts of sacrifice, charity and austerity are commenced; as enjoined in the scriptures by the expounders of the *Brahman*.

Bhagavad Gītā describes Kṛṣṇa's instructions to Arjuna just before the great war on the battlefield of *Kurukṣetra Bhagavad Gītā* Madhusudhan *Sarasvatī*, Gambhirānanda *Svāmī*, 1998).

OM is the central element in Kṛṣṇa's exposition of spiritual life and practice, speaking from his perspective as the infinite being, enumerating his major manifestations and embodiments. The meaning is that *OM* is nothing less than the supreme consciousness; so there can be nothing greater or a subject more important than *OM*. This is illustrated as "One who is engaged in the practice of concentration, uttering the monosyllable *OM* (the *Brahman* or consciousness) who remembers it always, he attains the supreme goal *Bhagavad Gītā* Madhusudhan *Sarasvatī*, Gambhirānanda *Svāmī*, 1998).

In Summary: the sacred syllable *OM* is the primordial sound from which all other sounds and creation emerge. It underlies all phonetic creations. The utterance of *OM*, consisting of the three letters *A*, *U*, and *M*, covers the whole process of articulation. It is like the sound of a gong that gradually tapers to a point and merges in silence. One who attains *OM*, merges with the Absolute.

2.5.3 BRAHMASŪTRA-NYĀYA PRASTHĀNA

Brahmasūtra is the exposition primarily of the *Upaniṣats*. It is an attempt to systematize and reconcile the various strands of the *upaniṣats*

which form the background of Vedanta philosophy. The *sūtra* are arranged in four chapters, each subdivided into four parts or quarters (*pāda*).

ईक्षतिकर्मव्यपदेशात्सः ॥१३॥

Īkṣatikarmavyapadeśāt ||13||

(Vidyānanda *svāmī*, *Brahmasūtra* Ch: I; Part III; V: 13)

Īkṣatikarma can be interpreted: Anyone, who meditate on the Supreme Puruṣa

(Ṛgveda. 10. 90. 1) with the syllable 'OM' as possessed of three *mātrās*, becomes illumined like the sun." the word *Puruṣa* is used for God as well as the individual soul.

त्रयाणामेव चैवमुपन्यासः प्रश्नश्च ॥६॥

Trayāṇāmeva caivamupanyāsaḥ praśnaśca ||6||

(Vidyānanda *svāmī*, *Brahmasūtra* Ch: I; Part IV; V: 6)

Yamācārya replied to Naciketā the Supreme Lord whom all penances and austerities, including *Brahmācārya*, are performed, I tell you in brief- that is 'OM'.

2.5.4 PATAÑJALI'S YOGA SŪTRAS

Patañjali's Yoga Sūtras (PYS) is one of the classical yoga texts in which the explanation about *OM* is well-defined *Patañjali's Yoga Sūtras* (Taimni, 1961). In PYS there is a single direct mention about *Praṇava* (*OM*).

That is:

तस्य वाचकः प्रणवः

Tasya vācakaḥ praṇavaḥ (Ch: I; V: 27).

This literally means that *praṇava* is virtually *Īśvara* or *OM*, where *Īśvara* is the word denoting God. Even though there is only one mention about *OM* in PYS, the definition of *Īśvara* and the attributes are given in PYS Chapter I, Verses 24-26. In *Sūtras* 24, it is said:

क्लेशकर्मविपाकाशयैरपरामृष्टः पुरुषविशेष ईश्वरः ॥२४ ॥

Kleśakarmavipākāśayairaparāmṛṣṭaḥ Puruṣa viśeṣa īśvaraḥ ||24||

(Ch: I; V: 24).

This means that God is unique, untouched by affliction, acts and their consequences. In *Sūtras* 25 it is said

तत्र निरतिशयं सर्वज्ञबीजम् ॥२५ ॥

Tatra niratiśayaṁ sarvajñabījam ||25|| (Ch: I; V: 25)

This means that in God there is the root for endless omniscience. This description is taken further in *Sūtras* 26.

पूर्वेषामपि गुरुः कालेनानवच्छेदात् ॥२६ ॥

Pūrveṣāmapī guruḥ kālenānavacchedāt ||26||

(Ch: I; V: 26).

This means that since *Īśvara* is not limited by time, He is the original *guru* or the *guru* of the earliest *guru*.

Since PYS has described *praṇava* (*OM*) as *Īśvara*, it is interesting to note that *Sūtras* 28 describes what *sādhana* requires for *Īśvara* realization. *Sūtra*: 28 states

तज्जपस्तदर्थभावनम् ॥२८ ॥

Tajjapastadarthabhāvanam ||28||

(Ch: I; V: 28).

This means that mental repetition of *OM* (although *OM* is not specifically mentioned) should be carried out while dwelling on its meaning 'Four Chapters on Freedom' (Satyānanda *Sarasvatī Svāmī*, 1976.)

2.6 CONCEPT OF OM MEDITATION

While the goal of all meditation techniques remains the same, the types of mediation vary because of the different approaches used by different systems of thought. The meditation techniques mentioned in different traditional scriptures could be broadly classified (Sukhānanda natha, 1992) as (a) Meditation on concrete (*dhyāna* on *sākāra saguṇa vastu* object): (i) Meditation on sound (*śabda*) i.e. on certain *mantra*, *bīja akṣara* (syllable in seed form) in form of *japa* meditation (silent repetition of *mantra OM*) or meditation on inner sounds (*OM nāda*), (ii) Meditation on form (*rūpa*) i.e., on specific ideal or image of *OM* or deity (*iṣṭadevatā*), *tāntric* codified shapes called *yantras* or neutral symbol like flame or light (*jyoti*), and (iii) *OM* meditation on inner objects like breath, movement of *prāṇa*, *cakras*, genesis of thoughts, or sense of 'I'. (b) Meditation on abstract (*OM dhyāna* on *nirākāra nirguṇa* object or idea): (i) Meditation on meaning of *upaniṣadic* statements of universal truths called as *mahāvākyas* like अहं ब्रह्मास्मि (*aham brahmāsmi*), तत्त्वमसि (*tattvamasi*), अयमात्मा ब्रह्म (*ayamātmā brahma*) and प्रज्ञानं ब्रह्म (*prajñānaṁ brahma*).

The scriptural texts of yoga and spirituality mention following statements about *OM* meditation.

ॐ क्रतो स्मर

OM kṛto smarā (Īśāvāsya Upaniṣat, V: 17)
O' devout worshipper, meditate on 'OM'

2.6A Praśnopaniṣat

अथ हैनं शैब्यः सत्यकामः पप्रच्छ ।

स यो ह वै तद्भगवन्मनुष्येषु प्रायणान्तमोकारमभिध्यायीत ।

कतमं वाव स तेन लोकं जयतीति । तस्मै स होवाच ॥

Atha hainam śaibyaḥ satyakāmaḥ papraccha ।

Sa yo ha vai tadbhagavanmanuṣyeṣu prāyaṇāntamoṅkāramabhidhyāyīta ।

katamaṁ vāva sa tena lokam jayatīti ।

tasmai sa hovāca ॥

(Praśnopaniṣat, V.01)

Satyakāma, son of *Śibi*, asked him, “O venerable sir, which world does he really win thereby, who among men, intently meditates on *OM* in that wonderful way till death?” To him he said:

एतद्वै सत्यकाम परं चापरं च ब्रह्म यदोकारः ।

तस्माद्विद्वानेतेनैवाऽऽयतनेनैकतरमन्वेति ॥

Etadvai satyakāma param cāparam ca brahma yadoṅkāraḥ ।

Tasmādvividvānetenaiivā' yatanenaikataramanveti ॥

(*Praśnopaniṣat*, V.02)

O *Satyakāma*, this very *Brahman*, that is (known as) the inferior and superior, is but this *OM*. Therefore' the illumined soul attains either of the two through this one means alone.

स यद्येकमात्रमभिध्यायीत स तेनैव संवेदितस्तूर्णमिव जगत्यामभिसंपद्यते ।

तमृचो मनुष्यलोकमुपनयन्ते स तत्र तपसा ब्रह्मचर्येण श्रद्धया संपन्नो महिमानमनुभवति ॥

Sa yadyekamātramabhidhyāyīta sa tenaiva saṁveditastūrṇameva jagatyāmabhisampadyate ।

Tamṛuco manuṣyalokamupanayante sa tatra tapasā brahmacaryeṇa śraddhayā sampanno mahimānamanubhavati ॥

(*Praśnopaniṣat*, V. 03)

Should he meditate on *OM* as consisting of one letter he becomes enlightened even by that and attains a human birth on the earth. The *Ṛk mantras* lead him to the human birth. Being endued there with self-control, continence, and faith he experiences greatness. Even *sādhaka* may not know all the letters by which *OM* is constituted, still meditates on *OM*, he attains an excellent goal, human birth on the earth. Being a prominent *Brāhmaṇa* with self-control, continence and faith experiences greatness, without any deviation from Yoga.

अथ यदि द्विमात्रेण मनसि संपद्यते सोऽन्तरिक्षं यजुर्भिरुन्नीयते सोमलोकम् ।

स सोमलोके विभूतिमनुभूय पुनरावर्तते ॥

Atha yadi dvimātreṇa manasi sampadyate so'ntarikṣaṁ yajurbhirunnīyate somalokam ।

sa somaloke vibhūtimanubhūya punarāvartate ॥

(*Praśnopaniṣat*, V.04)

Now again, if he meditates on *OM* with the help of the second letter, he becomes identified with the mind. By the *Yajur mantras* he is lifted to the intermediate space, the world of the Moon. Having experienced greatness in the lunar world, he turns round again.

यः पुनरेतं त्रिमात्रेणोमित्येतेनैवाक्षरेण परं पुरुषमभिध्यायीत स तेजसि सुर्ये संपन्नः । यथा पादोदरस्त्वचा विनिर्मुच्यत एवं ह वै स पाप्मना विनिर्मुक्तः स

सामभिरुन्नीयते ब्रह्मलोकं स एतस्माज्जीवघनात् परात्परं पुरिशयं पुरुषमीक्षते । तदेतौ प्लोकौ भवतः ॥

*Yaḥ punaretaṁ trimātreṇomityetenaivākṣareṇa paraṁ Puruṣa mabhidhyāyīta sa tejasi surye sampannaḥ |
Yathā pādodarastvacā vinirmucyata evaṁ ha vai sa pāpmanā vinirmuktaḥ sa sāmabhirunnīyate brahmalokaṁ sa etasmājjīvaḥ
parātparam purīṣayaṁ Puruṣa mīkṣate |
Tadetau ślokaḥ bhavataḥ ||*

(*Praśnopaniṣat*, V.05)

Again, any one who meditates on the supreme *Puruṣa* with the help of this very syllable *OM*, as possessed of three letters, becomes unified in the Sun, consisting of light. As a snake becomes freed from its slough, exactly in a similar way, he becomes freed from sin, and he is lifted up to the world of *Brahmā* (*Hiraṇyagarbha*) by the *Sāma* mantras. From this total mass of creatures (that is *Hiraṇyagarbha*) he sees the supreme *Puruṣa* that penetrates every being and is higher than the higher One (viz *Hiraṇyagarbha*). Bearing on this, there occur two verses :

तिस्रो मात्रा मृत्युमत्यः प्रयुक्ता

अन्योन्यसक्ता अनविप्रयुक्ताः ।

क्रियासु बाह्याभ्यन्तरमध्यमासु

सम्यक् प्रयुक्तासु न कम्पते ज्ञः ॥

*Tisro mātrā mṛtyumatyaḥ prayuktā anyonyasaktā anaviprayuktāḥ |
Kriyāsu bāhyābhyantaramadhyamāsu samyak prayuktāsu na kampate jñāḥ ||*

(*Praśnopaniṣat*, V.06)

The three letters (by themselves) are within the range of death. But if they are closely joined, one to another, are not divergently applied to different objects, and are applied to the three courses of action – external, internal, and intermediate – that are properly resorted to, then the man of enlightenment does not shake (i.e. remains undisturbed). For whom it is known that the death is encompassed by three letters, cannot possibly be deflected, since the *puruṣa* in the waking, dream & sleep states, together with the states, has been seen by him as identical with the three letters and as identical with *OM*. Thus a man, who is enlightened has become the Self of all and one with *OM*, therefore from where can he deviate and to where?

ऋग्भिरेतं यजुर्भिरन्तरिक्षं
सामभिर्यत् तत् कवयो वेदयन्ते ।
तमोकारेणैवाऽऽयतनेनान्वेति विद्वान्
यत्तच्छान्तमजरममृतमभयं परं चेति ॥
Ṛgbhiretaṁ yajurbhirantarikṣaṁ
sāmathiryat tat kavayo vedayante ।
Tamoṅkāreṇaivā' 'yatanenānveti vidvān
Yattacchāntamajaramamṛtamabhayaṁ paraṁ ceti ॥

(*Praśnopaniṣat*, V.07)

The intelligent know this world that is attainable by the *Ṛk mantras*, the intermediate space achievable by the *Yajur mantras*, and that which is reached by the *Sāma mantras*. The enlightened man attains that (threefold) world through *OM* alone; and through *OM* as an aid, he reaches that also which is the supreme Reality that is quiet and beyond old age, death, and fear.

Yogīc teachings consider the syllable 'OM' to be the force behind all thoughts. Either chanting or thinking about 'OM' is supposed to cause a quiet mental state. *OM* is the primordial sound from which all other sounds and creation emerge. In *OM* meditation the meditator first concentrates on an *OM* picture and then mentally chants *mantra* 'OM' effortlessly and finally expands to an all-pervasive level and goes for blissful silence.

Meditation is also defined as concentration (continuous thinking) and some times as contemplation (repetitive thinking). Whereas' in yogéc understanding meditation is not mere concentration but it is more than concentration. Therefore' it is essential to distinguish the meaning of meditation.

2.6B *Kaṭha Upaniṣat*

एतद्ध्येवाक्षरं ब्रह्म एतद्ध्येवाक्षरं परम् ।

एतद्ध्येवाक्षरं ज्ञात्वा यो यदिच्छति तस्य तत् ॥

Etadadhyeavākṣaram brahma etadadhyeavākṣaram param |

Etadadhyeavākṣaram jñātvā yo yadicchati tasya tat ||

(Kaṭha Upaniṣat, 1. II. 16)

This letter (*OM*), indeed, is the (inferior) *Brahman* (*Hiraṇyagarbha*); and this letter is, indeed, the supreme *Brahman*. Anybody, who, (while) meditating on this letter, wants any of the two, to him comes that.

2.6C *Muṇḍaka upaniṣat*

अरा इव रथनाभौ संहता यत्र नाड्यः स एषोऽन्तश्चरते बहुधा जायमानः

ओम् इत्य् एवं ध्यायथात्मानं स्वस्ति वः पाराय तमसः परस्तात् ।

Arā iva rathanābhau saṁhatā yatra nāḍyaḥ sa eṣo'ntaścarate bahudhā jāyamānaḥ. Aumityevam dhyāyatha ātmānaṁ svasti vaḥ pārāya tamasaḥ parastāt.

Muṇḍaka upaniṣat- (Gamabhirānada, 1995, 2. 2. 6)

Where the arteries of the body are brought together like the spokes in the center of a wheel , within it (this self, moves about) becoming manifold. Meditate on *Om* as the Self. May you be successful in crossing over to the farther shore of darkness.

Within that (heart) in which are fixed the arteries like the spokes on the hub of a chariot wheel, moves this aforesaid Self by becoming multiformed. Meditate on the Self thus, with the help of Om. May you be free from hindrances in going to the other shore beyond darkness. Knowing him alone, one goes beyond death; there is no other path to proceed by. As the imperishable Self is hard to grasp, it is being presented over & over again so as to make it easily compensable.

To the wheel of the chariot there are many spokes attached to the hub of the wheel. In the same way, many arteries are connected to the heart. The great *Self*, manifesting itself in many forms (such as anger, hatred, etc.) in that heart, moves inside. Meditate on that *Self* as *OM* in order to go beyond darkness. Here in the *upaniṣat* again it is discussed how the universe is related to *Brahman*. This time the *upaniṣat* gives the example of a wheel on a chariot. There are many spokes in a chariot wheel, and all these spokes are attached to a hub. First there is hub, and from that all the spokes radiate. If there is no hub, the spokes cannot be there. Similarly, *Brahman* supports the entire universe. The spokes are compared in this verse to the arteries connected with our heart. They appear separate, but they all converge at the heart.

Then how to meditate on *OM*? It must be a bright, shining, effulgent *OM*. Consider the *Self* within as that *OM*. Those who practise meditations know they have to imagine that the form they are meditating on is shining and luminous. It is very difficult at the beginning to meditate on *Brahman*, because *Brahman* has no form. So the *upaniṣat* says to meditate on *OM*, as is the symbol of *Brahman*. Later you can dispense with *OM*. When you feel you are on with *Brahman*, you do not need to meditate on a form. But to begin with, the *upaniṣat* says to meditate on the *Self* within as that effulgent *OM*. If you continue to meditate this way, you will go beyond darkness and ignorance, *tamaśaḥ*. The teacher is here blessing the student that he may attain this state.

प्रणवो धनुः शरो ह्यात्मा ब्रह्म तल्लक्ष्यमुच्यते ।

अप्रमत्तेन वेद्धव्यं शरवत्तन्मयो भवेत् ॥

Praṇavo dhanuḥ śaro hyātmā brahma tallakṣyamucyate ।

Apramattena veddhavyaṁ śaravattanmayo bhavet ॥

Muṇḍaka upaniṣat- (Gambhirānanda, 1995, 2. 2. 4)

OM is the bow; the soul is the arrow; and *Brahman* is called its target. It is to be hit by an unerring man. One should become one with It just like an arrow. This is to become one with the imperishable by eliminating the ideas of the body, ego, *prāṇa* etc being the *Self*.

2.6D *Chāndogya upaniṣat*

सर्वं खल्विदं ब्रह्म तज्जलानिति शान्त उपासीत ।

अथ खलु क्रतुमयः पुरुषो यथाक्रतुरस्मिंल्लोके पुरुषो भवति तथेतः प्रेत्य भवति स क्रतुं कुर्वीत ॥

Sarvaṁ khalvoidaṁ brahma tajjalāniti śānta upāsīta.

Atha khalu kratumayaḥ puruṣo yathākraturasmimlloke

puruṣo bhavati tathetaḥ pretya bhavati sa kratum kuroṭa.

Chāndogya upaniṣat- (Svāmī Swahānada, 1984, Ch: 3 V: 14.1)

All this is *Brahman*. From it the universe comes forth, in It the universe merges, and in It the universe breathes. Therefore' a man should meditate on *Brahman* with a calm mind.

Let one meditate That as adoration ; desires pay adoration to him. Let one contemplate That as the supreme, he becomes possessed of the supreme. Let one contemplate That as *Brahman's* destructive agent, one's hateful rivals perish as also those rivals whom he does not like . He who is here in the person and he who is yonder in the Sun, He is one.

2.6E Ṭaittirīya upaniṣat

ॐ ब्रह्मविदाप्नोति परम् । तदेषाऽभ्युक्ता । सत्यं ज्ञानमनन्तं ब्रह्म । यो वेद निहितं गुहायां परमे व्योमन् । सोऽश्रुते सर्वान् कामान् सह ब्रह्मणा विपश्चितेति । तस्माद्वा एतस्मादात्मन आकाशः संभूतः । आकाशाद्वायुः वायोरग्निः । अग्नेरापः । अद्भ्यः पृथिवी । पृथिव्या ओषधयः । ओषधीभ्योऽन्नम् । अन्नात्पुरुषः स वा एष पुरुषोऽन्नरसमयः । तस्येदमेव शिरः । अयं दक्षिणः पक्षः । अयमुत्तरः पक्षः । अयमात्मा । इदं पुच्छं प्रतिष्ठा । तदप्येष श्लोको भवति ।

Om brahmavidāpnoti param | Tadeṣā'bhyuktā | Satyaṁ jñānamanantaṁ brahma | Yo veda nihitaṁ guhāyāṁ parame vyoman | So'snute sarvān kāmān saha brahmaṇā vipaściteti | Tasmādvā eatasmādātmana ākāśaḥ sambhūtaḥ | Ākāśādvāyuh vāyoragniḥ | Agnerāpaḥ | Adbhyaḥ pṛthivī | Pṛthivyā oṣadhayaḥ | Oṣadhībhyo'nnam | Annātpuruṣaḥ sa vā eṣa puruṣo'nnarasamayaḥ | Tasyedameva śiraḥ | Ayaṁ dakṣiṇaḥ pakṣaḥ | Ayamuttaraḥ pakṣaḥ | Ayamātmā | Idaṁ pucchaṁ pratiṣṭhā | Tadapyeṣa śloko bhavati |

Ṭaittirīya upaniṣat – (Gamabhirānanda, 1998, Ch: 2 V:1)

OM. The knower of *Brahman* attains their Supreme (the Highest). In reference to that is the following hymn recited: “*Brahman* is Truth, knowledge and Infinity. He is who knows it is as existing hidden in the heart, the transcendent Akasa (Parama Akasa) realises all this desires along with the Omniscient *Brahman*.”

Though a man may perform penance standing on one leg for a thousand years, it will not, in the least, be equal to one-sixteenth part of concentrated meditation.

Piṅgalā upaniṣat – (Adiswarānanda, 2004, Ch: 4 V: 15)

2.6F Bhagawat Gītā

समं कायशिरोग्रीवं धारयन्नचलं स्थिरः ।

सम्प्रेक्ष्य नासिकाग्रं स्वं दिशश्चानवलोकयन् ॥६॥१३॥

Samam kāyaśirogrīvaṁ dhārayannacalam sthiraḥ.
Sampreksya nāsikāgraṁ svaṁ diśaścānavalokayan.

(Tapasyānanda, 2002, Ch: 6 V: 13).

Keeping the trunk, head and neck straight and steady sitting firmly,
 one should look at the tip of the nose, without looking in other directions

प्रशान्तात्मा विगतभीर्ब्रह्मचारिव्रते स्थितः ।

मनः संयम्य मच्चित्तो युक्त आसीत् मत्परः ॥६॥१४॥

Prasāntātmā vigatabhīrbrahmacārivrate sthitaḥ.
Manah saṁyamya maccitto yukta āsīt matparaḥ.

(Tapasyānanda, 2002, Ch: 6 V: 14).

A majestically calm, fearless, and a confirmed celibate should
 withdraw his senses and sit carefully fixing his mind upon Me

युञ्जन्नेवं सदात्मानं योगी नियतमानसः ।

शान्तिं निर्वाणपरमां मत्संस्थामधिगच्छति ॥६॥१५॥

Yuñjannevaṁ sadātmānaṁ yogī niyatamānasah.

Śāntim nirvāṇaparamāṁ matsaṁsthāmadhigacchati

(Tapasyānanda, 2002, Ch: 6 V: 15).

Uyjh6In this manner, constantly meditating with controlled mind,
 the yogī, emancipated and eternally peaceful,attains Me

तत्रैकाग्रं मनः कृत्वा यतचित्तेन्द्रियक्रियः ।

उपविश्यासने युञ्ज्याद्योगमात्मविशुद्धये ॥ ६ ॥१२ ॥

Tatraikāgraṁ manaḥ kṛtvā yatacittendriyakriyaḥ.

Upaviśyāsane yuñjyādyogamātmaśuddhaye.

(Tapasyānanda, 2002, Ch: 6 V: 12).

Sitting on that seat he should concentrate the mind, control the senses and thoughts, and practise yoga for self-purification.

युञ्जीत प्रणवे चेतः प्रणवो ब्रह्म निर्भयम् ।

प्रणवे नित्ययुक्तस्य न भयं विद्यते क्वचित् ॥

Yuñjīta praṇave cetāḥ praṇavo brahma nirbhayaṁ ।

Praṇave nityayuktasya na bhayaṁ vidyate kvacit ॥

(Gauḍapāda Kārikā, V: 25)

One should concentrate one's mind on *OM*, (for) *Om* is Brahman, beyond fear. For a man, ever fixed in Brahman, there can be no fear anywhere.

In *Āgama Prakaraṇa* it is said that concentrate the mind on *praṇava* (*OM*).

Yuñjīta praṇave cetāḥ – unite the mind with *praṇava*, with *OM*. Fix your mind on *OM* and meditate on that *Om* as *Brahman*, as your own self. *Brahman* is infinite, without any form without any quality, so how can you meditate on it? It is very difficult, but not impossible. You can imagine a bright, luminous *OM* in the heart. Remember that *OM* is nothing but *Brahman*, the *Self*, and you are that *Self*. That *Self* is also the *Self* of everyone. *Praṇave nitya-yuktasya* - you must always be conscious that you are *OM*, that you are *Brahman*. Keep this in mind always.

If you can meditate like this then you will have no fear. Then where is fear? When we think there are two, when we have sense of duality. I see you and thing you are different from me. May be you are superior to me and so you may defeat me. With duality comes this fear, conflict, and competition. But if I do not see duality, if I see the one *Self* everywhere, then what is there to be afraid of? I cannot be afraid of my own *Self*. I am everywhere- in you, in me, in everyone.

प्रणवं हीश्वरं विद्यात् सर्वस्य हृदि संस्थितम् ।

सर्वव्यापिनमोङ्कारं मत्वा धीरो न शोचति ॥

Prāṇavaṁ hīśvaraṁ vidyāt sarvasya hṛdi saṁsthitam ।

Sarvavyāpinamoṅkārāṁ matvā dhīro na śocati ॥

(*Gauḍapāda Kārikā*, V: 28)

One should know *OM*, to be God seated in the hearts of all. Meditating on the all-pervasive Om, the intelligent man grieves no more. Know this *praṇava* to be *Īśvara*, the Lord. Instead of saying *Brahman*, *Gauḍapāda* is using the word *Īśvara* here. *Īśvara*, the Lord who controls, is in the heart of everyone. He is the common indwelling Spirit of us all. This *praṇava*, *OM*, is all-pervasive (*sarvavyāpi*). Knowing this, that *OM* is that all-pervasive *Brahman* and that you are one with that *Brahman*, the wise person (*dhīra*) does not grieve (*na śocati*). When you have this knowledge you are wise. Then there is no more sorrow for you, no more pleasure and pain. You go beyond all dualities. We suffer because of our ignorance. When we have knowledge of the unity of everything, then there is no more suffering.

त्रिरुन्नतं स्थाप्य समं शरीरं हृदीन्द्रियाणी मनसा सन्निवेश्य ।

ब्रह्मोडुपेन प्रतरेत विद्वान् स्रोतांसि सर्वाणि भयावहानि ॥

Trirunnataṁ sthāpya samam śarīraṁ hṛdīndriyāṇī manasā sanniveśya.

Brahmoḍupena pratareta vidvān srotāṁsi sarvāṇi bhayāvahāni.

Śvetāśvatara upaniṣat - (Gamabhirānanda, 1986, Ch: 2 V: 8)

The wise man should hold his body steady, with the three (upper) parts erect, turn his senses, with the help of the mind, toward the heart, and by means of the raft of *Brahman*; cross the fearful torrents of the world.

वह्यैर्यथा योनिगतस्य मूर्तिर्न दृश्यते नैव च लिङ्गनाशः ।

स भूय एवेन्धनयोनिगृह्य-स्तद्वोभयं वै प्रणवेन देहे ॥१३॥

Vahneryathā yonigatasya mūrtirna dṛśyate naiva ca liṅganāśaḥ.

Sa bhūya eavendhanayonigṛhya-stadvobhayaṁ vai praṇavena dehe||13||

स्वदेहमरणिं कृत्वा प्रणवं चोत्तरारणिम् ।

ध्याननिर्मथनाभ्यासाद्देवं पश्येन्नगूढवत् ॥१४॥

Svadehamaraṇiṁ kṛtvā praṇavaṁ cottarāraṇim|

Dhyānanirmathanābhyāsāddevaṁ paśyennigūḍhavat||14||

Śvetāśvatara upaniṣat - (Gamabhirānanda, 1986, Ch: 1 V: 13 & 14)

Śvetāśvatara upaniṣat- describes that *OM* is fire though potentially present in firewood is not seen until one stick is rubbed against another. The Self is like that fire; it is realized by constant awareness of the sacred syllable *OM*. Let your body be the stick that is rubbed and *OM* be the stick that is rubbed against (meditation). Then the real nature is realized which is hidden within, just as fire in a sense hidden in the wood.

बृहच्चतद् दिव्यमचिन्त्यरूपं सूक्ष्माच्च तत्सूक्ष्मतरं विभाति ।

दूरात्सुदूरे तदिहान्तिके च पश्यत्स्वहैव निहितं गुहायाम् ॥

Bṛhacca tadidhiavyamacintyarūpaṁ sūkṣmācca tatsūkṣmataraṁ vibhāti.

Dūrātsudūre tadihāntike ca paśyatsvahaiva nihitam guhāyām.

Muṇḍaka upaniṣat- (Gambhirānanda, 1995, Ch: 3 V: 1.7)

That *Brahman* shines forth, vast, self-luminous, inconceivable, and subtler than the subtle. He is far beyond what is far and yet here very near at hand. Verily, He is seen here, dwelling in the cave of the heart of conscious beings.

2.6G *Śrīmad Bhāgavata Mahāpurāṇa* (Tapasyānanda, 1982)

“Do you restrain by all means your fickle mind; my son by your superior intelligence set steady on Me. This is the sum and substance of all yoga.” So spoke the Lord to Ūddhava (11.23.61). “The mind that dwells on sense objects gets stuck in them. The mind that remembers Me constantly gets dissolved in Me” says Lord Kṛṣṇa to Ūddhava. That is the mode of meditation advocated by the *Bhāgavat*. (11.14). Further from verses numbers 31 to 46 of *Bhāgavat Mahāpurāṇa* (chapter 14 of sub-chapter 11) it is mentioned, how the devotees should meditate on Lord Kṛṣṇa’s personal and impersonal form and with what attributes one should meditate, when asked by Ūddhava.

2.6H *Yoga Vāsiṣṭha*

मनः प्रशमनोपायः योगः इत्यभिधीयते ॥

Yoga is the trick to calm down the mind.

तदभ्यासेन निर्वाणम् इत्यभ्यासो महोदयः ।

षम्भा ष्यैवम् निशायाम् ते निर्विकल्प समाधिना ॥

Tadabhyāsena nirvāṇam ityabhyāso mahodayaḥ.

ṣambhā ṣyāvam niśāyām te nirvikalpa samādhinā.

बभूवतुः चिदाकाशरूपिण्यौ व्योमगाकृती ।

दुरात् दूरम् अभिप्लुत्य ततो ब्रह्माण्डमडतत् ॥

Babhūvatuḥ cidākāśarūpiṇyau vyomagākṛtī.

Ḍurāt dūram abhiplutya tato brahmāṇḍamaḍatat.

(*Yoga Vāsiṣṭha* 5.40, 41; Atreya, 1993)

Since liberation is (attained) by such practice, the practice (itself) is the supreme fulfillment. Conversing thus in the night, they two (Leela and goddess) became of the form of the space of consciousness by *Nirvikalpa Samādhi* (or yogic state of absolute consciousness transcending the differentiation of the knower, knowledge and the known and possessed of the bodily form of heavenly beings)

2.6I *Haṭha* Yoga Text

भ्रुवोर्मध्ये शिवस्थानं मनस्तत्र विलीयते ।

ज्ञातव्यं तत्पदं तुर्यं तत्र कालो न विद्यते ॥ ४८ ॥

Bhruvormadhye śivasthānaṁ manastatra vilīyate |

Jñātavyaṁ tatpadaṁ turyaṁ tatra kālo na vidyate || 48 ||

(Muktibodhānanda, Ch: IV, V: 48)

The external point of the eyebrow centre is actually the trigger point of concentration arousing the *ājñā cakra* or *guru cakra*. If this *cakra* is awakened by the *kuṇḍalinī śakti* the experience is altogether beyond the scope of the five lower elements. It is the centre of consciousness. Its *bīja mantra* is 'OM'.

In *Haṭha* yoga meditation, more specifically *kuṇḍalinī* meditation, the divine power that lies dormant in every human being is aroused and pulled upward through the *cakras*, the psychic centers of the body. At the top of the head, the seat of the highest consciousness the

union of the individual and absolute consciousness takes place. This is expressed symbolically as the union of *Śakti* or *kuṇḍalinī* with Lord *Śiva*. During meditation each *cakra* is visualized as a lotus with a certain number of petals. The *mūlādhāra*, *svādhiṣṭhāna*, *maṇipura*, *anāhata*, *viśuddhi* and *ājñā cakras* have four, six, ten, twelve, sixteen and two petals respectively, while *sahasrāra* has one thousand. The number of petals is determined by the number and position of *nāḍīs* that emanate from the *cakras* and give it the appearance of a lotus. Hanging downward when *kuṇḍalinī* is dormant, the *nāḍīs* turn upward with its ascendance. The *cakras* may be focused upon by chanting of *OM*, the all inclusive universal sound vibration, in different pitches. When *kuṇḍalinī* is awakened it does not proceed directly to the *sahasrāra* unless one is an exceptionally pure *yogī*. It must be moved up from one *cakra* to another and a great of concentration and patience is required. When the *kuṇḍalinī* finally rises from the *ājñā* to the *sahasrāra* union take place and this is called liberation. In summary, *Haṭha yoga* itself (by practicing preliminary practices called *āsanas*, *prāṇayāmas*, *kriyās*, *bandhas mudrās*) leads to stages of meditation, while it also prepares one's body and mind for the practice of meditation (*Haṭha yoga Muktibodhānanda*, 2003).

Yoga teachings consider the syllable *OM* to be the force behind all thoughts. Either chanting or thinking about *OM* is anecdotally reported to cause a quiet mental state.

Summary

The sacred syllable *OM* is the primordial sound from which all other sounds and creation emerge. It underlies all phonetic creations. The utterance of *OM*, consisting of the three letters *A*, *U*, and *M*, covers the whole process of articulation. It is like the sound of a gong that gradually tapers to a point and merges in silence. One who attains *OM*, merges with the Absolute.

Yoga teachings consider the syllable *OM* to be the force behind all thoughts. Either chanting or thinking about *OM* is anecdotally reported to cause a quiet mental state.

2.6 CONCEPT OF *OM* MEDITATION

2.6.1 TECHNIQUE OF *OM* MEDITATION

There are different techniques of meditation depending upon the object and the strategy chosen. Despite the difference in objects of focus and techniques of meditation, three key factors have to be present in the practice of any kind of meditation. Those three factors are (i) the object of meditation (locus of focus), (ii) the centre of consciousness (point of awareness) where the mind is held during meditation, and (iii) the method employed to invoke concentration (Adhīśwarānanda, 2004).

The object of meditation can be anything as described earlier, but to practice of *OM* meditation the object should be only *OM* internal or external, stable or dynamic. The sacred texts of Yoga and *Vedānta* maintain that the object of meditation must not be frequently changed. The object of *OM* meditation is generally held within at a particular center, such as the heart, the forehead, the tip of the nose, or the crown of the head or the seeker may place it outside his body, in-front of him on the ideal. However' in some meditation techniques the object of concentration and the center of consciousness (awareness) where the mind is held are same. The method employed to invoke concentration is either selected by the seeker or prescribed by the teacher (*Guru*), and it also must not be changed.

In *OM* meditation the meditator first concentrates on an *OM* picture and then mentally chants *mantra* 'OM' effortlessly and finally expands to an all-pervasive level and goes for blissful silence.

शनैः शनैरुपरमेद् बुद्ध्या धृतिगृहीतया ।

आत्मसंस्थं मनः कृत्वा न किञ्चिदपि चिन्तयेत् ॥६॥२५॥

Śanaiḥ śanairupamed buddhyā dhṛtigrhītayā.

Ātmasansthān manah kṛtvā na kiñcidapi cintayet.

(Cinmayānanda, 2001, Ch: 6 V: 25)

With intellect set in firmness, attain quietitude little by little (step by step); with the mind fixed on the Self, do not think of anything. The methodology of yoga is to control and purify the subconscious (region of *vāsanās* and *saṁskāras*) with the help of conscious effort. Restlessness of body is to be overcome by slow and mindful practice of postures (*āsanas*). Irregular breath, an indicator of mental restlessness, is to be made regular by smooth and rhythmic breathing (*prāṇāyāma*). The outgoing thoughts and improper tendencies of the mind must be substituted by cultivating of moral and ethical virtues. Meditation helps to gain this control and constant awareness. Meditation begins with concentration and intense focusing on the chosen object and *dhyāna* happens only when mind becomes effortlessly and continuously one-pointed like the flow of oil poured from one vessel into another. Sage Patañjali says “meditation is uninterrupted flow of mind on its object. This itself turns into *samādhi* when the object alone shines and the thought of meditation (and of the meditator) is lost, as it were” (Usharbudh, 1986). That state of mind is *niruddha* where thoughts do not exist. Meditation is only possible in wakeful state of consciousness. How mind exists in different states of consciousness and can be evolved higher is schematically depicted in Fig. 5

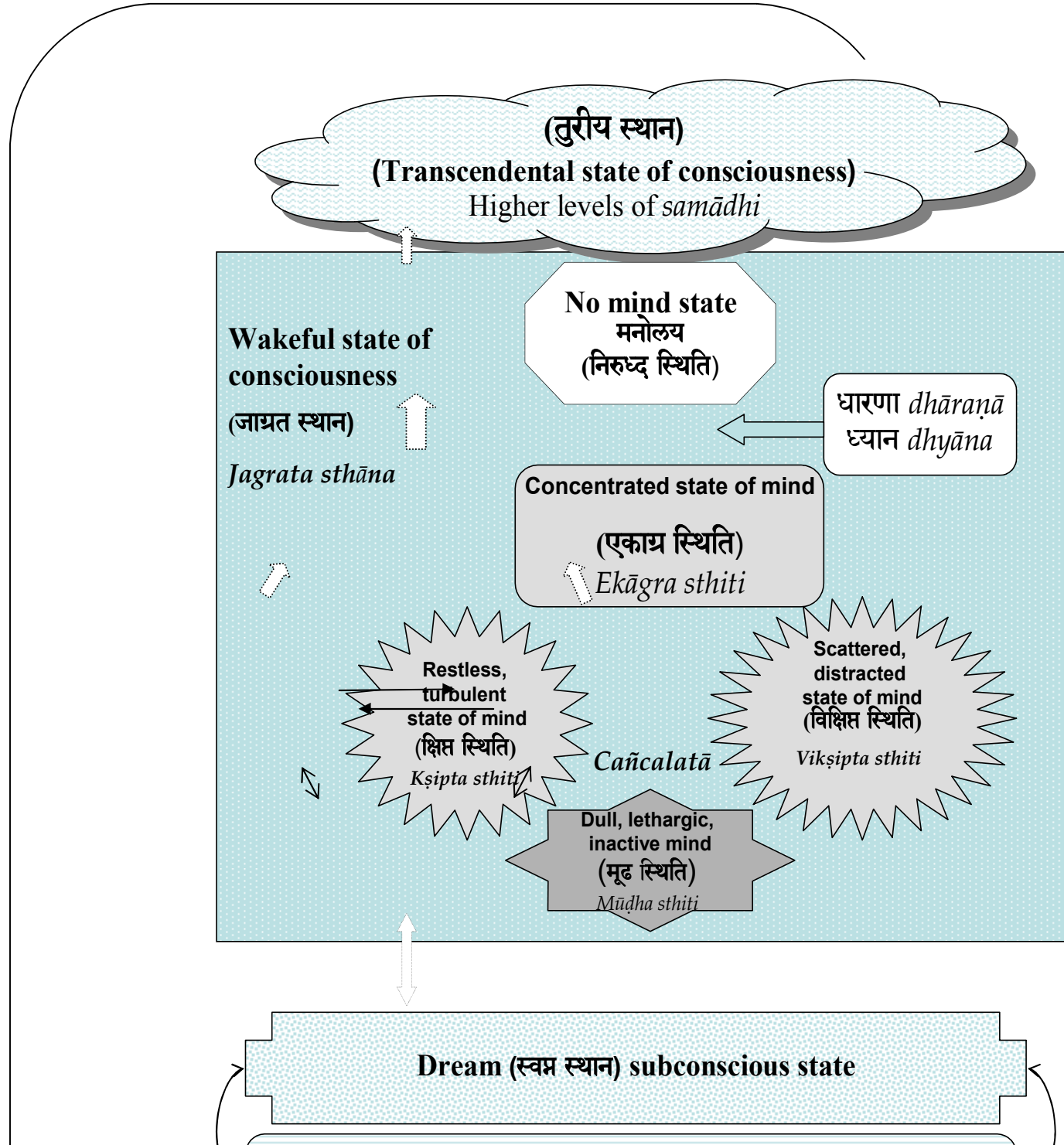


Fig. 5 Stages of growth of mind

2.6.2 THE CONCEPT OF *JAPA*

Japa is the spiritual practice of repeating a sacred word referring to the Divine. Such a sacred word can be a verse, a short prayer, a phrase, or a mystic syllable. The purpose of the repetition is to bring the mind to a state of devotion and concentration. The practice of *japa* is as old as religion itself, it is the most concentrated form of prayer. Faith in the purifying and transforming power of such sacred holy names can be called “key words” which has every religious that inspire its followers. Many saints and prophets achieved God-consciousness by chanting or repeating them. When a seeker repeats such a words with faith and fervor, it releases the power of holiness, which fills his mind with devotion and then leads it to concentration, absorption, and illumination. *Japa* is the easy tool for *dhyāna* by increasing and decreasing the speed of *japa* mind can reach to the deeper level of relaxation.

OM is the concentrated prayer of the *Vedas* that says: “*OM*” meditate on the effulgence of that Supreme Divine Being, the creator of the world Planes—earth, heaven, and interspaces. May that Divine Being direct our intelligence “*OM*.” *OM* is the seed word of all prayer, in which concentrated prayer becomes most condensed. The repetition of *OM* merges in silence gradually culminates in meditation. To help one maintain a constant remembrance of God, *japa* has many advantages over other methods. The practice of meditation and ceremonial worship require disciplined will, fixed posture, faith, and effort, but the practice of *japa* needs only effort.

Even when the repetition of a sacred word is merely mechanical, its healing, transforming, and purifying effect is certain. Since *japa* does not require any special posture, time, place, formality, or environment, it can be practiced under all circumstances.

2.6.3 STEPS OF OM MEDITATION

The system of yoga teaches the means by which the individual human spirit (*jīvātmā*) can be in communion with the Supreme Universal spirit (*paramātmā*). It is a systematic approach for an individual to become one with, or attain the highest level of consciousness of which man is capable. Around 200 B.C. the sage Patañjali evolved eight stages of yoga. These were systematically presented in the yoga *sūtras*, which consists of 196 aphorisms. The eight stages of yoga are: *yama* (universal moral commandments), *niyama* (rules for self-purification), *āsanas* (postures), *prāṇāyāma* (conscious rhythmic regulation of breathing), *pratyāhāra* (withdrawal and emancipation of the mind from the domination of the senses), *dhāraṇā* (concentration), *dhyāna* (meditation), and *Samādhi* (a state in which the aspirant becomes one with the *Paramātmā* or Universal spirit). The eight stages are meant to follow each other in sequence, with each stage preparing the practitioner for the next stage. These eight limbs can also be practiced independently and are paths to *Kaivalya* (a state of liberation/freedom and enlightenment).

Specific to meditation, it has been described that in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of ‘streamlining the thoughts’ (*ekāgratā*), and one-pointed concentration (*dhāraṇā*), before reaching

the meditative state (*dhyāna*) (Cinmayānanda, 1984). The process of meditation thus encompasses *ekāgratā*, *dhāraṇā* and *dhyāna*, where *ekāgratā* and *dhāraṇā* are the preliminary steps. All types of meditation techniques whether traditional or modern comprise these steps in varying duration.

| Steps | Process | Key features | Experience |
|----------------------------------|--|---|--|
| <i>Ekāgratā</i> Concentration | Channelizing the multiple thoughts in one direction | <ul style="list-style-type: none"> - Voluntary control - Intense effort - Analytical focusing | alertness, fatigue |
| <i>Dhāraṇā</i> Focusing | Fixing the mind on one single object with single thought | <ul style="list-style-type: none"> - Confined repetitions - Withdrawal from irrelevant - Non-analytical focusing | Sustained attention, tiredness |
| <i>Dhyāna</i> Meditation | Continuous and spontaneous dwelling of mind on a single object | <ul style="list-style-type: none"> - Single thought - Effortless awareness - Slow expansion | Awareness Silence Peace Happiness |

| | | | |
|----------------|---|-------------------------|--------------------|
| <i>Samādhi</i> | Absorption of subject, object and the process | - Expansion - Powers | Knowledge Bliss |
|----------------|---|-------------------------|--------------------|

Svāmī Vivekānanda in his book (Vivekānanda, 2001) on *Rāja* yoga says, when the mind is focused on a specific object uninterruptedly for twelve seconds, one achieves one unit of *dhāraṇā*. Twelve such successive units of *dhāraṇā* make one unit of *dhyāna*, and twelve such successive units of meditation, lead to *Samādhi*. *Samādhi* is a state of complete absorption. Sage Patañjali says:

तदेवार्थमात्रनिर्भासं स्वरूपशून्यमिव समाधिः ॥

Tadevārthamātranirbhāsaṁ svarūpaśūnyamiva samādhiḥ.

(Taimni, 1961, Ch: 3 V: 3)

The same (contemplation) when there is consciousness only the object of meditation and not of itself (the mind) is *Samādhi*. The absorption is attained when meditation becomes constant and continuous, and the mind merges in the object of meditation. There exists no *tripuṭi*. *Samādhi* is a quantum jump into next level of consciousness, the realm of knowledge, power and bliss (Nagendra, Svāmy, & Mohan, 2003).

2.6.4 REQUISITES OF OM MEDITATION

Posture: The perfect posture for meditation is that in which the spine, the head, the chest, and the neck are kept erect and there is no movement of the body, and the mind remains in a state of equilibrium (Madhusudhan, & Gambhiranda, 1998, Ch: 6 V: 35). However, *OM* meditation can also be practiced while body is in slow actions or motion.

Time: Although there is no fixed time for the practice of meditation, the sacred texts mention ‘four timings’ that are most favorable and auspicious. The first of them is time between three and five in the morning (*brahmamūhurta*). The second is midday, when nature has a tendency to return to calmness and rest. The third is the hour of dusk (*godhuli*), when day merges into night and nature becomes tranquil. And the fourth is midnight, when a deep silence pervades all of nature. Experienced teacher advocate that the time for meditation once chosen, must be observed every day, because there is a cycle or rhythm in the movement of forces, spiritual as well as material (Mokshadānanda, 1997).

Place: The *Vyāsa Sūtras* state “There is no law of place; wherever the mind is concentrated, meditation should be practiced” (Adhīśwarānanda, 2004). According to sacred texts of *Vedānta*, a mountain, a riverbank, a temple, a place where the practice of meditation has been successfully carried out by many spiritual seekers (*tapobhūmi*) and a solitary place free from distractions (Vivekānanda, 1971).

समे शुचौ शर्करावह्निवालुका विवर्जिते शब्दजलाश्रयादिभिः ।

मनिनुकूले न तु चक्षुपीडने गुहानिवाताश्रयणे प्रयोजयेत् ॥

Same śucau śarkarāvahnivālukā vivarjite śabdajalāśrayādibhiḥ.

Maninukūle na tu cakṣupīḍane guhānivātāśrayaṇe prayojayet.

Śvetāśvatara upaniṣat - (Gambhirānanda, 1986, Ch: 2 V: 10)

Let yoga (meditation) be practiced within a cave protected from the high wind, or in a place which is level, pure, and free from pebbles, gravel, and fire, undisturbed by the noise of water or of market –booth, and which is delightful to the mind and not offensive to the eye.

Bhagavad Gītā: शुचौ देशे प्रतिष्ठाप्य स्थिरमासनमात्मनः ।

नात्युच्छ्रितं नातिनीचं चैलाजिनकुशोत्तरम् ॥६॥११॥

Śucau deśe pratiṣṭhāpya sthīramāsanamātmanaḥ.

Nātyucchitram nātinīcam cailājīnakuśottaram.

(Tapasyānanda, 2002, Ch: 6 V: 11)

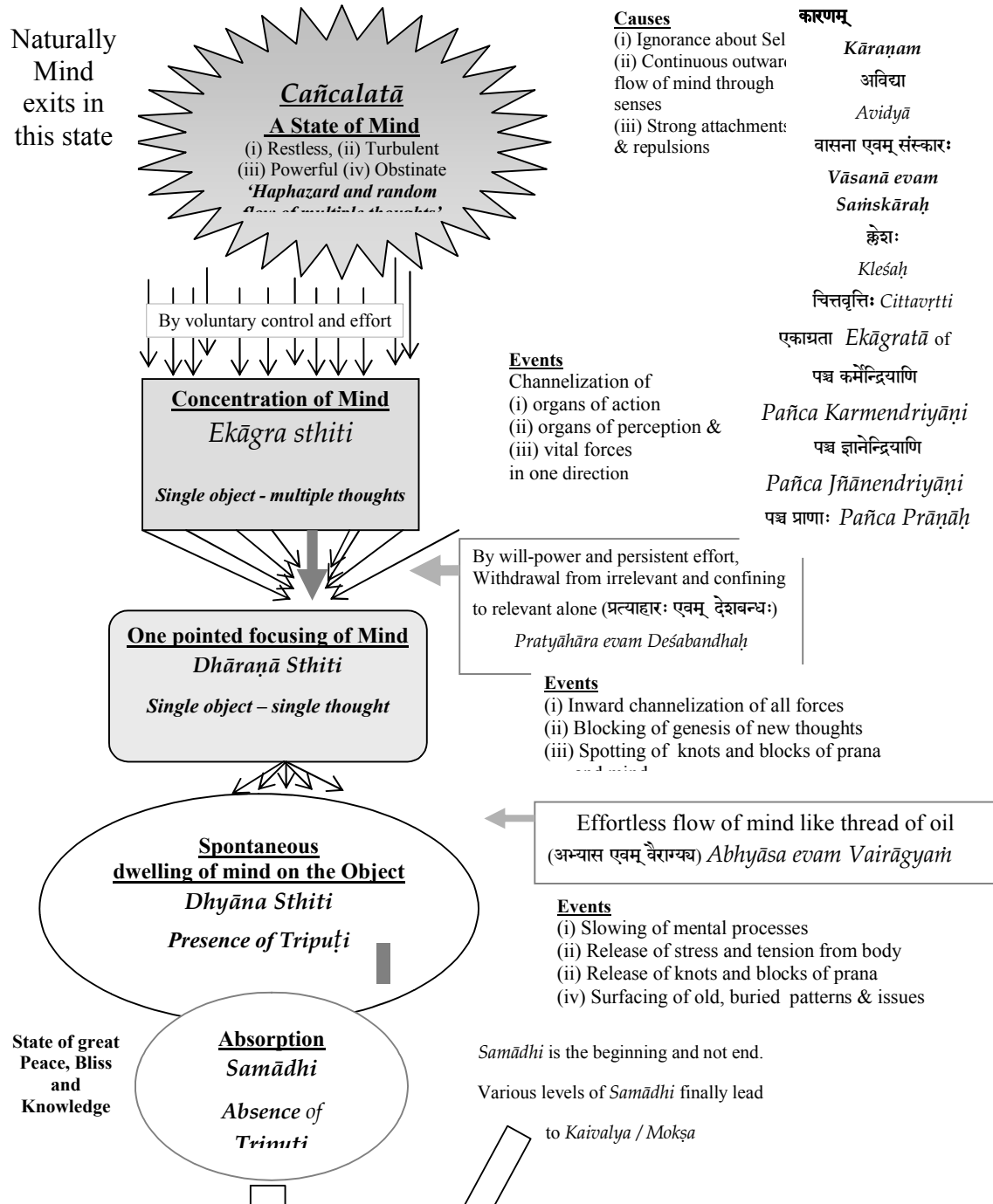
On a clean and pure place neither too high nor too low he spreads kuśagrass, a deerskin and a cloth.

Direction: The meditator is advised to sit facing the east, because the earth's daily rotation is from west to east. By facing the east, one faces the direction of motion (Adhīśwarānanda, 2004).

2.6.5 PROCESS OF OM MEDITATION

In this technique, willpower plays an important role. Through the exercise of willpower, the mind consciously and deliberately cultivates a single thought to the exclusion of all other thoughts. *OM* Meditation begins with concentration on single *OM* picture and culminates in absorption in that object. Absorption reveals the subtle nature of the object. By knowing it one is able to know the reality of subtle entities in the universe. This is schematically presented in Fig. 2. 6.5.

Fig. 6



2.7 GOAL OF OM MEDITATION

The goal of meditation is complete absorption in the object of meditation (*Samādhi*), finally leading to communion or union with the Ultimate Reality. Different systems of thoughts and philosophies call it by different names: liberation - *Mokṣa*, beatific vision of divine – *nirvana*, awakening, and enlightenment – *Kaivalya*, Self knowledge or knowledge of *Brahman*, attaining the Kingdom of Heaven within. Longing for this goal distinguishes a human individual from the subhuman beings says Sri Rāma Kṛṣṇa (Mumukhsānanda, 1998).

The goal of meditation is the cessation of all miseries through the realization of the indwelling Self, or *Puruṣa*, which is Pure Consciousness. The yoga system maintains that the cause of all miseries is ignorance, which deludes the Self, and entangles It in the world of matter. This entanglement is essentially of the mind, and the remedy lies in disentangling the Self from the world of matter and the world of mind. This is only possible through the knowledge of Reality. The aim of meditation is to find the Reality. Meditation leads to Self realization (Satyānanda, 1992).

The seers of the *Vedas* mention four goals of life: knowledge of the right and wrong (*dharma*), worldly prosperity (*artha*), fulfillment of legitimate desires (*kāma*) and Self –Knowledge (*mokṣa*). Self-knowledge is the consummation of all the other goals. According to *Upaniṣads* in this state, the dualities of subject and object, knower and known, seer and seen, all merge in the indescribable expanse of the Absolute. Consciousness of time and space obliterate, and the fetters of causality broken for forever. No sacrifice is too great to achieve this goal; no effort in this venture is ever lost or wasted. All scriptures of Yoga and *Vedānta* emphasize on this goal which is the goal of all goals in human life.

The present thesis focused on the concepts of the four waking states of consciousness (*Cañcalatā, Ekāgratā, Dhāraṇā* and *Dhyāna*).

2.8 BENEFITS OF ‘OM’ MEDITATION

The benefits of meditation are threefold: physical, psychological and spiritual. Meditation enables the physical and psychic energies to flow into creative, constructive channels instead of burning out in destructive forms. Mind gains the poise, peace, naturalness, serenity, stability of emotions, conservation of energy, and a capacity to bear the frustrations and the ups and downs of the life. For a spiritual aspirant *OM* meditation purifies the heart, steadies the mind, destroys the obstracles, destroys the bondage of birth and death, annihilates attachments (induces *vairāgya*), roots out all desires, makes one fearless, removes delusion, gives supreme peace, develops

prema (divine love), brings God consciousness, bestows eternal bliss, awakens the *kuṇḍalinī*. The *japa* of ‘OM’ either done mentally or physically has a tremendous influence on the mind. Meditation addresses all the unresolved issues and notions of subconscious. Meditation brings about complete behavioral transformation. A new worldview induces a new quality of consciousness, which leads to change in interpersonal relationships. Meditation teaches to act and not to react (Chao Khun, 1968).

Meditation awakens the dormant powers of the mind. Just as a vast amount of energy is hidden in an atom, so too is there a vast reservoir of energy hidden in the depths of our psyche. The sacred texts of Yoga call this sleeping power of the mind *kuṇḍalinī* (Muktibodhānanda, 2003). Life becomes blessed when the *kuṇḍalinī* is awakened. Practitioner attains certain powers known as *siddhīs* (Taimni, 1961). Using the power of the mind, human beings have been able to achieve great wonders in the realm of science and technology. It is the same power of the mind that makes impossible things possible in the realm of spirituality. The story of the evolution of life is the story of the manifestation of mental powers. The mind being clear and free from conflicts becomes more effective and efficient. Meditation brings spiritual illumination which liberates the Self from the trappings of the body-mind complex. Meditation is the only way to Self-Knowledge, and Self-Knowledge can put an end to all the sorrows and sufferings of the life.

2.9 LIMITATIONS

1. Too much of meditation done indiscriminately could cause hazards leading to distortion of personality.

2. Psychiatric patients normally are prohibited from the practice of meditation
3. Wrong practice could cause problems

2.10 SUMMARY

Meditation offers a fascinating window into human consciousness, psychology and experience. During meditation a state of mind is reached which is characterized by deep relaxation as well as increased internalized attention.

Meditation is the freedom from thought, a state of no-mind. It is a state of pure consciousness with no contents. It is the activation of natural 'seeing' activity, of the 'Self' or Consciousness. It is the finest way to increase one's personal energy by getting connected to the Source. Meditation is one such technique that helps to purify, control (*nirodha*) and slowdown (*praśamana*) the mind and its modifications (*vṛttis*) by skill (*kauśala*) and regular practice (*abhyāsa*). The process of meditation begins with concentration (*ekāgratā*) and focused attention (*dhāraṇā*) on the chosen object and *dhyāna* happens only when mind becomes effortlessly and continuously one-pointed like the flow of oil poured from one vessel in to another. Sage Patañjali says “*dhyāna* is an uninterrupted, spontaneous flow of mind on its object. This itself turns into *samādhi* when the object alone shines and the thought of meditation (and of the meditator) is lost, as it were”. The five characteristic features of meditation (*dhyāna*) are (i) single thought, (ii) effortlessness, (iii) awareness, (iv) slowness and (v) expansiveness (defocusing). Meditation involves three factors i.e., meditator, the object of meditation and the process

of meditation (*trīpuṭī*). The object of focus is generally sacred and can be personal or neutral, stable or dynamic, concrete or abstract, a word or an idea, an image or a symbol, a divine form or personality.

The concept of *OM* meditation has been well described in various Indian scriptures as well as *Yogīc* teachings consider the syllable ‘*OM*’ to be the force behind all thoughts. *OM* covers the whole threefold experience of man. It is the combination of three letters viz., 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.

Either chanting or thinking about ‘*OM*’ is supposed to cause a quiet mental state. *OM* is the primordial sound from which all other sounds and creation emerge.

In the traditional texts (the Patañjali’s *Yoga Sūtras* and *Bhagavad Gītā*) it has been described that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of ‘streamlining the thoughts’ (concentration or *ekāgratā*), and one-pointed concentration (focusing or *dhāraṇā*), before reaching the meditative state (defocused, effortless single thought state or *dhyāna*).

Earlier study suggested that meditation on ‘*OM*’ produces a state of an alertful rest. The relationship between the mental state and body physiology; emotional and cognitive processing and the biological correlates of religious experience.

In *OM* meditation the meditator first concentrates on an *OM* picture and then mentally chants *mantra* ‘*OM*’ effortlessly and finally expands to an all-pervasive level and goes for blissful silence. This is one of the technique which develops tremendous willpower and deliberately cultivates a single thought to the exclusion of all other thoughts. *OM* Meditation begins with concentration on single object and culminates in absorption in that object. Absorption reveals the subtle nature of the object. By knowing it one is able to know the reality of subtle entities in the universe.

3.1. INTRODUCTION

In India research on yoga and meditation started in 1918 at the Yoga Institute at Versova near Mumbai, the precursor of the Yoga Institute at Santa Cruz (Khalsa, 2004; Yogendra, 1970). This was soon followed by the clinical work at the Kaivalyadhama Yoga Institute in Lonavala under *Svāmī* Kuvalayananda in the 1920’s (Khalsa, 2004; Gharote, 1991). In 1925 early scientific studies were reported by *Svāmī* Kuvalayananda of Lonavala in a quarterly journal *Yoga Mīmāṃsā*. These studies helped to initiate interest in yoga research by showing that the physiological effects of yoga could be examined in the laboratory. This was followed by a number of studies which reported that yogis could exert voluntary control over the cardiovascular system and reduce their metabolic rate at will. Maharishi Mahesh Yogi introduced the Transcendental Meditation (TM) program to the United States and Canada around 1960. TM

is a natural mental technique that requires no elaborate yoga postures, paraphernalia or particular environment. A number of scientific studies were conducted on meditation based on different variables. The studies which are most relevant to the present study are mentioned below in to three parts, 1. Studies on: Evoked Potentials, Autonomic & Respiratory Variables, and Studies on visual scanning, attention, concentration and repetitive motor response followed by over all summary and finally also presented in separate summary **Tables: 3.2.1, 3.3.1, 3.4.1.**

3.2 MEDITATION STUDIES BASED ON EVOKED POTENTIALS

Evoked potentials are used in meditation studies since a correlation between different evoked potential components and underlying neural generators is reasonably well worked out (Woods & Clayworth 1985). Apart from this it appears that the cerebral cortex is actively involved in meditation (Lazar Kerr, Wasserman, Gray, Greve & Treadway, 2005 et al.). Hence, one may expect cortico-efferent gating with changes occurring at subcortical relay centers (Napadow, Dhond, Conti, Makris, Brown & Barbieri, 2008). For these reasons, there have been studies of short and midlatency auditory evoked potentials during meditation.

An early study on meditation (Telles & Desiraju, 1993a) used for the first time two important modifications in the research design for yoga research. Here subjects were studied using the ‘self-as-control’ design and the two types of sessions, meditation and non-

meditation, were repeated thrice in each subject. This study highlighted two points, (i) meditation is best described as a physiological state of 'alertful rest', and (ii) considerable physiological variations are seen both intra- and inter-individually. This study assessed the effects of meditation on the syllable 'OM' on mid-latency auditory evoked potentials, it was found that in seven experienced meditators during meditation there was a significant decrease in the peak latency of the Nb wave (the maximum negativity occurring between 35 and 65 ms.) In another study on the effects of meditation on 'OM' on mid-latency auditory evoked potentials were studied in experienced meditators and novices (Telles, Nagarathna & Nagendra, 1994). There were two types of sessions before, during and after (i) mental repetition of 'OM' (meditation session) and (ii) mental repetition of 'ONE' (control session). The experienced meditators showed a significant increase in the peak amplitude of the Na wave (the maximum negative peak between 14 and 18 msec.) during the meditation with a significant decrease in the Na wave peak amplitude during the control session. Hence during mental repetition of a meaningful syllable ('OM') and of a neutral syllable ('ONE') neural changes occurred at the same level (possibly diencephalic) though in opposite directions.

The studies on midlatency auditory evoked potentials have most often shown, changes in a component called the Na wave a negative wave occurring (between 14 and 19 msec.). There have been changes in form of an increased amplitude (Telles, Nagarathna & Nagendra, 1994) suggesting recruitment of more neurons. A decrease in latency has also been reported (Telles & Naveen, 2004), suggesting a decrease in time taken to transmit sensory information.

Studies on short latency auditory evoked potentials have not shown such clear changes. At moderate intensities (40—50 dB), the latency of the inferior collicular wave (wave V) increased following meditation. However at higher stimulus intensities (55—70 dB), the latency of this wave was slightly decreased (McEvoy, Frumkin & Harkins, 1980). This study on short latency auditory evoked potentials in TM meditation practitioners demonstrated that short latency auditory evoked potential vary with stimulus characteristics. Also a study on TM program appears to longitudinally reduce the brain's response to acute pain along major sectors of the affective dimension of the pain matrix, apparently related to reduced distress (Orme-Johnson, Schneider, Sonb, Nidicha., & Cho, 2006). Different changes in evoked potentials (ABR, MLR & P200) were observed before, during, and after a Qi-gong meditation session in a within-subject design (Liu, Cui, Li & Huang, 1990). ABR Waves I through V increased in amplitude 55-76%, whereas MLR Na and Pa amplitudes decreased 50-73% during Qi-gong meditation relative to the before and after conditions. It was hypothesized that the brainstem may be synergistically released from descending inhibition to produce the ABR amplitude increase when the initial cortical activity indexed by MLR potentials decreases during meditation. Also, presenting 10 m sec. tones Qi-gong meditators were assessed before, during, and after a 30 min Qi-gong meditation session. P200 amplitude decreased 44% from the baseline to the meditation state and returned to baseline after meditation suggestive of attenuated cortical responses/believed to be due to inhibition of neural activity at thalamo-cortical and cortical levels.

TM meditators presented with auditory tones (1/s) demonstrated decreased P1, N1, P2, and N2 component latencies for meditators at baseline and meditation/rest states compared to non-meditator control group values (Wandhöfer, Kobal & Plattig, 1976). Another

study used 50 tones (1s duration) presented in three blocks to TM meditators before, during, and after meditation in a within subject design; additional recordings were made during sleep. Although N1 latency was longer in the before-control relative to the meditation condition, this effect was unreliable and no other condition differences were found for any of the AEP components (Barwood, Empson, Lister & Tilley, 1978).

TM meditators with two years practice demonstrated increased amplitudes of early components of SEPs relative to controls (Petrenko, Orlova & Liubimov, 1993).

An auditory oddball task was used with eyes-closed to assess experienced TM meditators at pre-test baseline, after 10 min of rest, or after 10 min of TM practice with conditions counter balanced across subjects (Travis & Miskov, 1994). P300 latency decreased at Pz after TM practice relative to no change after the rest condition. TM practice was studied using a passive auditory paradigm listening study with variable inter-stimulus intervals (1-4s) between identical tone stimuli (Cranson, Goddard & Orme-Johnson, 1990). The subjects were non-meditator controls, novices, and highly experienced TM meditators with mean ages of 20, 28, and 41 years, respectively; IQ scores did not differ among the groups. Passive P300 potential latency was shorter for the two meditation groups, with the long-term meditators showing the shortest P300 latency regardless of their age (Polich, 1996). These results imply that AEPs might reflect meditation trait differences.

Meditative practice and aging in TM meditators were evaluated relative to non-meditating controls (66 years) with visual ERPs elicited by female and male names in a button-press task (Goddard, 1989, 1992). P300 latency was shorter in meditators than controls

(543 ms. vs. 703 ms). The same subjects also performed an auditory oddball task, but neither P300 latency nor RT differed between the groups. The results were interpreted as indicating trait effects of long-term TM practice are observed only if mental processing demands are increased with more difficult visual tasks. A visual oddball task used to compare four groups of young (20 years) and older (69 years) meditators and controls found that P300 latency and RT increased (as the discriminability of the targets was made more difficult for all groups) (Goddard, 1992). P300 latencies were longer in older subjects in all conditions, while RTs were shorter only as task difficulty increased. Further, P300 latencies were shorter in the older meditators vs. non-meditator comparison. These results suggest the possibility of primarily P300 latency trait effects for meditating relative to non-meditating older subjects.

Brahmakumaris Raja Yoga meditators were assessed before and during meditation, with a decrease in Na peak latency found (Telles & Naveen, 2004). The Na potential is thought to be generated at the midbrain-thalamic level, so that concentrative mantra meditation may affect early thalamic sensory processes.

Sahaja Yoga emphasizes adopting the witness posture towards thoughts instead of flowing with them during meditation and is therefore very close to the mindfulness end of the meditational spectrum. The practice of this method was assessed in three groups of young adult epileptic patients (Panjwani, Selvamurthy, Singh, Gupta, Mukhopadhyay & Thakur, 2000). One group practiced Sahaja meditation, another group sat quietly in 'sham' meditation, and a control patient group had no meditation instruction. ABR and MLR measures were obtained prior to the meditation intervention, three months, and six months later. No ABR effects were obtained, but

the Sahaja Yoga group demonstrated an increase in MLR Na-Pa amplitude at six months. Although Sahaja Yoga meditation in normal control subjects was not assessed, this outcome also suggests the influence of meditation on initial cortical auditory processing.

A study on Cyclic meditation reported the P300 peak amplitudes after CM were higher at Fz, Cz, and Pz sites compared to the "pre" values, which suggests cyclic meditation enhances cognitive processes underlying the generation of the P300 ([Sarang, & Telles, 2006](#)). A review study on meditation reports Cognitive event-related potential evaluation of meditation implies that practice changes attentional allocation as well as neuroimaging studies indicate increased regional cerebral blood flow measures during meditation. Taken together, meditation appears to reflect changes in anterior cingulate cortex and dorsolateral prefrontal areas ([Cahn, & Polich, 2006](#)).

A recent study reported that there was a significant increase in the peak amplitude of the Nb wave compared to before Cyclic meditation (CM). Post Supine rest (SR) there was a significant increase in the peak latency of the Na wave compared to before SR. In conclusion following CM the latencies of neural generators corresponding to cortical areas is prolonged, whereas following SR a similar change occurs at mesencephalic-diencephalic levels ([Subramanya, & Telles, 2009](#)). A subsequent study on Vipassana meditation suggested that meditation state can decrease the amplitude of neurophysiologic processes that subserve attentional engagement elicited by unexpected and distracting stimuli ([Cahn, & Polich, 2009](#)).

It has been shown that meditators significantly increased mismatch negativity amplitudes immediately after meditation, suggesting transient state changes owing to meditation. Which indicate that concentrative meditation practice enhances preattentive perceptual processes, enabling better change detection in auditory sensory memory

([Srinivasan & Baijal](#), 2007).

3.3 MEDITATION STUDIES ON AUTONOMIC AND RESPIRATORY VARIABLES

Past four decades research has been going on to explore the physiological and psychological benefits of meditation and the first study conducted by Wallace, Benson and Wilson concluded that meditation is a wakeful hypometabolic physiologic state ([Wallace, Benson, & Wilson](#), 1971). In spite of forty years of research within and across meditation techniques, whether meditation increases the autonomic arousal or decreases is not certain ([Wallace, Orme-Johnson, Mills, Dillbeck](#), 1984; [Zeier](#), 1984). Meditation was used an indicator of academic achievement perhaps as a result of its relationship to awareness or wakefulness level suggesting the autonomic arousal ([Wallace, Orme-Johnson, Mills, Dillbeck](#), 1984). It was also suggested that exhalation feedback helps to concentrate on the exhalation process and by this means slows respiration rate, and as a consequence, also heart rate ([Zeier](#), 1984). Therefore, respiratory feedback could be a useful tool for inducing relaxation and slowing of heart rate suggesting a decrease in autonomic arousals.

An earlier study by Orme-Johnson (1973) reported a study on 16 subjects, 8 of them were meditators and 8 were controls. The meditators had a mean experience of fifteen months. They studied GSR habituation and spontaneous GSR fluctuations. In a second experiment, they studied 6 meditators (with experience of meditation ranging from 2 - 54 months) and 8 non meditators. Though

habituation was initially similar for the two groups, the meditators habituated in significantly fewer trials than non-meditators. Also, there was a low frequency of spontaneous GSR fluctuations in meditators as compared to controls. The mean rate of spontaneous GSR fluctuations was 6.14 in 10 minutes compared to 18 - 25 in 10 minutes meditation Vs pre-control periods. The meditators had 8.7 responses in 10 minutes during rest compared to 21.0 in 10 minutes for non-meditators.

In 1960 Hirai found changes in breathing during Zen meditation. The breath rate decreased to 4 - 5 breaths per minute. The same study reported an acceleration of the pulse rate during meditation to a rate between 80 and 100 beats/minute.

In another study on experienced Zazen meditators, a decrease in spontaneous skin conductance responses during Zazen was reported (Akishige, 1968). The same study also showed that there was a decrease in oxygen consumption and rate of respiration, associated with Zen meditation. Sugi and Akutsu (1968) observed a 20% decrease in oxygen consumption associated with meditation in 10 Zen monks with many years of experience. Goyeche, Chihara and Shimizu (1972) compared Zen meditation with relaxation in 8 subjects. There was reduction in breath and heart rate during Zen meditation.

Elson, Hauri and Cunis (1977) studied on Ananda Marga meditators; both amateur and experienced practitioners (average experience was 1.8 years). They found an increase in alpha and theta activity during meditation. There was a decrease in skin conductance and rate of respiration. In another study Corby and others investigated 2 groups of 10 meditators each (Corby, Roth, Zarcone, & Kopell, 1978). One group had an average experience of 4.4 years. All the subjects were very committed to the practice of meditation and practiced for a minimum of three hours per day. There was also a control group. Meditators showed a statistically significant increase

in alpha and theta activity compared to the control group. This study also reported changes in autonomic variables. There was an increase in skin conductance (i.e., lowered skin resistance) and absence of a deceleratory heart rate orienting response. Heart rate and respiratory rate changes were not significant within the group. During meditation there was a trend for heart rate to decrease relative to the control group. One of the subjects had a near *samādhi* experience, and they recorded an increase in heart rate, respiratory rate and a marked decrease in skin resistance.

The autonomic and respiratory variables were studied in *OM* meditators (Telles, Nagarathna & Nagendra, 1995). The meditators showed a statistically significant reduction in heart rate during meditation compared to the control period. During both types of sessions, there was a comparable increase in the cutaneous peripheral vascular resistance. This was interpreted as a sign of increased mental alertness even while being physiologically relaxed (as shown by the reduced heart rate). When repetition of ‘*OM*’ was compared with the repetition of ‘*ONE*’ in 12 meditators, there was a difference in the autonomic and respiratory responses (Telles, Nagarathna & Nagendra, 1998). Both types of sessions resulted in a decrease in the heart and breath rates, but repetition of *OM* alone reduced the skin resistance, suggesting a subtle change in the mental state, related to the significance of the syllable. Finally, it was interesting to note in a single case study that an accomplished meditator was able to switch between ‘single thought’ and ‘no thought’ states at will, with significant differences in the breath rate and pattern between the states (Telles & Desiraju, 1992).

Another study reports eighteen male subjects were studied using the 'self-as-control' design and the two types of sessions, meditation and non-meditation, were repeated thrice in each subject. The heart rate during the meditation period was increased compared to 'baseline' as well as compared to during the non-meditation period of control sessions. In contrast there was no significant change during meditation, for the group as a whole, in GSR, respiratory rate and finger plethysmogram amplitude. The individual level analysis revealed that changes in autonomic variables suggestive of both activation and relaxation occurred simultaneously in different subdivisions of the autonomic nervous system in a meditator. Apart from this, there were differences in patterns of change among the persons who practiced the same meditation (Telles, & Desiraju, 1993a). A similar study on yoga *mantras* and prayers have been found beneficial in many physiological and psychological functions of the body. It has been demonstrated in a study, comparing the effects of recitation of the *Ave Maria* (in Latin) or of a typical yoga *mantra* "Om-mani-padme-Om. It was found that both the *Ave Maria* and yoga *mantra* caused striking, powerful, and synchronous increase in existing cardiovascular rhythms when recited six times a minute. There was an increase in baroflex sensitivity, suggestive of induced favorable psychological and physiological effects (Bernardi, Sleight, Bandinelli, Simone Cencetti, Lamberto Fattorini, Johanna Wdowczyk-Szulc, et al, 2001). Also a study on TM appears, it has a beneficial impact upon cardiovascular functioning at rest and during acute laboratory stress in adolescents at-risk for hypertension ([Barnes](#), [Treiber](#), & [Davis](#), 2001). It was also suggested that a 16 week of TM practice may modulate the physiological response to stress and improve coronary heart disease risk factors, which may be a novel therapeutic target for the treatment of coronary heart disease (Paul-Labrador, Polk, Dwyer, Velasquez, Nidich, Rainforth, Schneider, Merz, 2006).

Meditation is the attainment of a restful, alert physical and mental state which suggest that internalized attention and mindfulness as two major core factors of behaviors of mind during meditation are characterized by different combinations of psychophysiological properties and personality traits ([Takahashi](#), [Murata](#), [Hamada](#), [Omori](#), [Kosaka](#), [Kikuchi](#), [Yoshida](#), & [Wada](#), 2005). In a subsequent study the frontal midline theta rhythm was correlated with cardiac autonomic activities during Zen meditation (Kubota, Sato, Toichi, Murai, Okada, Hayashi, & Sengoku, 2001). A standard procedure of Zen meditation requiring sustained attention and breath control was employed as the task to provoke frontal midline theta rhythm (F_m theta), and simultaneous EEG and ECG recordings were performed. For the subjects in which F_m theta activities were provoked (6 men, 6 women, 48% of the total subjects), peripheral autonomic activities were evaluated during the appearance of F_m theta as well as during control periods. Successive inter-beat intervals were measured from the ECG, and heart rate variability was used to assess cardiac sympathetic and parasympathetic functions separately. Both sympathetic and parasympathetic indices were increased during the appearance of F_m theta compared with control periods. Theta band activities in the frontal area were correlated negatively with sympathetic activation. This suggested a close relationship between cardiac autonomic function and activity of the medial frontal neural circuitry. In another study conducted on 22 healthy subjects to evaluate the effect of Zen meditation on EEG coherence and heart rate variability (HRV) in relation to trait anxiety scores, there was an increase in slow alpha interhemispheric EEG coherence in the frontal regions and an increase in the HF power and a decrease in the LF/HF ratio and heart rate (Murata, Takahashi, Hamada, Omori, Kosaka, Yoshida, & Wada, 2004). Another

study suggest that specific correlated relationships exist between the change in autonomic nervous activity and EEG power depending on the difference in mental task or meditation (Hamada, Murata, Takahashi, Ohtake, Saitoh, Kimura, Wada, & Yoshida, 2006).

These results suggest that lower trait anxiety more readily induces meditation with a predominance of internalized attention, while higher trait anxiety more readily induces meditation with a predominance of relaxation. A review study reports that some of the cardiovascular disease related benefits as a result of Transcendental Meditation technique could arise from normalization of neuroendocrine systems whose function has been distorted by chronic stress (Walton, Schneider & Nidich, 2004).

Peng et al. (2004) analyzed beat-to-beat heart rate and continuous breathing signals from 10 experienced meditators (4 females; 6 males; mean age 42 years; range 29-55 years) during three traditional interventions: relaxation response, breath of fire, and segmented breathing. Heart rate and respiratory dynamics were generally similar during the relaxation response and segmented breathing. It was observed that high amplitude, low frequency (approximately 0.05-0.1 Hz) oscillations due to respiratory sinus arrhythmia during both the relaxation response and segmented breathing, along with a significantly ($p < 0.05$) increased coherence between heart rate and breathing during these two maneuvers when compared to baseline. The third technique, breath of fire, was associated with a different pattern of response, marked by a significant increase in mean heart rate with respect to baseline ($p < 0.01$), and a significant decrease in coherence between heart rate and breathing ($p < 0.05$). These findings suggest that different meditative/breathing protocols may evoke common heart rate effects, as well as specific responses. The results support the concept of a "meditation paradox," since a variety of

relaxation and meditative techniques may produce active rather than quiescent cardiac dynamics, associated with prominent low frequency heart rate oscillations or increases in mean resting heart rate.

A similar study reported that spirituality appears to be associated with a specific pattern of cardiac autonomic regulation, characterized by a high level of cardiac autonomic control, irrespective of the relative contribution of the two autonomic branches. This pattern of autonomic control may have health significance (Berntson, Norman, Hawkey & Cacioppo, 2008). Another study on Zen meditation reports shifts in the respiratory modulation of heart rate, or respiratory sinus arrhythmia (RSA), reflect the different levels of practice among practitioners with variable experience in Zazen; in turn the modulation of the RSA may reflect changes in the breathing pattern as in the parasympathetic outflow related to the quality and focus of attention in each stage (Peressutti, Martín-González, García-Manso, & Mesa, 2009). A short term meditation by EEG and HRV suggests involvement in the autonomic nervous system during and after training also Imaging data demonstrated stronger subgenual and adjacent ventral anterior cingulate cortex activity (Tang, Ma, Fan, Feng, Wang, Feng, Lu, Hu, Lin, Li, Zhang, Wang, Zhou, & Fan, 2009).

Hence, the autonomic–respiratory changes during meditation are suggestive of a state of ‘alertful rest’.

3.4 MEDITATION STUDIES RELATED TO VISUAL SCANNING, ATTENTION, CONCENTRATION AND REPETITIVE MOTOR RESPONSE

Several Studies on meditation has shown that during meditation a state is reached which is characterized by deep relaxation as well as increased internalized attention (Murata, Takahashi, Hamada, Omori, Kosaka, Yoshida, & Wada, 2004). This is particularly the case as recent neuroimaging studies have shown that mindfulness meditation is associated with increased activation in parts of the brain related to attention (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). Also meditation practice associated with reduced sympathetic activity and in some cases increased parasympathetic nervous system activity as well (Wallace, 1970; Wallace, Benson, & Wilson, 1971).

A further study on Zen meditators, demonstrated an alpha suppression response, a sudden attenuation of alpha waves in response to a stimulus, which did not habituate to repeated click stimuli during Zen meditation whereas controls habituated after the fifth or sixth click (Kasamatsu, & Hirai, 1966). This was taken to reflect a 'hypersensitivity' of attention during Zen meditation.

Banquet (1973) compared meditators with matched controls measuring the hypo metabolic state reaction time (RT) during a series of visual stimuli. Meditators showed faster RT with less mistakes, and N100 and P200 of larger amplitude and shorter latency. The transient effects were opposite for the two groups, i.e., longer RT and larger P300 amplitude was observed following meditation while following rest there was no change in RT and a decrease in the P300 amplitude. These results suggest selective attention capacity and information processing strategies associated with meditation.

Subsequently there have been reports of other studies on TM indicating its clinical applications and usefulness in enhancing the cognitive performance and perceptual and motor skills.

TM practice was studied using a passive auditory paradigm listening trial with variable inter-stimulus intervals (1- 4 seconds) between identical tone stimuli (Cranson, Goddard, & Orme-Johnson, 1990). The subjects were non-meditator controls, novice, and highly experienced TM meditators with mean ages of 20, 28, and 41 years, respectively; IQ scores did not differ among the groups. Passive P300 potential latency was shorter for the two meditation groups, with the long-term meditators showing the shortest P300 latency regardless of their age. These results imply that AEPs might reflect meditation trait differences. An auditory oddball task was used with eyes-closed to assess experienced TM meditators at pre-test baseline, after 10 min of rest, or after 10 min of TM practice with conditions counterbalanced across subjects (Travis, & Miskov, 1994). P300 latency decreased at Pz after TM practice relative to no change after the rest condition. Taken together, these reports suggest the possibility of some meditation effects on the P300 component.

A study shown that it was more likely that the control group felt deprived of the additional attention in the form of interaction with the yoga instructor which the yoga group had, this could possibly have made the control group more likely to experience poor motivation for the task. This is especially possible since additional care (in this case interaction with the yoga instructor), is known to have psychological benefits (Delbanco, 1993).

Some earlier studies reports there was a activation in frontal, prefrontal and cingulate areas which may represent the mental state of altered self-experience (Neumann & Frasch, 2006). A study on TM suggests longitudinally reduces the affective/motivational dimension of the brain's response to pain (Orme-Johnson, Schneider, Son, Nidich, & Cho,2006). A subsequently study on cyclic

meditation reports there was a greater improvements in compare to supine rest on performance in letter cancellation task, which requires selective attention, concentration, visual scanning abilities, and a repetitive motor response (Sarang & Telles, 2007). A recent study suggests five days of 20-min integrative meditation training from traditional Chinese medicine showed greater improvement in conflict scores on the Attention Network Test, lower anxiety, depression, anger, and fatigue, and higher vigor on the Profile of Mood States scale, a significant decrease in stress-related cortisol, and an increase in immunoreactivity. (Tang, Ma, Wang, Fan, Feng, Lu, Yu, Sui, Rothbart, Fan, & Posner, 2007).

A practice of concentrative meditation enhances preattentive perceptual processes, enabling better change detection in auditory sensory memory (Srinivasan, Baijal, 2007). Also Meditation produces long-term increases in the efficiency of the executive attentional network (anterior cingulate/prefrontal cortex) but no effect on the orientation network which includes parietal systems (Chan & Woollacott, 2007) as well as mindfulness training may improve attention-related behavioral responses by enhancing functioning of specific subcomponents of attention (Jha, Krompinger & Baime 2007). A study on Zen meditation suggests a regular practice of meditation may have neuroprotective effects and reduce the cognitive decline associated with normal aging (Pagnoni & Cekic 2007). A fMRI study on meditation showed the activation in attention regions and visual cortex (14, 16, 24, 26), which emphasize a cognitive component called concentration, which includes aiming and sustaining attention. ([Brefczynski-Lewis](#), [Lutz](#), [Schaefer](#), [Levinson](#), & [Davidson](#) 2007). A longitudinal study showed there was a decreased in the test of anxiety, nervousness, self-doubt, and concentration loss.

A recent review study showed meditation increased activation in frontal, prefrontal and cingulate areas which may represent the mental state of altered self-experience. Also suggests neurobiological examination methods - especially neuroimaging techniques - may contribute to enlighten the phenomenon of qualitatively different states of consciousness ([Neumann](#) & [Frasch](#), 2006)

A recent study on cyclic meditation was shown to improvement in performance in a letter cancellation task (Sarang & Telles, 2007). Since the letter cancellation task assesses selective attention and concentration (Uttl & Pilkenton-Taylor, 2001), these results support the idea of improved attention following cyclic meditation. The cancellation task also showed correlation with other tasks for cognitive ability and sustained attention (Amador-Campos & Kirchner-Nebot, 1999).

3.5 SUMMARY

In summary based on these reports meditation may influence on cortical auditory processing suggestive of attenuated cortical responses/believed to be due to inhibition of neural activity at thalamo-cortical and cortical levels. There have been changes in form of an increased amplitude suggesting recruitment of more neurons and a decrease in latency has also been reported, suggesting a decrease in time taken to transmit sensory information. An autonomic based earlier reports suggest whether meditation increases the autonomic arousal or decreases is not certain. The individual level analysis revealed that changes in autonomic variables suggestive of both activation and relaxation occurred simultaneously in different subdivisions of the autonomic nervous system in a meditator. Meditation was used an indicator of academic achievement perhaps as a result of its relationship to awareness or wakefulness level suggesting the autonomic arousal. It was also suggested that exhalation feedback helps to concentrate on the exhalation process and

by this means slows respiration rate, and as a consequence, also heart rate. Therefore, respiratory feedback could be a useful tool for inducing relaxation and slowing of heart rate suggesting a decrease in autonomic arousals. An increase in baroflex sensitivity, suggestive of induced favorable psychological and physiological effects Hence, the autonomic – respiratory changes during meditation are suggestive of a state of ‘alertful rest’. Meditation is associated with increased activation in parts of the brain related to attention. These results suggest selective attention capacity and information processing strategies associated with meditation. Concentrative meditation enhances preattentive perceptual processes, cognitive ability and enabling better change detection in auditory sensory memory and increases efficiency of the executive attentional network (anterior cingulate/frontal- prefrontal cortex). As well as lower trait anxiety more readily induces meditation with a predominance of internalized attention, while higher trait anxiety more readily induces meditation with a predominance of relaxation.

TABLE 3.2.1 MEDITATION STUDIES BASED ON EVOKED POTENTIALS

(The references are arranged in year-wise)

| Author & Year of Publication | (N) | Experimental Design | Variable studied | Findings |
|--|-----|--|--------------------------|---|
| Barwood et al., (1978) | 8 | Before, during, and after meditation | AEP | Non significant decrease in N1 latency during meditation |
| Banquet, J. P. , Bourzeix, J. C. , & Lesèvre, N. (1979). | 20 | A comparative matched controlled study (10 +10) | VEPs & RT | After meditation showed faster RT's with less mistakes, and N120 and P200 of larger amplitude and shorter latency. |
| Mc Evoy et al., (1980) | 5 | Meditators vs. controls; Before vs. after | ABR | Wave V latency increased at 45- 50 dB and decreased at 60- 70 dB; intensity/ latency relationship increased in slope from 45- 70 dB |
| Becker, D.E., Shapiro, D. (1981). | 50 | Comparative study on Zen, Yoga, TM, attend and ignore to stimuli. (10+10+10+10+10) | EEG , EP (Cz-A2) EOG, SC | All 5 groups showed: EEG alpha suppression and SC responses to click stimuli which showed clear habituation with no differences among groups . The 2 control groups did not differ in the orienting responses. AEP: 3 medtn gps did not differ significantly in P-300.For all 5 gps P200 amplitude ↓ N100 responses were larger for yoga and TM meditators |

| Author & | (N) | Experimental Design | Variable studied | Findings |
|----------|-----|---------------------|------------------|----------|
|----------|-----|---------------------|------------------|----------|

| | | | | |
|---|----|---|-----------------------------|--|
| Year of Publication | | | | |
| Goddard, (1989) | 26 | Elderly meditators vs. elderly controls | Auditory and visual oddball | Visual P300 latencies shorter in meditators, no auditory P300 effects |
| Cranson et al., (1990) | 39 | Long Term Meditators vs. Short Term Meditators vs. controls | Auditory oddball | P300 latency inversely correlated with length of meditation practice: none>short> long |
| Liu et al., (1990) | 21 | Before, during, and after meditation | ABR, MLR, AEP | ABR- increased I - V wave amplitudes; MLR-decreased Na- Pa amplitudes; Decreased P200 amplitude |
| Goddard, (1992) | 32 | Elderly meditators vs. elderly controls vs. young meditators vs. young controls | Visual oddball | P300 latencies longer in elderly than young; elderly meditators vs. elderly controls had shorter P300 latencies and longer Reaction Times {RT}; Dissociation of P300 latency and RT |
| Gordeev, S. A. , Baziiian, B. Kh. , & Liubimov, N. N. (1992). | 29 | A comparative study meditation vs control (17+12) | SEPs & VEPs | Meditation has the ability of extrasenses for reversible changes of their mind by direct adjustment of the activity of the ascending nonspecific systems of the brain and by alterations of interhemispheric relations forms the basis of extrasensory activity. |
| Zhang, et al., (1993). | 48 | A comparative study between 4 groups - Long Term vs. Short Term vs. Controls. (14+12+11+11) | Flash VEP | Qigong mediation may have either facilitative or inhibitory effects on the visual cortex depending on the Qigong methods practiced by different individuals. |

| Author & Year of Publication | (N) | Experimental Design | Variable studied | Findings |
|---|------------|----------------------------|-------------------------|-----------------|
|---|------------|----------------------------|-------------------------|-----------------|

| | | | | |
|--|----|---|---|--|
| Travis & Miskov, (1994) | 11 | Before vs. after meditation vs. after rest | Auditory oddball | Decreased latency P300 after TM but not rest; trend towards higher amplitude P300 after TM |
| Telles, S. & Desiraju, T. (1993). | 14 | <i>Self as control design Meditation vs. Non-meditation condition; Before vs. during meditation technique.</i> | <i>MLR</i> | <i>Nb latency decreased in meditation but no effect seen in control session, small effect size</i> |
| Telles, S., Nagarathna, R., & Desiraju, T. (1994). | 18 | <i>Self as control design Meditation vs. Non-meditation condition; baseline vs. "OM" meditation vs. repetition of "one"</i> | <i>MLR</i> | <i>Na amplitude increased in meditation and decreased in non- meditation; Na amplitude decreased while repeating "one"</i> |
| Murthy et al., (1997, 1998) | 45 | Sudarshana Kriya Yoga; Patients: depressed vs. dysthymic vs. controls | Auditory oddball | Improvement in depressive symptoms and increase in P300 amplitude in novice meditators; effect may be due to alleviation of depression |
| Luo, Y., Wei, J., Weekes, B. (1999). | 23 | Musical Meditation Case control design Pre and post recording sessions | (i) auditory mismatch negativity (MMN) (ii) P300 of event-related potentials | (i) MMN amplitudes in the trained children were larger than those in the control group. (ii) MMN amplitudes were identical in attend and ignore conditions. For both groups. This evidence suggests that auditory brain function has been affected by musical meditation training |
| Panjwani et al., (2000). | 34 | <i>Epilepsy patients: Yoga group vs. "sham Yoga"</i> | <i>ABR, MLR, Visual</i> | ABR= no effects; MLR= increased Na- Pa amplitude at 6 months in meditation group; VCS increased |

| | | | | |
|--|--|--|---|--|
| | | | <i>Contrast Sensitivity [VCS]</i> | |
|--|--|--|---|--|

| Author & Year of Publication | (N) | Experimental Design | Variable studied | Findings |
|--|------------|--|-------------------------|--|
| Telles, S. & Naveen, K.V. (2004). | 16 | Meditation session vs. non-meditation session | AEP-MLR | Decreased peak latency of the Na wave; Decreased latency in Na of AEP-MLRs |
| Sarang, S.P & Telles, S. (2006). | 42 | Self as controlled | P300 AERPs | Cyclic meditation enhances cognitive processes underlying the generation of the P300. |
| Srinivasan, N & Baijal, S. (2007). | 10-10 | Meditators vs.non-meditators---- A comparatative controlled | EEG & ERP | Concentrative meditation practice enhances preattentive perceptual processes, enabling better change detection in auditory sensory memory. |
| Subramanya, P & Telles S. (2009). | 47 | Self as controlled design | MLAEPs | CM the latencies of neural generators corresponding to cortical areas is prolonged, whereas following SR a similar change occurs at mesencephalic-diencephalic levels. |
| Cahn, B.R. & Polich, J. (2009). | -- | Self as controlled design | ERPs | ↓the amplitude of neurophysiologic processes that subserve attentional engagement elicited by unexpected and distracting stimuli |

TABLE 3.3.2 MEDITATION STUDIES BASED ON AUTONOMIC AND RESPIRATORY VARIABLES

| Author & Year of Publication | (N) | <i>Experimental Design</i> | <i>Variables studied</i> | <i>Findings</i> |
|---|------------|---|--|--|
| Bagchi & Wenger, (1957) | 14 | Meditation session vs. control session | Autonomic & respiratory variables | Increase in skin resistance & decrease in respiratory rate |
| Wenger & Bagchi, (1961) | 4+4 | Novice & experienced; | Autonomic & respiratory variables | Increased heart beat-both groups; Decreases respiratory rate & palmar conductance-both groups; 20% reduction in pulse volume in experienced meditators |
| Wallace, R.K. (1970). | 15 | Self as control design EO → EC → MEDIN → EC → EO 5 min 15 min 30 min 10 min 5 min | Variables: (i) OC (n = 9) Both open and closed circuit method (ii) GSR (iii) ECG (n = 5) (iv) EEG (n = 5) FP1, Cz, T3, P3, O1, O2 | During meditation (compared to before) (i) OC: ↓ 20 % (ii) ECG: HR ↓ by 5/min (iii) GSR: ↓ (iv) EEG: ↑ alpha wave amplitude and regularity, occasional slow alpha and low voltage theta. (v) EEG: alpha blocking present, without habituation |

| Author & Year of Publication | (N) | Experimental Design | Variables studied | Findings |
|---|-------------------------------|--|--|--|
| Elson, B.D., Hauri, P., & Cunis, D. (1977). | 11 | Before → 40min → After During Meditn or Relaxation | Assessments: EEG, GSR, Respiration | During (40 min) of Meditation / Relaxation. Meditation: Stable EEG with alpha and theta activity, ↑ basal GSR, ↓ RR Controls: 6 out of 11 showed K complexes and spindles in the EEG |
| Corby et al., (1978) | ---- | Rest vs. meditation | Autonomic & respiratory variables & EEG | Respiratory suspension during meditation; No changes in EEG |
| Wallace, R.K., Benson, H., & Wilson, A.F. (1971). | 36 | EO → EC → MEDIN → EC → EO 5 min 15 min 30 min 10 min 5 min | Variables: BP, HR, GSR, Rectal temperature, OC [closed circuit method (n = 5), open circuit method (n = 15)] | During Meditation: (i) OC: ↓ 17%, ↓VE by 1liter (ii) RR: ↓ by 3/min (iii) HR: ↓ by 3/min (iv) ↓Mean blood lactate: (v) EEG: ↑intensity slow alpha waves (8- 9 cps), with occasional theta waves. |
| Orme- Johnson, D.W. (1973). | EXPT I: 8 EXPT II: 8 | EXPT I : GSR habituation & Spontaneous GSR changes EXPT II: Spontaneous GSR changes EO MEDTN EO REST → NON MEDTN → REST (10 min) EC (10 min) (10 min) | EXPT I: GSR habituation & Spontaneous GSR changes EXPT II: Spontaneous GSR changes | Meditators Vs Controls (i) Initially more stable (ii) Habituated faster (11 trials Vs 26.1 trials) (iii) less spontaneous fluctuations of 100 Ω or more. |

| Author & Year of Publication | (N) | <i>Experimental Design</i> | <i>Variables studied</i> | <i>Findings</i> |
|--|------------|---|---|--|
| Corby, J.C., Roth, W.T., Zarcone, V.P., & Kopell, B.S. (1978). | 30 | <p>All 30 ss received: 55 dE tones every sec, different frequency tones every 10-20 sec, 70 dB white noise every 4 min and continuous 40 dB white noise during medtn</p> <hr/> <p>Gp I : =10 Gp II: =10 Gp III: =10</p> | <p>Condition I Condition I Condition III Baseline Concentrating All ignored Relaxation on breathing tones Attending ignoring Gp I repeated to tones a word of their choice Duration of Gp II & III each condition-repeated the 20 min pecific mantra</p> | <p>Autonomic measures: (i) Meditators relative to controls, during meditation: ↑HR ↑ SC (ii) All groups ↓ RR (Condition III) (iii) HR Orienting response during condition III: Controls - biphasic with deceleratory component meditators deceleratory component absent. EEG; experts showed ↑ alpha and ↑ theta power and minimal of EEG defined sleep.</p> |

| Author & Year of Publication | (N) | Experimental Design | Variables studied | Findings |
|---|-----|--|--|---|
| Telles & Desiraju, (1992). | 1 | <i>Single thought state – No thought state</i> | <i>Autonomic & respiratory</i> | <i>Distinct breath rate & pattern in the two states</i> |
| Telles & Desiraju, (1993) | 18 | Experienced meditators- meditation & control sessions, 3 each | Autonomic & respiratory | Increased heart rate in meditation; Changes in autonomic variables -both activation and relaxation - simultaneously in different subdivisions of the autonomic nervous system. |
| Telles, Nagarathna & Nagendra, (1995) | 7 | <i>Self as control design Meditation vs. non-meditation</i> | <i>Autonomic & respiratory</i> | <i>Decrease in breath rate; Increase in the skin resistance in both conditions</i> |
| Telles, Nagarathna & Nagendra, (1998) | 12 | <i>Meditation on OM & repetition on ONE</i> | <i>Autonomic & respiratory</i> | <i>Both sessions-decreased heart rate & breath rate Reduced skin resistance in meditation session</i> |
| Kubota, Y., Sato, W., Toichi, M., Murai, T., Okada, T., Hayashi, A., & Sengoku, A. (2001). <i>Brain Research Cognitive Brain Research</i> , 11(2): 281-287. | 25 | Self as control trial Assessments: two sessions: meditation & control | i) Electroencephalogram ii) Electrocardiogram iii) Cardiac autonomic variables like HRV & inter beat intervals <i>For the Ss in whom Fm theta activities were provoked (6M&6F 48% of n) peripheral autonomic</i> | i) Both sympathetic and parasympathetic indices were ↑ during the appearance of Fm theta compared with control periods. ii) Theta band activities in the frontal area were correlated negatively with sympathetic activation. iii) Results suggested a close relationship between cardiac autonomic function and activity of medial frontal neural circuitry. |

| | | | <i>activates were evaluated.</i> | |
|--|----|---|----------------------------------|---|
| Barnes, V. A., Treiber, F. A., & Davis, H. (2001). <i>J Psychosom Res</i>, 51(4): 597-605. | 35 | Randomized Controlled Trial | Autonomic | TM appears to have a beneficial impact upon cardiovascular functioning at rest and during acute laboratory stress in adolescents at-risk for hypertension |

| Author & Year of Publication | (N) | <i>Experimental Design</i> | <i>Variables studied</i> | <i>Findings</i> |
|---|------------|--|---|---|
| Bernardi, et al. (2001) | 23 | A comparatative study on two types of mantra chanting | Electrocardiogram, respiration, blood pressure, baroreflex sensitivity, Transcranial Doppler ultrasonography, | ↓respiration to almost exactly 6/min, and enhanced heart rate variability and baroreflex sensitivity in both sessions. |
| Arambula et al., (2001) | 1 | <i>Rest vs. meditation vs.rest; Befor-During-After</i> | <i>EEG, Heart rate [HR], Skin Conductance level [SCL], Blood Volume Pulse [BVP]& Respiration</i> | <i>Decreased Breath rate; Increased alpha power in P4- O2 electrodes; Shift in breathing patterns –increased alpha</i> |
| Travis, F. (2001). | -- | A comparative study between EEG & Autonomic changes | EEG & Autonomic changes | Monitoring patterns of physiological variables may index dynamically changing inner experiences during meditation practice. |

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|---|----|--|---|--|
| Murata, T., Takahashi, T., Hamada, T., Omori, M., Kosaka, H., Yoshida, H., & Wada, Y. (2004). | 22 | Baseline Control | (i) EEG coherence (ii) Heart rate variability (HRV) (iii) Spielberger's State-Trait Anxiety Inventory | During meditation in all subjects showed, (i) ↑ slow alpha interhemispheric EEG coherence in the frontal region, (ii) ↑ high-frequency (HF) power and ↓ ratio of low-frequency to HF power. (iii) a negative correlation between the percent change (with the control condition as the baseline) in slow alpha interhemispheric coherence reflecting internalized attention and the percent change in HF reflecting relaxation. The trait anxiety score was negatively correlated with the percent change in slow alpha interhemispheric coherence in the frontal region and was positively correlated with the percent change in HF. |
| Peng et al., (2004) | 10 | Relaxation response, breath of fire & segmented breathing. | Beat-to-beat heart rate and continuous breathing signals | Common as well as specific [increased mean heart rate in breath of fire] changes for all the 3 conditions |

| | | | | |
|--|----|--|----------------------------|---|
| Takahashi, T. , et al., (2005) | 20 | A comparative study design | <i>EEG & Autonomic</i> | Internalized attention and mindfulness as two major core factors of behaviors of mind during meditation are characterized by different combinations of psychophysiological properties and personality traits. |
| Cysarz & Bussing, (2005) | 9 | For all subjects-spontaneous breathing, mental task, Zen meditation, and Kinhin meditation | ECG & Respiratory trace | High degree of synchronization in Zen & Kinhin meditation compared to mental task & spontaneous breathing |
| Hamada, et al., (2006) | 30 | <i>A comparative study between Autonomic & EEG</i> | <i>Autonomic & EEG</i> | <i>Specific correlated relationships exist between the change in autonomic nervous activity and EEG power depending on the difference in mental task or meditation.</i> |

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|--|-------------------------|--|--|---|
| Paul-Labrador, M. et al., (2006). | 103 | Randomized placebo controlled trial | <i>Autonomic & biochemical test</i> | May modulate the physiological response to stress and improve coronary heart disease risk factors, which may be a novel therapeutic target for the treatment of coronary heart disease. |
| Phongsuphap et al. (2008). | -- | A comparative study | <i>Autonomic and respiratory variables</i> | ↑baroreflex sensitivity, ↑parasympathetic tone, and improving efficiency of gas exchange in the lung. |
| Barnes , et al (2008) <i>Ethn Dis</i> : 18(1):1-5. | 66 (BAM=20, Control=46) | Randomized controlled trial breathing awareness meditation (BAM) vs health education | Urine samples were collected, and ambulatory SBP, diastolic blood pressure, and heart rate | urinary sodium excretion rate ↓in the BAM group but ↑in the control group, day & night time SBP ↓in the BAM group, day time heart rate ↓ in BAM |

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|---------------------------------|-----|----------------------|-----------------------------------|--|
| Berntson, G. G. et al., (2008). | 229 | A longitudinal study | Autonomic variables | Spirituality appears to be associated with a specific pattern of cardiac autonomic regulation, characterized by a high level of cardiac autonomic control, irrespective of the relative contribution of the two autonomic branches. This pattern of autonomic control may have health significance |
| Peressutti, C et al., (2009). | 19 | A comparative study | Autonomic & respiratory variables | Zazen in turn the modulation of the respiratory sinus arrhythmia may reflect changes in the breathing pattern as in the parasympathetic outflow related to the quality and focus of attention in each stage. |
| Tang, Y.Y. et al., (2009). | -- | A comparative study | Autonomic, EEG & Neuro Image | EEG and HRV suggests involvement in the autonomic nervous system during and after training also Imaging data demonstrated stronger subgenual and adjacent ventral anterior cingulate cortex activity |

TABLE 3.4.1 MEDITATION STUDIES RELATED TO VISUAL SCANNING, ATTENTION, CONCENTRATION AND REPETITIVE MOTOR RESPONSE

| Author & Year of Publication | (N) | <i>Experimental Design</i> | <i>Variables studied</i> | <i>Findings</i> |
|---|------------|---|--|---|
| Orme-Johnson et al (2006). | 24 | <i>Longitudinal comparative design experience vs non experience TM meditators</i> | <i>fMRI</i> | TM meditation longitudinally reduces the affective/motivational dimension of the brain's response to pain. |
| Sarang & Telles , (2007). | 69 | <i>Self as control CM vs Supine rest.</i> | <i>SLCT</i> | Cyclic Meditation improves the performance in letter cancellation task, which requires selective attention, concentration, visual scanning abilities, and a repetitive motor response. |
| Tang, Ma, Wang , et al (2007). | 40 + 40 | <i>A randomized controlled study (Meditation Vs Relaxation)</i> | Attention Network Test, Raven's Standard Progressive Matrix, Profile of Mood States, a stress challenge of a mental arithmetic task, measures of cortisol and <i>secretory IgA</i> | Meditation showed greater improvement in conflict scores on the Attention Network Test, lower anxiety, depression, anger, and fatigue, and higher vigor on the Profile of Mood States scale, a significant ↓ in stress-related cortisol, and ↑ in immunoreactivity. |
| Srinivasan & Baijal , (2007). | | The study was carried out with 10 meditators and 10 nonmeditator controls | <i>Mismatch negativity (MMN) paradigm</i> | The results indicated that concentrative meditation practice enhances preattentive perceptual processes, enabling better change detection in auditory sensory memory. |

| | | | | |
|--|-------------------|--|--|--|
| Chan & Woollacott (2007) . | 50 + 10 | The study was carried out with 50 meditators vs 10 controls | <i>Stroop (measures executive attention) and Global-Local Letters (measures orientational attention) tasks</i> | Meditation produces long-term increases in the efficiency of the executive attentional network (anterior cingulate/prefrontal cortex) but no effect on the orientation network (parietal systems). |
| Jha, Krompinger & Baime (2007) . | 17 | A comparative study meditators vs naïve pre post design. | <i>Attention Network Test, behavioral test</i> | Mindfulness training may improve attention-related behavioral responses by enhancing functioning of specific subcomponents of attention. |
| Pagnoni & Cekic (2007) . | 26 | 13 meditators vs 13 age matched control study | <i>MRI, computerized sustained attention task</i> | A regular practice of meditation may have neuroprotective effects and reduce the cognitive decline associated with normal aging. |
| Simpson, et al (2007) . | | A Comparative clinical controlled trial Vipassana meditation vs treatment as usual | <i>PTST</i> | Vipassana meditation is worthy of further study for those with comorbid PTSD and substance use problems. |
| Brefczynski-Lewis, et al (2007). | 14, 16 & 11 | Age matched comparative study meditators vs naïve | <i>fMRI</i> | Meditation showed the activation in attention regions and visual cortex (14, 16, 24, 26), which emphasize a cognitive component called concentration, which includes aiming and sustaining attention. |
| Hölzel et al (2007) . | 15 + 15 | Age matched control study | <i>fMRI</i> | Meditators showed stronger activations in the rostral anterior cingulate cortex and the dorsal medial prefrontal cortex bilaterally, compared to controls, which may reflect that meditators are stronger engaged in emotional processing. |

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|---|------------|---|--|---|
| Paul, Elam, & Verhulst (2007). | 64 | A longitudinal followup study | <i>student performance on academic courses</i> | ↓ test anxiety, nervousness, self-doubt, and concentration loss. |
| Morone, Greco, & Weiner (2008). | 37 + 37 | Randomized Controlled Trial | <i>Pain Acceptance Questionnaire, Activities Engagement subscale</i> | Mindfulness meditation lead to improvement in pain acceptance (P=.008) and physical function (P=.03). |

4.1 AIM

The present study aims at exploring the four states of mind (*Cañcalatā*, *Ekāgratā*, *Dhāraṇā* and *Dhyāna*) described in texts of yoga and spiritual lore as possible basis in different types of Meditation and different stages of a single meditation technique.

4.2 OBJECTIVES

The objectives of this work are to study the effects of ‘OM’ Meditation during *cañcalatā* (random thinking), *ekāgratā* (focusing), *dhāraṇā* (meditative focusing), and *dhyāna* (meditation without focusing) on the psycho-physiological changes namely:

- Brainstem auditory evoked potentials
- Autonomic and Respiratory variables
- Performance in a six letter cancellation task

4.3 RATIONALE OF THE STUDY

Evoked potentials (EPs) that can be elicited after a stimulus. EPs are evoked automatically with repetitive sensory stimulation, whereas ERPs are elicited with cognitive task processing (Hall, 1992; Picton & Hillyard, 1974; Picton, et al. 1974). Auditory stimuli produce the auditory brainstem response (ABR) and middle latency response (MLR). Long latency auditory evoked potentials (LLAEP) are thought to reflect the activation of the primary auditory cortex (Polich & Starr, 1983; Wood & Wolpaw, 1982), while

brainstem auditory evoked potentials (BAEPs) reflect neuronal activity in the auditory nerve, cochlear nucleus, superior olive and inferior colliculus of the brainstem. Brainstem components of the auditory pathway correspond to components of short-latency potentials. This was considered especially important as the present study aimed at examining the changes during phases of consciousness which have distinct differences related to ‘states of the mind’, which would be expected to be seen at the brainstem level.

The autonomic nervous system can be controlled and its’ responses integrated and modified by the central nervous system (CNS). Autonomic and respiratory variables are good indicators of levels of arousal and relaxation.

Performance in a letter cancellation task, which is known to be a quick measure of selective attention, concentration visual scanning abilities, and a repetitive motor response (Uttl & Pilkenton-Taylor, 2001), has been shown to improve with other yoga practices such as a moving meditation called ‘cyclic meditation’ (Sarang & Telles, 2007) and certain *prāṇāyāmas*. Hence it was considered interesting to assess the performance in this task following non-meditative focusing (*ekāgratā*) and meditative focusing (*dhāraṇā*).

4.4 HYPOTHESIS

The present study hypothesized that *OM* meditation may influence selective attention and concentration, as well as the baseline autonomic functions and information processing at the brainstem level.

4.4.1 NULL HYPOTHESIS

In different phases of *OM* meditation null hypothesis postulates that:

1. The information transmission in auditory pathway will not be delayed in *cañcalatā*, *ekāgratā*, and *dhāraṇā* while it will not remain unaltered if not delayed at the brainstem level in *dhyāna* phase.
2. *Dhyāna* would not induce a state of deep rest with alertness and there will be no autonomic arousal in other phases of *ekāgratā* and *dhāraṇā*.

3. There will be no increased attention in all phases *ekāgratā*, *dhāraṇā* and *dhyāna* with no higher increase in *dhyāna*.

In this thesis the changes in (i) brainstem auditory evoked potentials (ii) autonomic and respiratory variables and (iii) performance in a paper and pencil letter cancellation test were studied in normal volunteers while practicing in four different states of consciousness viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Methodology of the research has been described under the following sub-headings:

5.1 PARTICIPANTS

5.1.1 SAMPLE SIZE

The sample size was calculated and the effect size obtained, based on reports in an unpublished Ph.D thesis entitled ‘psychophysiology of meditation including responses to external stimuli’ (Naveen KV, 2005). It was calculated using G-power software, University of Duesseldorf, Germany; <http://www.psych.uni-duesseldorf.de/aap/projects/gpower>;

Where the level was 0.05, power = 0.95 and the recommended sample size was thirty subjects. The number of subjects varied across the variables studied. The details are as follows:

| Sl. No. | Variable studied | No. of subjects* | No. of recording sessions |
|---------|-------------------------------------|------------------|---------------------------|
| 1. | Brainstem auditory evoked potential | 30 | 30 x 4 = 120 |
| 2. | Autonomic and respiratory Variables | 30 | 30 x 4 = 120 |

| | | | |
|----|------------------------------|--------------|----------------------------------|
| 3. | Six letter cancellation test | 35 | $5 \times 2 = 10$ (in subgroup) |
| 4. | Visual analogue scale | $(30+30=60)$ | $120 \times 2 = 240$ |

*Note: the number of subjects varied for different variables as it was not always possible for all subjects to attend all sessions.

5.1.2 SELECTION AND SOURCE OF PARTICIPANTS

Thirty participants had a minimum of six months experience of *OM* meditation who were regular in their practice. The participants were residential students at *Svāmī Vivekānanda Yoga Anusandhāna Saṁsthānaa Deemed University, Bangalore*. They had all enrolled for graduate and postgraduate study programs.

5.1.3 INCLUSION CRITERIA

Participants who fulfilled following conditions were included in the study:

(i) The participants were healthy volunteers with age range from 20 and 45 years (group mean age \pm SD was 29.1 ± 5.1). This age range was selected as the BAEPs, did not show variation within this age range in healthy individuals (Lanter, et al. 1993). Also, based on previous experience of the difficulty in getting meditators who were committed to the practice of meditation it was decided to keep the age range as wide as possible. (ii) male participants alone were studied as short latency auditory evoked potentials (Yadav, et al. 2002; 2003) and autonomic variables (Yildirim, et al. 2002) have been shown to vary with the phases of the menstrual cycles in

females, (iii) readiness to participate in the trial, and (iv) practice of meditation for a minimum of 30 minutes per day, 4 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 (where possible) consultations with the meditation teacher (*guru*). (v) apart from their prior experience of 'OM' meditation they had undergone a two-month orientation program in 'OM' meditation under the guidance of an expert. The further details of each subject have been given in the **Appendix-2 & 3. Table 5.1A & 5.1B.**

5.1.4 EXCLUSION CRITERIA

The following criteria were used to exclude the volunteers: (i) any health disorders especially psychiatric or neurological disorders, In order to determine the health status of the participants, in all cases a routine case history was taken and a routine clinical examination was conducted, (ii) auditory deficits assessed by checking the auditory thresholds of each ear separately (iii) autonomic dysfunction, and (iv) any medication which alters the function of the nervous system (including autonomic functions), and (v) smoking or alcoholism which may have influenced the autonomic and respiratory variables. None of the volunteers had to be excluded based on these criteria.

5.1.5 ETHICAL CONSIDERATIONS

The study protocol was explained to the subjects and the signed informed consent was obtained from all subjects (a copy of the signed informed consent form is enclosed as **Appendix-1**). None of them was aware of the hypothesis of the study. Approval was obtained from the Institutional Ethical Committee.

5.2. DESIGN OF THE STUDY

Each subject was assessed in four sessions i.e., two meditation and two control sessions to record brainstem auditory evoked potentials (BAEP), respiratory with autonomic variables (ARV) and the six letter cancellation test (SLCT) were assessed before and immediate after each session. The two control sessions were: (i) *ekāgratā*, i.e., single topic listening to a lecture on meditation, with multiple, yet associated thoughts and (ii) *cañcalatā*, i.e., non-targeted thinking. The two meditation sessions were (i) *dhāraṇā*, i.e., focusing on the symbol 'OM' and (ii) *dhyāna*, i.e., an effortless with effortless absorption with the object of meditation. The meditation on 'OM' is specifically done on its meaning as it described under chapter 2 and not on its' sound or form. All four sessions consisted of three states, i.e., 'pre' (5 minutes), 'during' (20 minutes), and 'post' (5 minutes) separately on different days, for BAEP and ARV.

The assessments were made on four different days for each recording, not necessarily on consecutive days, but at the same time of the day (i.e., the self-as-control design). The allocation of the subjects to the four sessions was randomized using a standard random number table (ZAR, 2005). This was done to prevent the influence of being exposed to the laboratory for the first time, from influencing the results.

To assess the quality of the practice visual analogue scale (VAS) were used at the end of each session.

5.2.1 STRUCTURE OF SESSIONS

Subjects were assessed in twelve sessions. They underwent three *dhyāna* (meditation), three *dhāraṇā* (one-pointed focusing), three *ekāgratā* (concentration) and three *cañcalatā* (random thought) sessions, while (i) recording brainstem auditory evoked potentials, (ii) recording respiratory and autonomic variables and (iii) assessments for letter cancellation test (this test was administered before and after the each session at the same time on different days, subjects were divided in to five subgroups).

5.2.2 ORDER OF SESSIONS

Subjects were allocated to the following four sessions separately (i) BAEP, (ii) ARV and (iii) SLCT (in five subgroups) using a random number table and hence the order of the sessions was different for each subjects. The sessions were:

- 1 = Control session [Non-targeted thinking (*cañcalatā* session)]
- 2 = Non-Meditation session [Concentrating on a single subject, but with several thoughts (*ekāgratā* session)]
- 3 = Meditation session [Focused attention on an object of meditation (*dhāraṇā* session)]
- 4 = Meditation [Effortless de-focusing (*dhyāna* session)]

5.2.A SCHEMATIC REPRESENTATION OF THE STUDY DESIGN

Fig.7

| | | | |
|---|-------------|---|--------------|
| 1 | Pre: 5 min. | CTL1 [Non-targeted thinking (<i>cañcalatā</i>): 20 min. | Post: 5 min. |
| 2 | Pre: 5 min. | NON-MED 2 [Concentration (<i>ekāgratā</i>)]: 20 min. | Post: 5 min. |
| 3 | Pre: 5 min. | MED 3 [Focused attention (<i>dhāraṇā</i>): 20 min. | Post: 5 min. |
| 4 | Pre: 5 min. | MED 4 [Meditation (<i>dhyāna</i>): 20 min. | Post: 5 min. |

(CTL = CONTROL; MED = MEDITATION)

5.2.B Schematic representation of the SLCT study design

Fig.8

| | | | |
|---|-----------------|---|------------------|
| 1 | Pre Assessments | CTL1 [Non-targeted thinking (<i>cañcalatā</i>): 20 min. | Post Assessments |
|---|-----------------|---|------------------|

| | | | |
|---|-----------------|---|------------------|
| 2 | Pre Assessments | NON-MED 2 [Concentration (<i>ekāgratā</i>): 20 min. | Post Assessments |
| 3 | Pre Assessments | MED 3 [Focused attention (<i>dhāraṇā</i>): 20 min. | Post Assessments |
| 4 | Pre Assessments | MED 4 [Meditation (<i>dhyāna</i>): 20 min. | Post Assessments |

(CTL = CONTROL; MED = MEDITATION)

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, et al. 1993). Hence in the present thesis the term ‘variable’ has been used to describe the assessments studied.

5.3.1 RATIONALE FOR STUDYING BRAINSTEM AUDITORY EVOKED POTENTIALS (BAEPS)

Evoked potentials that can be elicited after a stimulus is presented. EPs are evoked automatically with repetitive sensory, stimulation, whereas ERPs are elicited with cognitive task processing (Hall, 1992; Picton & Hillyard, 1974; Picton, et al. 1974). Auditory stimuli

produce the auditory brainstem response (ABR) and middle latency response (MLR). The long latency auditory evoked potential (LLAEP) measures are thought to reflect the activation of primary auditory cortex (Polich & Starr, 1983; Wood & Wolpaw, 1982). Visual and somatosensory sensory EPs also can be evoked, with standard clinical procedures now well defined (Chiappa, 1996). The P300 component is usually elicited by assigning subjects a stimulus discrimination task and can be obtained across modalities (Donchin, 1981; Johnson, 1988; Picton, 1992; Polich, 2003, 2004).

The clinical use of evoked potentials (EPs) has changed over time. Progressive advances in imaging technology have limited the frequency of evoked-response studies in clinical practice. Current use of MRI technology is mostly responsible for this. The basic difference that persists is that the MRI largely remains an imaging, structural, or anatomical test, while the EPs explains the functionality of certain pathways of the nervous system. The MRI scan gives more accurate information about structural problems, while the EPs give us information about the physiology of a certain anatomical pathway with much less spatial or localizing information. Under given circumstances they may be complementary.

Brainstem Auditory evoked potentials (BAEPs) are very small electrical voltage potentials which are recorded in response to an auditory stimulus from electrodes placed on the scalp. They reflect neuronal activity in the auditory nerve, cochlear nucleus, superior olive and inferior colliculus of the brainstem. They typically have a response latency within 0 to 10 milliseconds with an amplitude of approximately less than 1 μ V. Due to their small amplitude 500 or more repetitions of the auditory stimulus are required in order to

average out the random background electrical activity. Brain stem auditory evoked potentials (i.e., 0-10 msec. range of components) were recorded in the four states of consciousness viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, as previous studies have shown that middle latency auditory evoked potential components (0-100 msec. range of components; reflecting sub-cortical and primary auditory cortex activity change during the practice of both meditation on *OM* (Telles & Desiraju, 1993a; Telles, et al. 1994) and during *Brahmākumaris Rāja* Yoga (BK) meditation (Telles & Naveen, 2004).

5.3.1A 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 Evoked Potentials (AEP), Somatosensory Evoked Potentials (SEP), Visual Evoked Potentials (VEP) and P300 Event Related Potentials (ERP). The Bravo EP amplifier has 4 acquisition channels, a headbox for electrode connections and a LED electrode impedance panel. To perform AEP tests, acoustically shielded earphone (TDH-39, Amplivox, UK) 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). The Bravo EP has software package, which allows running P300 cognitive response test. The main features of the P300 software include 4-channel recording and

independent averaging for frequent and rare stimuli (Nicolet Biomedical Inc., 1998). **Plate. 1** shows the Nicolet Bravo EP - 4 channels amplifier (Nicolet, USA) and closed circuit TV.

5.3.1B Computer averaged brain stem auditory evoked potentials [BAEPs]

BAEPs were recorded using only one channel the Nicolet Bravo system (Nicolet Biomedicals, U.S.A). Sample record of BAEPs responses are presented in Figure.11 in Appendix-10.

5.3.1C The amplifier settings were as follows

low frequency filter 100Hz, high frequency filter 3KHz, sensitivity 50 microvolts, number of sweeps averaged 1500, sweep width 10 ms, with 0 ms delay. Binaural click stimuli, of alternating polarity, with 11.1 Hz frequency and 100 micro-seconds duration were delivered through acoustically shielded earphones (Amplivox, UK). The stimulus intensity was kept at 80dB nHL. The rejection level was expressed as a percentage of the full scale range of the analog-to-digital converter. This level was set at 90%. Silver chloride (Ag/AgCl) disc electrodes were placed on the scalp using a conductive water soluble paste. The active electrode was at Cz according to the International 10-20 system (Jasper, 1958) referenced to the linked ear lobes; with the ground electrode on the forehead (FPz). All electrode impedances were kept below 5K Ω throughout the session.

5.3.1E Testing procedure:

Plate .1 Setup in the Evoked Potentials Laboratory



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



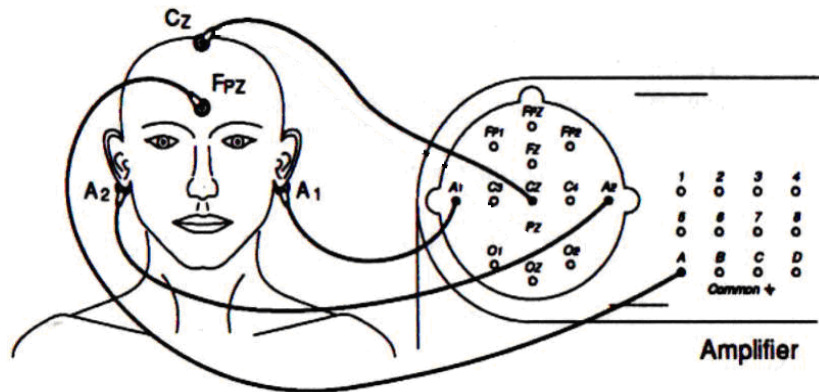
A subject seated in a sound attenuated cabin with electrodes at Cz (active) referred to linked ear lobe and a ground electrode (FPz), with acoustically shielded ear phones to deliver binaural clicks during the recording of BAEP.

Subjects were comfortably seated during recording sessions in a dimly lit, air-conditioned and sound attenuated cabin. They were monitored on a closed circuit TV. Instructions were given through two-way intercom so that the subjects remained relatively undisturbed during the session. **Plate.1** shows a subject in sitting posture with electrode connections and earphone in the recording cabin with acoustically shielded earphone (Amplivox, UK) used to deliver the 'clicks', and a head-box for electrode connections with LED electrode impedance panel.

5.3.1F Electrode positions

The recording sites were prepared using electrode gel (Ten20 Conductive EEG Paste, D.O. Weaver & Co., USA). Silver chloride disk electrodes were used for recording. There were one active recording sites C_z according to the International 10-20 system (Jasper, 1958), referenced to the linked ear lobes [A1 – A2], with the ground electrode on the forehead (FPZ). All electrode impedances were kept below $5K\Omega$ throughout the session.

Figure.9 Electrode sites Cz, Fpz, & A1-A2 of BAEPs responses.



5.3.1.1 Variables Measured

The following variables were measured:

For the BAEPs the peak latencies and peak amplitudes of all seven waves were measured at Cz (vertex electrode site). Peak latency (msec) is defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window. Peak amplitude (μV) is defined as the voltage difference between a pre stimulus baseline and the largest positive going peak within a given latency window.

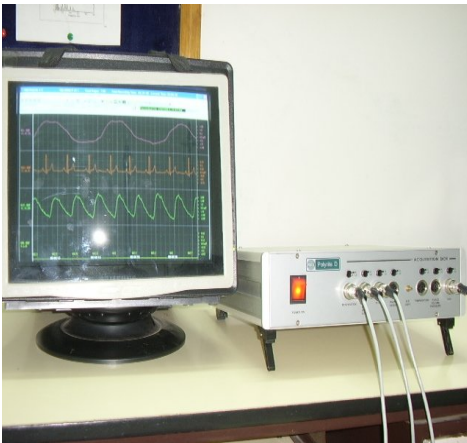
5.3.2 RATIONALE FOR STUDYING AUTONOMIC AND RESPIRATORY VARIABLES

In the present study, the autonomic variables, which were measured, were the galvanic skin resistance, the finger plethysmogram amplitude, the heart rate, and heart rate variability (HRV). Some variables mentioned clearly reflect activity in either sympathetic or parasympathetic subdivisions of the autonomic nervous system. For example, an increase in skin conductance would reflect increased sudomotor sympathetic activity while a decrease in finger plethysmogram amplitude reflects an increase in sympathetic vasomotor activity (Appenzeller, 1982). The HRV spectrum is believed to be a useful indicator of cardiac sympathetic activity (reflected by low frequency [LF] band power values) and parasympathetic activity (reflected by high frequency [HF] band power values) (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

5.3.2A Condition of recordings of autonomic and respiratory variables (ARV)

Subjects were seated in an air-conditioned sound attenuated cabin with dim lighting. The temperature of the recording room was maintained between 20 - 25° Celsius, The recording leads led out of the cabin and were connected to A 4-channel polygraph [Polyrite D] (Recorders & Medicare Systems, Chandigarh, India) used to record the electrocardiogram (EKG), galvanic skin resistance (GSR), Respirogram (RS1) and Finger Plethysmogram (FPA), and monitored on a closed circuit TV. Instructions were given through two-way intercom so that the subjects remained relatively undisturbed during the session. **Plate. 2** shows a subject in seated with transducers to record the EKG, GSR, RS1 and FPA.

Plate. 2 Setup in the Autonomic Function Testing Laboratory



A 4-channel polygraph [Polyrite D] (Recorders & Medicare Systems, Chandigarh, India) used to record the EKG, GSR, Respirogram and Finger Plethysmogram., and a PC to digitize the heart rate signal to obtain the HRV spectrum

A subject seated in a sound attenuated cabin with transducers to record the EKG, GSR, Respirogram and Finger Plethysmogram



5.3.2B Autonomic and respiratory variables measured

- i. Heart Rate (HR): The electrocardiogram was recorded using standard bipolar limb lead II configuration and an AC amplifier with 99 Hz high cut filter and 1.5 Hz low cut filter settings. The ECG was digitized using a 14 bit analog-to-digital converter (ADC) at a sampling rate of 1024 Hz. The data recorded was visually inspected off-line and only noise free data was included for analysis. The following variables were measured (i) LF: Low frequency power of HRV spectrum is known to correspond to sympathetic modulation when expressed in normalized units. Low frequency band ranges between 0.05 - 0.15 Hz. (ii) HF: High frequency power (normalized units) of HRV spectrum ranges between 0.15 – 0.4 Hz. The efferent vagal activity is a major contributor to the HF component. (iii) Ratio of low and high frequency powers (LF/HF ratio) is correlated with the sympathovagal balance.

- ii. Skin conductance: Skin conductance was recorded using Ag/AgCl disc electrodes with electrode gel, placed in contact with the volar surface of the distal phalanges of the index and middle fingers of the left hand. A low level DC preamplifier was used and a constant voltage of 0.5V was passed between the electrodes (Vempati & Telles, 2002).
- iii. Respiration: Respiration was recorded using a volumetric pressure transducer fixed around the trunk about 8 cm below the lower costal margin as the subject sat erect.
- iv. A photo plethysmograph: For this recording, the transducer was placed on the volar surface of the distal phalanx of the left thumb to record the digit pulse volume (DPV), also called the finger plethysmogram.

5.3.2C Heart rate and Heart rate variability spectrum (HRV)

Heart rate variability (HRV) describes the variations between consecutive heartbeats. The regulation mechanisms of HRV originate from the sympathetic and parasympathetic nervous systems in addition to other controls and hence, HRV is used as a quantitative marker of the autonomic control over the heart. The electrocardiogram was recorded using standard bipolar limb lead II configuration and an AC amplifier with 99 Hz high cut filter and 1.5 Hz low cut filter settings. The ECG was digitized using a 14 bit analog-to-digital converter (ADC) at a sampling rate of 1024 Hz. The data recorded was visually inspected off-line and only noise free data was included for analysis.

The R waves were detected to obtain a point event series of successive R-R intervals, from which the beat-to-beat heart rate series was computed. The data recorded was visually inspected off-line and only noise free data was included for analysis. The heart rate

was obtained based on R-R inter beat interval analysis. The HRV power spectrum was obtained using Fast Fourier transform analysis (FFT) (Raghuraj, et al. 1998). Schematic representation of ECG and Heart rate variability (HRV) are presented in **Figure.10**. According to guidelines of the Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, the low frequency and high frequency values were expressed as normalized units (Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

5.3.2.1 Definition and components of Heart rate variability

Heart rate variability is the measure used to describe variation of both instantaneous heart rate and RR intervals from an electrocardiographic recording (EKG). Also, other terms like cycle length variability and heart period variability have been used to describe oscillations in consecutive cardiac cycles.

History: the link between brain and heart the heart has been a subject of intense study since ancient times. The Greek medicine in 3rd century BC, put forward the concept of ‘pneuma’ or ‘spirit’ a kind of delicate airy substance within the body that was believed to mediate between the brain and the heart, between thoughts and emotions, and to be responsible for the translation of ‘mental’ states into ‘physical’ action and vice versa; and sympathy’ (*sympatheia*), a notion that was called in to account for the simultaneous emotional experiences in different bodily parts, and which proved to be a very useful concept to refer to psychosomatic connections that escaped empirical validation. Claude Bernard was quoted in Cournand (1979) “In man the heart is not only the central organ of circulation of blood, it is a center influenced by all sensory influences. They may be transmitted from the periphery through the spinal

cord, from the organs through the sympathetic nervous system, or from the central nervous system itself. In the fact the sensory stimuli coming from the brain exhibit their strongest effects on the heart". Two way communication between brain and heart was proposed initially by Darwin in 1872 who stated" when the mind is strongly excited, we might expect that it would instantly affect in a direct manner the heart; and this is universally acknowledge. When the heart is affected it reacts on the brain; and the state of the brain again reacts through the pneumo-gastric [now known as vagus] nerve on the heart; so that under any excitement there will be much mutual action and reaction between these, the two most important organs of the body.." Studies which exemplified the phenomenon of respiratory sinus arrhythmia (RSA) were evident as early as 1773 when Hales noted respiratory rhythms in the BP and pulse of a horse. In 1847 Ludwig in his experiments with dogs with a kymograph described RSA. Wundt (1902) proposed that pulse rate increases during inspiration and decreases during expiration. Hering (1910) in his study concluded that vagus has an important role in reducing the heart rate and can be demonstrated during respiration. In 1915 Eppinger and Hess states that "clinical facts, such as respiratory arrhythmia, habitual bradycardia have furnished the means of drawing our attention to the variations in the tonus of the vagal system in man. Bainbridge (1920) reported that changes in blood flow as a result of changes in thoracic pressure associated with respiration were related to alterations in baroreceptor and volume receptor responses.

The influence of respiratory rate and amplitude, blood gas concentrations, and efferent cardio regulatory neural pathways on RSA was evidenced by Anrep et al (1936). Hon in 1958 and 1963, working on obstetrics elucidated HRV as an index of global foetal distress. Wolf in 1967 illustrated HRV as an effective measure of communication between heart, vagus and brain.

The task force report (Malik et al, 1996) came with detailed explanation and applications of HRV are assessment of neurocardiac regulation.

Measurement of HRV: HRV represents an economical, non-invasive and sensitive procedure for investigating autonomic neurocardiac regulation, giving good quantitative estimation of cardiac autonomic activity (Task force report, 1996). According to Bernston et al 1997, HRV is being extensively used in investigations of central regulations of autonomic state and to study the link between psychological process and physiological functions.

There are several methods for the calculation of the HRV. According to the mathematical processing they can be divided into two classes, time domain and frequency domain methods. Time domain methods can be further divided into statistical methods and geometric methods. The frequency domain methods are divided into parametric and non-parametric methods.

5.3.2.2 Time domain analysis (Gujjar et al, 2004, Udupa et al, 2006):

| Time domain parameters | | | |
|-------------------------------|--------------|---|---|
| Parameters | Units | Description | Physiologic Correlates |
| SDNN | ms | Standard deviation of all NN intervals | Sensitive to all sources of variation, eg. Respiratory, baroreceptor, thermoregulation and activity. |
| SDANN | ms | Standard deviation of all NN intervals in all 5-minute segments of the entire recording | More sensitive to lowest frequencies, posture, activity and the basic day-night change in heart rate. This measure basically shows how much heart rate differs during each 5-minute period from |

| | | | |
|-------|-------|--|---|
| | | | the overall daylong mean heart rate. |
| RMSSD | ms | The square root of the mean of the sum of squares of differences between adjacent NN intervals | Both the RMSSD and pNN 50 indices are most sensitive to components. They select the changes that occurs from one QRS cycle to the very next. Some evidence suggests these time domains are the best predictors of parasympathetic activity. |
| NN50 | Count | Count of number of pairs of NN (Normal to normal RR) intervals differing by >50 ms | |
| pNN50 | % | NN50 divided by total number of all NN intervals | |
| TNN | ms | Triangular index of NN interval | Estimate overall HRV |

5.3.2.3 Frequency domain analysis: HRV is composed of certain well defined rhythms which contain information about the contribution of different regulatory mechanisms of cardiovascular control. To evaluate the dynamics of these rhythms and to understand how overall HRV is distributed into different rhythms, the variations of heart rate must be divided into frequency components. In order to provide deeper insight into the dynamics and components of HRV, more advanced second order statistics such as power spectral density analysis have to be applied. Power spectral analysis by definition, decomposes the heart rate signal into its frequency components and quantifies them in terms of their relative intensity, termed power. It provides estimates of the power spectrum density function of heart rate, i.e. information how overall HRV (variance of RR intervals or heart rates) is distributed as a function of frequency into different components. The heart rate spectrum can be analyzed with two methods; (1) Non-parametric Fast

Fourier transformation (FFT) spectra and (2) Parametric auto regressive (AR) modeling, directly to beat-to-beat time series or to ressembled data (Gujjar et al, 2004, Udupa et al, 2006).

| Frequency domain parameters | | | |
|------------------------------------|------------------|------------------------|---|
| Power | Units | Frequency range | Physiologic Correlates |
| Total power | ms ² | | Sensitive to all sources of variation |
| Low frequency power (LF) | ms ² | 0.04-0.15 Hz | Sympathetic and parasympathetic tone |
| Very low frequency power (VLF) | ms ² | 0.003-0.04 Hz | Thermoregulation? Rennin-angiotensin-aldosterone system (RAAS)? |
| High frequency power (HF) | ms ² | 0.15-0.4 Hz | Parasympathetic tone, Respiration |
| LF nu | Normalized units | LF/(LF+HF)*100 | Sympathetic and parasympathetic tone |

| | | | |
|-------|------------------|------------------|--------------------------------------|
| HF nu | Normalized units | $HF/(LF+HF)*100$ | Parasympathetic tone, Respiration |
| LF/HF | ratio | - | Sympathovagal balance |

5.3.3 RATIONALE FOR STUDYING SIX LETTER CANCELLATION TEST (SLCT)

Cancellation tests require visual selectivity and a repetitive motor response. A six letter cancellation test was administered to assess functions such as selective and focused attention, visual scanning, and the activation and inhibition of rapid responses. The six letter cancellation test has been used in similar type of design on Indian population (Natu & Agarawal, 1997). A sample worksheet of six letter cancellation test is given in **Appendix-6**.

5.3.3A Testing procedure

Thirty-five participants with age range between 20 and 45 years (M age \pm SD , 28.6 \pm 5.0) were assessed in four sessions (i.e., *Ekāgratā*, *Dhāraṇā*, *Dhyāna*, and *Cañcalatā*) each. A session consisted of 20 minutes of practice. The details have been given under intervention.

The assessments were made on four different days, not necessarily on consecutive days, but at the same time of the day (i.e., the self-as-control design). The allocation of the subjects to the four sessions was randomized using a standard random number table. This was

done to prevent the influence of being exposed to the laboratory for the first time, from influencing the results. Assessments were made immediately before and after each session.

5.3.3B Reliability and validity of the test

Reliability refers to the consistency of measurement which is reflected in the reproducibility of the scores. The six letter cancellation test has been evaluated for its reliability and validity based on standard criteria. Reliability is ascertained based on (i) temporal stability and (ii) internal consistency (Singh, 2002). Also have been established for use in an Indian population (Natu & Agarwal 1997; Agarwal, et al. 2002).

Validity concerns what the test measures and how well it does so. In the present study the six letter cancellation test is directly related to the attention of the person being examined. Cancellation tests require visual selectivity and a repetitive motor response. These tests assess many functions such as sustained attention, visual scanning, and the activation and inhibition of rapid responses (Lezak, 1995). Hence it may be said that the content validity of this test is adequate for the purpose for which it is intended.

5.3.3C Assessments

The six-letter cancellation task was presented on a worksheet which specified the six target letters to be cancelled and had a working section of letters of the alphabet arranged randomly in 22 columns and 14 rows. The participants were asked to cancel as many of the

six target letters as possible in the specified time of 90 seconds. They were told that there were two possible strategies, i.e., marking all six letters at a time or selecting any one target letter of the six. Participants were asked to choose whichever strategy suited them. They were also told that they could follow a horizontal, vertical, or a random path according to their choice (Natu & Agarwal, 1997).

The scoring was done by a person who was unaware when the assessment was made and whether the assessment was ‘before’ or ‘after’ the session. Each cancelled letter was scored as ‘1’ irrespective of whether it was correctly or incorrectly cancelled. The total number of cancellations and wrong cancellations were counted and the net scores were calculated by deducting wrong cancellations from the total cancellations attempted. As this test was administered before and immediately after the intervention, to avoid the test-retest effect of memory, parallel worksheets were prepared for each session by changing the target letters and the sequence of letters in the working section. The reliability and validity of the task have been established for use in an Indian population (Agarwal, et al. 2002).

5.4 INTERVENTIONS



Throughout all sessions subjects kept their eyes closed and followed prerecorded instructions. The instructions emphasized carrying out the practice slowly, with awareness and relaxation. The meditators who participated in the study underwent a month of orientation sessions where they practiced two phases which formed a continuum in meditation (*dhāraṇā* and *dhyāna*) as two separate states and two control states, i.e., *cañcalatā* or non-focused thinking and *ekāgratā* or focusing without meditation and on more than one thought.

These states are described in the traditional texts i.e., the *Patañjali's Yoga Sūtras* and *Bhagavad Gītā*, stating that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of 'streamlining the

thoughts' (concentration or *ekāgratā*), before moving on to the states of meditation. These are: one-pointed concentration or *dhāraṇā* and a defocused, effortless single thought state or *dhyāna*.

In the *cañcalatā* session the 20 minute period consisted of 'non-targeted thinking' during which subjects were asked to allow their thoughts to wander freely as they listened to a compiled audio CD consisting of brief periods of conversation and talks on multiple topics recorded from a local radio station transmission. In the *ekagrata* session the 20 minute period consisted of focusing on a single topic, which was listening to a lecture on meditation, with multiple, yet associated thoughts. In the *dhāraṇā* session the 20 minute period consisted of focusing on the symbol, 'OM'. During this session they were asked to focus on the meaning of the syllable, *OM*, which is used as a symbol for the entire universe because *OM* is considered to represent 'that which sustains everything' (Cinmayānanda 1984). In the *dhyāna* session the 20 minutes of the practice consisted of meditation with effortless absorption in the single-thought state of the object of meditation; i.e., 'OM'.

For the two meditation sessions and two control sessions, subjects were given guided instruction through a separate recorded video with specific images and instructions for each session: The quality of meditation was rated using the subjectivity rated Visual Analog Scale (VAS).

5.4.1 Visual analogue scale (VAS)

Visual analog scales were measured to test the qualitative subjective experiences like the quality of practice. A visual analog scale is a measurement scale that is used to measure a characteristic or attitude which is believed to range across a continuum of values and cannot easily be directly measured. It consists of a horizontal line, 10 cm in length, anchored by word descriptions at each end (Wewers & Lowe, 1990). A sample worksheet of visual analogue scale (VAS) is given in **Appendix-7**.

5.4.2 Testing procedure of VAS

The subjects were asked to mark the line at the point that they felt represented their perception of their current state. The VAS score was determined by measuring in millimeters from the left-hand end of the line to the point that the subject marked. There are no standard data available as this scale was used for the first time to understand these types of subjective experiences; however these types of scales are used in measurement of clinical phenomena like pain (Wewers & Lowe, 1990).

5.5 DATA EXTRACTION

5.5.1 BRAINSTEM AUDITORY EVOKED POTENTIAL (*BAEPs*)

For the BAEPs the peak latencies and peak amplitudes of all seven waves were calculated. Peak latency (msec) is defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window. Peak amplitude (μV) is defined as the voltage difference between a pre stimulus baseline and the largest positive going peak within a given latency window.

5.5.1.1 *Neural generators for BAEPs*

The latencies and the neural generators for the 5 BAEP components are given below:

| BAEPs components | Latency | Neural Generator |
|-------------------------|----------------|---|
| Wave I | 1.9 | Auditory portion of the eighth cranial nerve |
| Wave II | 3.6 | Near or at the cochlear nucleus A portion - from the eighth nerve fibers around the cochlear nucleus |
| Wave III | 4.2 | The lower pons through the superior olive and trapezoid body |
| Wave IV | 5.2 | The upper pons or lower midbrain, in the lateral lemniscus and the inferior colliculus; A contralateral brainstem generator for wave V is suggested |
| Wave V | 5.8 | |

A Schematic representation of BAEP responses (fig. 12) and a sketched auditory pathway (fig. 13) is presented in Appendix-10.

5.5.2 AUTONOMIC AND RESPIRATORY VARIABLES

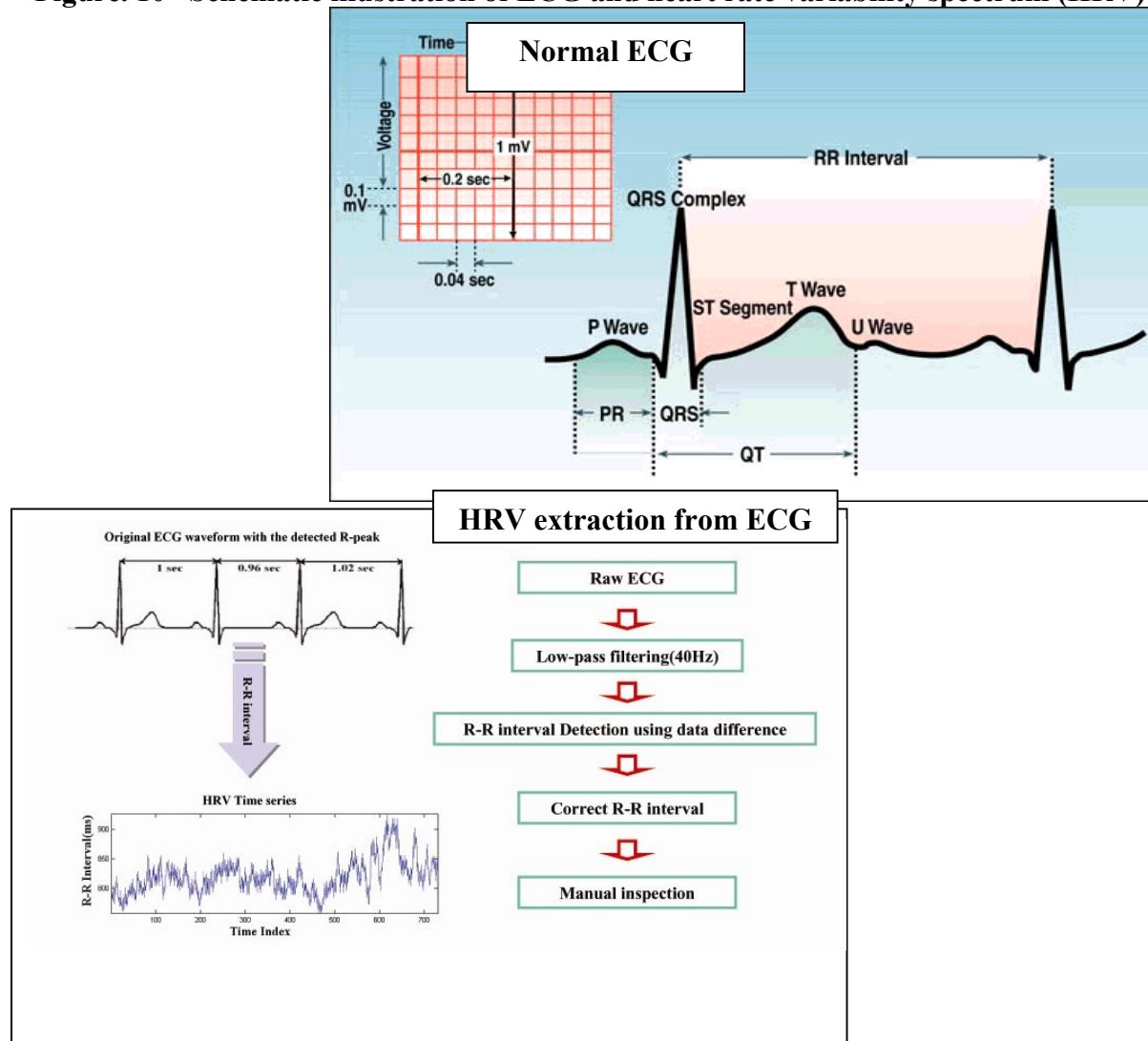
- (i) The Heart Rate [HR]: The heart rate in beats per minute (bpm) was calculated by counting the R waves of the QRS complex in the EKG in 60-second epochs, continuously. The data were continuously acquired throughout the recording session; hence it was divided into six phases of five minutes for analysis.
- (ii) The Galvanic Skin Resistance (GSR) was obtained at 20 sec intervals, continuously and expressed in Kilohms (K Ω).
- (iii) The breath rate in cycles per minute (cpm) was calculated by counting the breath cycles in 60 second epochs, continuously.
- (iv) The amplitude of the digit pulse volume (DPV) was sampled from the peak of the pulse wave at 30-second intervals and presented in μ V.

5.5.2.1 Heart rate variability

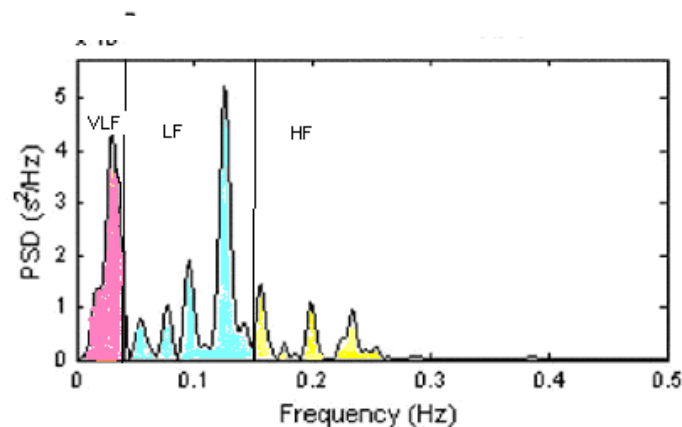
The data with small episodes of artifacts were shredded and were included for analysis. Data were analyzed with an ‘advanced HRV analysis software’ program developed by Biomedical Signal Analysis Group, University of Kuopio, Finland (Niskanen, Tarvainen, Ranta-aho, & Karjalainen, 2004). The heart rate in beats per minute was calculated by counting the R waves of QRS complex in the ECG in successive epochs of 60 seconds and averaged for each 5-minute block period. The HRV power spectrum was obtained using Fast Fourier Transform analysis (FFT). The energy in the HRV series of the following specific bands was studied, viz., the very low frequency component (0.0 - 0.04 Hz), low frequency component (0.05 - 0.15 Hz), and high frequency component (0.15 - 0.50 Hz). The low frequency and high frequency values were expressed as normalized units, which represent the relative of each power component in proportion to the total power minus VLF component [LF norm = LF / (total power-VLF) \times 100; HF norm = HF / (total

power – VLF) ×100)] (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, Heart Rate Variability: standards of measurement, physiological interpretation, and clinical use, 1996). **Figure.10** shows schematic illustration of ECG and heart rate variability spectrum (HRV) derived after Fast Fourier Transform analysis (FFT).

Figure. 10 Schematic illustration of ECG and heart rate variability spectrum (HRV)



Fast Fourier Transform analysis (FFT): HRV power spectrum
(VLF band = 0.0 - 0.05 Hz, LF band = 0.05 - 0.15 Hz and HF = 0.15 - 0.50 Hz)



5.5.3 SIX LETTER CANCELLATION TEST

The six-letter cancellation task was presented on a worksheet which specified the six target letters to be cancelled and had a working section of letters of the alphabet arranged randomly in 22 columns and 14 rows. The participants were asked to cancel as many of the six target letters as possible in the specified time of 90 seconds. They were told that there were two possible strategies, i.e., marking all six letters at a time or selecting any one target letter of the six. Participants were asked to choose whichever strategy suited them. They were also told that they could follow a horizontal, vertical, or a random path according to their choice (Natu & Agarwal, 1997).

The scoring was done by a person who was unaware when the assessment was made and whether the assessment was ‘before’ or ‘after’ the session. Each cancelled letter was scored as ‘1’ irrespective of whether it was correctly or incorrectly cancelled. The total

number of cancellations and wrong cancellations were counted and the net scores were calculated by deducting wrong cancellations from the total cancellations attempted. As this test was administered before and immediately after the intervention, to avoid the test-retest effect of memory, parallel worksheets were prepared for each session by changing the target letters and the sequence of letters in the working section. The reliability and validity of the task have been established for use in an Indian population (Agarwal, et al. 2002).

5.6 DATA ANALYSIS

5.6.1 BRAINSTEM AUDITORY EVOKED POTENTIALS

The raw data obtained for each subject in each recording session were tabulated separately. **Statistical analysis was done using SPSS (Version 10.0) in following steps:**

- The group mean and standard deviation were calculated of for all seven waves and data were tested for variance and normal distribution by F-test and Kolmogorov-Smirnov test respectively.
- For the normally distributed data, the peak latencies and peak amplitudes of all seven waves were analyzed using repeated-measures analyses of variance (ANOVAs), and *post-hoc* analyses with Bonferroni adjustment was to compare ‘pre’ data with ‘during’ and ‘post’.

- The repeated measures analyses of variance (ANOVAs) were performed with two ‘Within subjects’ factors, i.e., Factor 1: Sessions; with four levels, viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; with six levels, viz., Pre, During (D1 to D4), and Post. These repeated measures ANOVAs were carried out for the peak latency and peak amplitude of all levels.
- This was followed by a *post-hoc* analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre, During 1 to During 4 and Post).

5.6.2 AUTONOMIC AND RESPIRATORY VARIABLES

The raw data obtained for each subject in each recording session for each variable were tabulated separately. **Statistical analysis was done using SPSS (Version 10.0) in following steps:**

- The group mean and standard deviation were calculated for each variables and data were tested for variance and normal distribution by F-test and Kolmogorov-Smirnov test respectively.
- For the normally distributed data, of each variables were analyzed using repeated-measures analyses of variance (ANOVAs), and *post-hoc* analyses with Bonferroni adjustment was to compare ‘pre’ data with ‘during’ and ‘post’.

- The repeated measures analyses of variance (ANOVAs) were performed with two ‘Within subjects’ factors, i.e., Factor 1: Sessions; with four levels, viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; with six levels, viz., Pre, During (D1 to D4), and Post.
- This was followed by a *post-hoc* analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre, During 1 to During 4 and Post).

5.6.3 SIX LETTER CANCELLATION TEST

Statistical analysis was done using SPSS (Version 10.0). The total net scores were analyzed using a repeated-measures ANOVA. There was one Within-subjects factor, i.e., States with two levels (pre and post) and one Between-subjects factor, i.e., Groups, with four levels (*Cañcalatā*, *Ekāgratā*, *Dhāraṇā*, and *Dhyāna*). *Post-hoc* tests for multiple comparisons with Bonferroni adjustment were used to detect significance differences between mean values.

6.1 BRAINSTEM AUDITORY EVOKED POTENTIALS

6.1.1 RECAPITULATION

The BAEPs (peak latency and peak amplitude of all seven waves) were recorded pre during and post in 30 practitioners in four sessions i.e. *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* from Cz electrode sites, referenced to linked earlobes. As described under Methods (Data Analysis), repeated measures analysis of variance (RMANOVA) were performed with two ‘Within Subjects’ factors, i.e., Factor 1: Sessions; *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; Pre, During (D1 to D4), and Post. These RMANOVA were carried out for each wave of BAEP separately, for both peak latencies and peak amplitudes. This was followed by a Post-hoc analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre, During-D1 to D4 and Post). The results [latency and amplitude] for the individual waves [I-V] are given below.

The mean \pm SD with statistical significance for BAEPs are given below while **Summary Tables** and others are presented in **Appendix-4**.

The Graphs for the actual data of individual subject in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented in **Appendix-5**.

6.1.2 WAVE I – LATENCY

RMANOVA which consisted of the two Within-Subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between States ($F=2.898$, $p=0.037$, Huynh-Feldt epsilon=0.634), while the difference between Sessions ($F=1.093$, $p>0.05$, Huynh-Feldt epsilon=0.855), and the interaction between Sessions and States ($F=0.717$, $p>0.05$, Huynh-Feldt epsilon=0.372) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between States [Pre, During (D1 to D4) and Post] for each session ($p>0.05$, for all comparisons). The actual data of individual subjects in the Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table**

6.1.2.

6.1.3 WAVE I – AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.556$, $p>0.05$, Huynh-Feldt epsilon=0.834) and States ($F=0.150$, $p>0.05$, Huynh-Feldt epsilon=1.000, hence sphericity assumed). Also, the interaction between Sessions and States ($F=0.435$, $p>0.05$, Huynh-Feldt epsilon=0.595) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between States [Pre, During (D1 to D4) and Post] for each session ($p > 0.05$, for all comparisons). The actual data of individual subject in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table**

6.1.3. In Appendix-4.

6.1.4 WAVE II – LATENCY

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between the States ($F=4.811$, $p < 0.01$, Huynh-Feldt epsilon=0.515), while the difference between the Sessions ($F=0.707$, $p > 0.05$, Huynh-Feldt epsilon=0.730) and the interaction between the Sessions and States ($F=0.831$, $p > 0.05$, Huynh-Feldt epsilon=0.210) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed a significant increase in the latency of Wave II during the *ekāgratā* session when comparing the During 3 and During 4 epochs with the Pre values ($p=0.007$ and $p=.002$ respectively). The comparison of states [Pre, During (D1 to D4) and Post] during other sessions

(*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) showed no change ($p>0.05$, for all comparisons). The actual data of individual subject in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.1.4**.

Table 6.1.4.

Group Mean \pm SD values of Peak Latencies for Wave II recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|-----------------|-----------------|-----------------|------------------|------------------|-----------------|
| <i>Cañcalatā</i> | 2.94 \pm 0.21 | 3.01 \pm 0.15 | 3.00 \pm 0.14 | 2.99 \pm 0.13 | 3.01 \pm 0.14 | 2.99 \pm 0.13 |
| % Change | | 2.38 | 2.04 | 1.7 | 2.38 | 1.7 |
| <i>Ekāgratā</i> | 2.96 \pm 0.14 | 3.00 \pm 0.16 | 2.98 \pm 0.11 | 3.01 \pm 0.14* | 3.01 \pm 0.13* | 2.99 \pm 0.12 |
| % Change | | 1.35 | 0.68 | 1.69 | 1.69 | 1.01 |
| <i>Dhāraṇā</i> | 2.95 \pm 0.15 | 2.99 \pm 0.15 | 2.97 \pm 0.14 | 2.98 \pm 0.15 | 2.98 \pm 0.13 | 2.98 \pm 0.15 |
| % Change | | 1.36 | 0.68 | 1.02 | 1.02 | 1.02 |
| <i>Dhyāna</i> | 2.96 \pm 0.13 | 2.98 \pm 0.14 | 3.00 \pm 0.14 | 2.99 \pm 0.13 | 3.00 \pm 0.14 | 2.96 \pm 0.19 |
| % Change | | 0.68 | 1.35 | 1.01 | 1.35 | 0 |

* $p < 0.05$, RMANOVA with Bonferroni adjustment. Comparing individual states. (i.e. D1,D2,D3,D4, and Post). While there was an increase of 1.7% to 2.38% in *Cañcalatā*, *Ekāgratā* showed 0.68% to 1.69%, *Dhāraṇā* showed 0.68% to 1.36%, *Dhyāna* showed 0% to 1.35%

6.1.5 WAVE II – AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.240$, $p>0.05$, Huynh-Feldt epsilon=1.000, hence sphericity assumed) and States ($F=0.537$, $p>0.05$, Huynh-Feldt epsilon=0.932). Also, the interaction between the Sessions and States ($F=1.237$, $p>0.05$, Huynh-Feldt epsilon=0.919) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between states [Pre, During (D1 to D4) and Post] of each session ($p>0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table**

6.1.5. in the Appendix-4.

6.1.6. WAVE III – LATENCY

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between Sessions ($F=3.900$, $p=0.013$, Huynh-Feldt epsilon=0.962) and between States ($F=3.094$, $p=0.024$, Huynh-Feldt epsilon=0.691). The interaction between Sessions and States ($F=0.981$, $p>0.05$, Huynh-Feldt epsilon=0.223) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed a significant increase in the latency of Wave III during the *ekāgratā* session (Pre versus During 2; $p=0.03$). The comparisons during other Sessions (*cañcalatā*, *dhāraṇā* and *dhyāna*) showed no change ($p>0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean \pm SD in **Table 6.1.6**.

Table 6.1.6.

Group Mean \pm SD values of Peak Latencies for Wave III recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| <i>Cañcalatā</i> | 3.90 \pm 0.19 | 3.95 \pm 0.16 | 3.94 \pm 0.16 | 3.95 \pm 0.14 | 3.96 \pm 0.15 | 3.95 \pm 0.14 |
| % Change | | 1.28 | 1.03 | 1.28 | 1.54 | 1.28 |
| <i>Ekāgratā</i> | 3.93 \pm 0.14 | 3.97 \pm 0.17 | 3.97 \pm 0.13* | 3.96 \pm 0.14 | 3.96 \pm 0.15 | 3.96 \pm 0.14 |

| | | | | | | |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|
| % Change | | 1.02 | 1.02 | 0.76 | 0.76 | 0.76 |
| <i>Dhāraṇā</i> | 3.91±0.15 | 3.91±0.16 | 3.93±0.15 | 3.95±0.16 | 3.93±0.13 | 3.93±0.15 |
| % Change | | 0 | 0.51 | 1.02 | 0.51 | 0.51 |
| <i>Dhyāna</i> | 3.92±0.14 | 3.91±0.16 | 3.93±0.13 | 3.95±0.14 | 3.94±0.13 | 3.91±0.18 |
| % Change | | -0.26 | 0.26 | 0.77 | 0.51 | -0.26 |

* $p < 0.05$, RMANOVA with Bonferroni adjustment. Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was an increase of 1.03% to 1.54% in *Cañcalatā*, *Ekāgratā* showed 0.76% to 1.02%, *Dhāraṇā* showed decrease of 0% to 1.02%, *Dhyāna* showed 0.26% to 0.77% in Peak Latencies for Wave III.

6.1.7. WAVE III – AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.307$, $p>0.05$, Huynh-Feldt epsilon=1.000, hence sphericity assumed) and States ($F=0.912$, $p>0.05$, Huynh-Feldt epsilon=0.957). Also, the interaction between Sessions and States ($F=1.052$, $p>0.05$, Huynh-Feldt epsilon=0.981) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between states [Pre, During (D1 to D4) and Post] of each session ($p > 0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.1.7. in the Appendix-4.**

6.1.8. WAVE IV – LATENCY

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between States ($F=5.864$, $p < 0.001$, Huynh-Feldt epsilon=0.845) while the difference between Sessions ($F=0.669$, $p > 0.05$, Huynh-Feldt epsilon=0.953) and the interaction between Sessions and States ($F=0.824$, $p > 0.05$, Huynh-Feldt epsilon=0.476) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between States [Pre, During (D1 to D4) and Post] of each session ($p > 0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean \pm SD in **Table 6.1.8. in the Appendix-4.**

6.1.9. WAVE IV – AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.886$, $p>0.05$, Huynh-Feldt epsilon=0.977) and between States ($F=1.785$, $p>0.05$, Huynh-Feldt epsilon=0.831). Also, the interaction between Sessions and States ($F=1.109$, $p>0.05$, Huynh-Feldt epsilon=0.987) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed no significant difference between states [Pre, During (D1 to D4) and Post] for each session ($p>0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.1.9. in the Appendix-4.**

6.1.10. WAVE V – LATENCY

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between Sessions ($F=3.894$, $p=0.015$, Huynh-Feldt epsilon=0.893), and between States ($F=11.713$, $p<0.001$, Huynh-Feldt epsilon=0.836) while the interaction between Sessions and States ($F=1.350$, $p>0.05$, Huynh-Feldt epsilon=0.459) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed a significant increase in the latency of Wave V during the *cañcalatā* session (Pre versus During 2; $p=0.042$), *ekāgratā* session [Pre versus During 2 ($p=0.009$), Pre versus During 3 ($p=0.026$), Pre versus During 4 ($p=0.005$) and Pre versus Post ($p=0.001$)] and during *dhāraṇā* session (Pre versus Post; $p=0.018$). Other comparisons during the sessions mentioned above and all the comparisons during the *dhyāna* session were not significant ($p>0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.1.10**.

Table 6.1.10.

Group Mean \pm SD values of Peak Latencies for Wave V recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|-----------------|-----------------|-------------------|------------------|-------------------|--------------------|
| <i>Cañcalatā</i> | 5.78 \pm 0.18 | 5.82 \pm 0.18 | 5.84 \pm 0.17** | 5.84 \pm 0.20 | 5.84 \pm 0.18 | 5.82 \pm 0.17 |
| % Change | | 0.69 | 1.04 | 1.04 | 1.04 | 0.69 |
| <i>Ekāgratā</i> | 5.76 \pm 0.19 | 5.83 \pm 0.18 | 5.83 \pm 0.18** | 5.83 \pm 0.17* | 5.87 \pm 0.19** | 5.85 \pm 0.18*** |
| % Change | | 1.22 | 1.22 | 1.22 | 1.91 | 1.56 |
| <i>Dhāraṇā</i> | 5.75 \pm 0.20 | 5.80 \pm 0.19 | 5.80 \pm 0.19 | 5.78 \pm 0.21 | 5.80 \pm 0.21 | 5.82 \pm 0.18** |
| % Change | | 0.87 | 0.87 | 0.82 | 0.87 | 1.22 |
| <i>Dhyāna</i> | 5.79 \pm 0.18 | 5.81 \pm 0.19 | 5.82 \pm 0.19 | 5.81 \pm 0.18 | 5.81 \pm 0.20 | 5.82 \pm 0.18 |
| % Change | | 0.35 | 0.52 | 0.35 | 0.35 | 0.52 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). While there was an increase of 0.69% to 1.04% in *Cañcalatā*, *Ekāgratā* showed 1.54% to 1.22%, *Dhāraṇā* showed 0.82% to 1.22%, *Dhyāna* showed 0.35% to 0.52% in Peak Latencies for Wave V.

6.1.11. WAVE V – AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between Sessions ($F=6.515$, $p<0.001$, Huynh-Feldt epsilon=0.897), and

between States ($F=8.574$, $p<0.001$, Huynh-Feldt epsilon=0.858) while the interaction between Sessions and States ($F=1.320$, $p>0.05$, Huynh-Feldt epsilon=0.825) was not significant.

Post-hoc analysis with Bonferroni adjustment for each session (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) separately showed a significant decrease in the amplitude of Wave V during the *cañcalatā* session [Post versus During 1 ($p<0.001$), Post versus During 2 ($p<0.01$) and Post versus During 3 ($p<0.001$), *ekāgratā* session [Post versus During 1 ($p<0.05$), Post versus During 2 ($p<0.05$). Other comparisons during the sessions mentioned above and all the comparisons during *dhāraṇā* and *dhyāna* sessions were not significant ($p>0.05$, for all comparisons). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.1.11. in the Appendix-4.**

6.1.12. WAVE VI & VII – LATENCY AND AMPLITUDE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] did not show any significant difference between Sessions and between States of wave VI, VII in latency and amplitude.

The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Tables 6.1.12. 2, 3 & 4 respectively In the Appendix-4.**

6.1.13. FOUR ADDITIONAL DERIVED VALUES

In addition to the absolute values of the peak latency and peak amplitude there are four other, derived values which are used to get information about brainstem functioning. These are as follows: (i) Wave V to Wave I inter-peak latency interval. The wave V-I inter-peak latency interval is considered to represent conduction from the proximal part of the eighth nerve through pons and into the midbrain. (ii) Wave III to Wave I inter-peak latency interval. This inter-peak latency interval represents conduction from the eighth nerve into the core of the lower pons. (iii) Wave V to Wave III inter-peak latency interval. This latency interval reflects conduction from the lower to the upper pons, and possibly into the mid brain. It is not yet entirely clear whether the wave V-III inter-peak latency interval represents conduction along the ipsilateral or contralateral brainstem, in case the auditory stimulation was monaural. However, there is greater evidence to support a contralateral brainstem site. (iv) Wave V/ Wave I peak amplitude ratio.

It is well recognized that absolute amplitudes of BAEP peaks vary widely among normal individuals. In addition, several technical factors influence the absolute amplitudes of the BAEP peaks. Hence comparison of the absolute amplitudes across individuals, or even across the sessions of an individual cannot be considered to be meaningful. For this reason in the present project

the wave V/ wave I peak amplitude ratio was assessed. The wave V to wave I peak amplitude ratio gives an indication of the proportion of neurons recruited centrally and in the periphery. These derived, inter-peak data are also presented in the **Appendix-4**.

The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) for the above mentioned derived variables are presented with group mean values \pm SD are given in **Tables 6.1.13. in the Appendix-4**.

6.2. AUTONOMIC AND RESPIRATORY VARIABLES

6.2.1. RECAPITULATION

Autonomic and respiratory variables were recorded in 30 practitioners in four sessions i.e. *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. RMANOVA were performed with two ‘Within subjects’ factors, i.e., Factor 1: Sessions; *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; Pre, During (D1 to D4), and Post. These RMANOVA were carried out for each variable separately. This was followed by a Post-hoc analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre, During 1 to During 4 and Post). The mean \pm SD with statistical significance of autonomic & respiratory variables for all the sessions are given below in the result sections as **Summary Tables**.

The actual data of individual subject in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) for the individual variables i.e., heart rate [HR], respiration rate [RR], finger plethysmogram [PLT] and galvanic skin resistance {GSR}, as well as the individual variables of

frequency domain analysis of heart rate variability i.e., low frequency [LF], high frequency [HF] and low frequency and high frequency ratio [LF/HF], the individual variables of time domain analysis of heart rate variability i.e., mean RR, mean HR, NN50, pNN50, and RMSSD are presented with group mean values \pm SD in different tables.

The Graphs for the actual data of individual subject in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) for the all individual variables i.e., heart rate [HR], respiration rate [RR], finger plethysmogram [PLT] and galvanic skin resistance {GSR}, as well as the individual variables of frequency domain analysis of heart rate variability i.e., low frequency [LF], high frequency [HF] and low frequency and high frequency ratio [LF/HF], the individual variables of time domain analysis of heart rate variability i.e., mean RR, mean HR, NN50, pNN50, and RMSSD are presented with group mean values \pm SD in the **Appendix-5**.

6.2.2 RESPIRATORY RATE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between Sessions ($F=15.32$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.986$), and between States ($F=4.12$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.759$). Also significant interaction between Sessions and States ($F=5.75$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.323$) was observed.

Post-hoc analysis with Bonferroni adjustment for *cañcalatā* session showed a significant increase in the respiratory rate in sessions (Pre versus During 1, During 3 and During 4; $p < 0.05$), *dhāraṇā* session (Pre versus Post; $p < 0.05$). But in session *dhyāna* there was significant decrease in respiratory rate (Pre versus During 1; $p < 0.01$, During 2, During 3, During 4 and Post; $p < 0.001$ respectively). The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.2**.

Table 6.2.2.
Group mean values \pm S.D of the respiratory rate (in bpm) reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|------------|--------------|---------------|---------------|---------------|---------------|
| <i>Cañcalatā</i> | 14 \pm 3 | 16 \pm 3* | 17 \pm 6 | 16 \pm 2* | 16 \pm 2* | 15 \pm 2 |
| % Change | | 8.41 | 15.56 | 10.56 | 9.63 | 2.69 |
| <i>Ekāgratā</i> | 15 \pm 3 | 16 \pm 3 | 16 \pm 2 | 16 \pm 2 | 16 \pm 2 | 15 \pm 3 |
| % Change | | 3.39 | 1.99 | 2.87 | 2.59 | -3.50 |
| <i>Dhāraṇā</i> | 15 \pm 2 | 15 \pm 3 | 14 \pm 3 | 14 \pm 3 | 14 \pm 5 | 14 \pm 3* |
| % Change | | -1.51 | -3.71 | -5.96 | -4.33 | -8.33 |
| <i>Dhyāna</i> | 16 \pm 3 | 14 \pm 3** | 13 \pm 2*** | 12 \pm 3*** | 13 \pm 3*** | 13 \pm 3*** |
| % Change | | -8.86 | -15.50 | -19.59 | -18.58 | -14.29 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was an increase of 2.69% to 15.56% in *Cañcalatā*, *Ekāgratā* showed 1.99% to 3.39%, *Dhāraṇā* showed decrease of 1.51% to 8.33%, *Dhyāna* showed decrease of 8.86% to 19.59% in respiratory rate.

6.2.3 DIGIT PULSE VOLUME

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=1.11$, $p=0.35$, Huynh-Feldt epsilon $\epsilon=1.0$), but significant change was observed between States ($F=4.22$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.427$). No significant interaction between Sessions and States ($F=1.52$, $p=0.22$, Huynh-Feldt epsilon $\epsilon=0.144$) was observed.

Post-hoc analysis with Bonferroni adjustment for *cañcalatā* session showed a significant increase in the digit pulse volume in *dhyāna* session (Pre versus During 1; $p<0.05$). No significant changes were observed in other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.3**.

Table 6.2.3

Group mean values \pm S.D. of the digit pulse volume (in μ volts) recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|--------------------|---------------------|--------------------|--------------------|--------------------|--------------------|
| <i>Cañcalatā</i> | 2496 \pm 1636 | 2182 \pm 1399 | 2275 \pm 1503 | 2124 \pm 1609 | 2181 \pm 1867 | 2355 \pm 1827 |
| % Change | | -12.56 | -8.84 | -14.90 | -12.61 | -5.62 |
| <i>Ekāgratā</i> | 2623 \pm 1303 | 2543 \pm 1290 | 2424 \pm 1348 | 2277 \pm 1323 | 2280 \pm 1377 | 2280 \pm 1263 |
| % Change | | -3.04 | -7.60 | -13.20 | -13.07 | -13.07 |
| <i>Dhāraṇā</i> | 2350 \pm 1542 | 2586 \pm 1852 | 2422 \pm 1699 | 2235 \pm 1317 | 2231 \pm 1175 | 2184 \pm 1299 |
| % Change | | 10.06 | 3.05 | -4.89 | -5.07 | -7.06 |
| <i>Dhyāna</i> | 2548 \pm 1301 | 2860 \pm 1490* | 2887 \pm 1402 | 2766 \pm 1362 | 2738 \pm 1395 | 2605 \pm 1333 |
| % Change | | 12.26 | 13.31 | 8.57 | 7.48 | 2.28 |

* $p < 0.05$, RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post).

Minus sign indicate a decrease with respect pre data. While there was an decrease of 5.62% to 14.90% in *Cañcalatā*, *Ekāgratā* showed decrease of 3.04% to 13.20%, *Dhāraṇā* showed increase 3.05% to 10.06%, *Dhyāna* showed increase 2.28% to 12.26% digit pulse volume.

6.2.4 GALVANIC SKIN RESISTANCE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.99$, $p=0.40$, Huynh-Feldt epsilon $\epsilon=0.957$), while significant changes were observed between States ($F=18.56$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.535$). No significant interaction between Sessions and States ($F=1.05$, $p=0.39$, Huynh-Feldt epsilon $\epsilon=0.584$) was noticed.

Post-hoc analysis with Bonferroni adjustment for *cañcalatā* session showed a significant increase in the galvanic skin resistance in *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* sessions [(*cañcalatā* : Pre versus During 2; $p<0.05$), (*ekāgratā*: Pre versus During 1; $p<0.05$, During 2; $p<0.01$, During 3; $p<0.05$, During 4; $p<0.05$, and Post $p<0.05$) (*dhāraṇā*: Pre versus During 1; $p<0.05$, During 2; $p<0.05$, During 3; $p<0.05$, and During 4; $p<0.05$) and (*dhyāna*: Pre versus During 1; $p<0.01$, During 2, During 3, During 4, and Post; $p<0.001$ respectively)]. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.4**.

Table 6.2.4.

Group mean values \pm S.D. of the galvanic skin resistance (in K Ω) recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|------------------------|---------------------------|-----------------------|-----------------------|-----------------------|
| <i>Cañcalatā</i> | 429.9 ± 127.7 | 461.4 $\pm 137.2^*$ | 462.8 $\pm 113.7^*$ | 461.5 ± 111.8 | 474.1 ± 116.1 | 468.3 ± 109.7 |
| % Change | | 7.32 | 7.64 | 7.34 | 10.28 | 8.94 |
| <i>Ekāgratā</i> | 439.7 ± 141.3 | 472.3 $\pm 139.1^*$ | 486.6 $\pm 134.4^{**}$ | 489.1 $\pm 40.5^*$ | 491.0 $\pm 31.4^*$ | 489.2 $\pm 29.1^*$ |

| | | | | | | |
|----------------|------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| % Change | | 7.43 | 10.67 | 11.25 | 11.68 | 11.28 |
| <i>Dhāraṇā</i> | 429.1 ± 129.1 | 451.5 ± 125.5* | 460.1 ± 31.4* | 465.7 ± 127.9* | 477.9 ± 148.3* | 463.1 ± 125.9 |
| % Change | | 5.20 | 7.23 | 8.52 | 11.36 | 7.91 |
| <i>Dhyāna</i> | 434.9 ± 132.0 | 472.3 ± 122.5** | 495.0 ± 116.6*** | 505.8 ± 122.4*** | 509.0 ± 137.6*** | 497.3 ± 113.4*** |
| % Change | | 8.60 | 13.81 | 16.31 | 17.03 | 14.34 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post).. While there was an increase of 7.3% to 10.28% in *Cañcalatā*, *Ekāgratā* showed 7.43% to 11.36%, *Dhāraṇā* showed 5.20% to 11.36%, *Dhyāna* showed 8.60% to 17.03%.

6.2.5 HEART RATE

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed a significant difference between Sessions ($F=4.05$, $p<0.01$, Huynh-Feldt epsilon $\epsilon=0.930$), and

between States ($F=8.54$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.631$). Significant interaction between Sessions and States ($F=0.56$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.685$) was also observed.

Post-hoc analysis with Bonferroni adjustment for *cañcalatā* session showed a significant decrease in the heart rate in sessions (Pre versus During 1; $p<0.05$, During 2; $p<0.001$, During 3; $p<0.01$, During 4; $p<0.01$ and Post; $p<0.05$). No significant changes were observed in other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.5**.

Table 6.2.5.

Group mean values \pm S.D. of the heart rate (in BPM) recorded pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|-------------|-------------|----------------|--------------|--------------|-------------|
| <i>Cañcalatā</i> | 69 \pm 10 | 70 \pm 11 | 69 \pm 11 | 71 \pm 11 | 71 \pm 11 | 68 \pm 10 |
| % Change | | 0.90 | 0.41 | 2.43 | 2.47 | -0.88 |
| <i>Ekāgratā</i> | 70 \pm 10 | 70 \pm 10 | 68 \pm 11 | 68 \pm 10 | 69 \pm 11 | 69 \pm 11 |
| % Change | | -0.14 | -2.69 | -2.71 | -1.30 | -2.21 |
| <i>Dhāraṇā</i> | 70 \pm 11 | 68 \pm 12 | 68 \pm 12 | 68 \pm 12 | 68 \pm 11 | 68 \pm 11 |
| % Change | | -2.64 | -3.87 | -3.89 | -3.61 | -2.93 |
| <i>Dhyāna</i> | 69 \pm 9 | 66 \pm 9* | 65 \pm 10*** | 64 \pm 9** | 64 \pm 9** | 66 \pm 8* |
| % Change | | -5.40 | -6.59 | -7.73 | -7.18 | -4.93 |

*p < 0.05, **p < 0.01, ***p < 0.001; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was an decrease of 0.41% to 2.47% in *Cañcalatā*, *Ekāgratā* showed 0.14% to 2.71%, *Dhāraṇā* showed 2.64% to 3.89%, *Dhyāna* showed 4.93% to 7.73% in heart rate.

6.2.6 HEART RATE VARIABILITY (HRV)

The heart has extensive innervation from the parasympathetic and sympathetic limbs of the ANS and is responsible for the rapid regulation of the cardiac rhythm and pumping action in order to match the cardiac output with the body needs during various environmental stimuli of daily life viz, physical, mental stress, posture changes etc. Sino-atrial node and the atrio-ventricular node receive both parasympathetic and sympathetic efferent innervation whereas the ventricles are supplied only by the sympathetic division. The efficient way to demonstrate the effects of autonomic modulation of the heart is to monitor the function of the sino atrial node, which is represented by changes in the heart rate. Increased efferent vagal activity reduces the heart rate and increases the heart rate variability whereas increased sympathetic activity increases the heart rate and reduces the heart rate variability. Heart rate fluctuations therefore, are reflective of neurocardiac regulation and form the basis of assessment of HRV.

6.2.6A Low frequency (in normalized units)

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions ($F=11.39$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.978$), and between States ($F=2.52$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.895$). Also there was significant interaction between Sessions and States ($F=5.73$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.898$) was observed.

Post-hoc analysis with Bonferroni adjustment for *cañcalatā* session showed a significant increase in low frequency in *cañcalatā* and *ekāgratā* sessions [(*cañcalatā*: Pre versus During 1; $p < 0.05$, During 2; $p < 0.05$, During 3; $p < 0.01$ and Post; $p < 0.05$), (*ekāgratā*: Pre versus During 1, During 2, During 4, and Post; $p < 0.05$ respectively)]. But there was significant decrease in low frequency in *dhyāna* session (Pre versus During 1; $p < 0.001$, During 2; $p < 0.05$, During 3; $p < 0.05$, During 4; $p < 0.001$, and Post; $p < 0.05$). No significant change was observed in *dhāraṇā* session. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6A**.

Table 6.2.6A

Group mean values \pm S.D of the LF reordered before, during and after, during two phases of meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|-----------------------|-----------------------|------------------------|-----------------------|-----------------------|
| <i>Cañcalatā</i> | 52.83 \pm 18.64 | 61.24 \pm 16.05* | 62.33 \pm 17.55* | 64.81 \pm 17.38** | 62.53 \pm 17.66 | 62.11 \pm 18.82* |
| % Change | | 15.93 | 17.98 | 22.67 | 18.37 | 17.57 |
| <i>Ekāgratā</i> | 54.90 \pm 15.98 | 63.56 \pm 18.00* | 62.16 \pm 16.57* | 62.52 \pm 16.52 | 63.22 \pm 17.06* | 63.15 \pm 17.26* |
| % Change | | 15.78 | 13.22 | 13.87 | 15.15 | 15.03 |
| <i>Dhāraṇā</i> | 59.45 \pm 15.56 | 55.97 \pm 19.79 | 59.22 \pm 17.69 | 59.64 \pm 17.24 | 53.74 \pm 17.23 | 58.54 \pm 15.43 |

| | | | | | | | |
|---------------|------------------|--------------------|-------------------|-------------------|---------------------|-------------------|--------------|
| % Change | | -7.54 | -0.37 | 0.31 | -9.60 | -1.53 | |
| <i>Dhyāna</i> | 60.42 ± 15.57 | 46.20 ±20.16*** | 51.10 ± 19.55* | 50.46 ± 16.39* | 44.86 ± 13.07*** | 49.50 ± 17.07* | 0.01, ***p < |
| % Change | | -23.53 | -15.42 | -16.48 | -25.75 | -18.06 | RMANOVA with |

*p < 0.05, **p < 0.001;

Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was an increase of 15.95% to 22.67% in *Cañcalatā*, *Ekāgratā* showed 13.22% to 15.78%, *Dhāraṇā* showed decreased of 0.31% to 9.60%, *Dhyāna* showed decrease of 15.42% to 25.53% in LF.

6.2.6B High frequency (in normalized units)

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions (F=8.03, p<0.001, Huynh-Feldt epsilon ϵ =0.908) whereas no significant change was observed between States (F=1.14, p=0.33, Huynh-Feldt epsilon ϵ =0.593), while there was a significant interaction between Sessions and States (F=3.79, p<0.01, Huynh-Feldt epsilon ϵ =0.284) was observed.

Post-hoc analysis with Bonferroni adjustment showed a significant decrease in high frequency in *ekāgratā* session (Pre versus During 1; p<0.05, During 2; p<0.05, During 4; p<0.05 and Post; p<0.05), while there was significant increase in high frequency in *dhyāna* session (Pre versus During 1; p<0.001, During 2; p<0.05, During 3; p<0.05, During 4; p<0.001, and Post; p<0.05). But there

was no significant changes observed in *cañcalatā* and *dhāraṇā* sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6B**.

Table 6.2.6B

Group mean values \pm S.D of the HF reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|-------------------------|-----------------------|-----------------------|--------------------------|-----------------------|
| <i>Cañcalatā</i> | 46.43 \pm 19.45 | 38.75 \pm 16.05 | 37.67 \pm 17.55 | 35.21 \pm 17.35 | 37.40 \pm 17.57 | 37.89 \pm 18.82 |
| % Change | | -16.55 | -18.87 | -24.16 | -19.45 | -18.39 |
| <i>Ekāgratā</i> | 45.11 \pm 15.99 | 36.44 \pm 18* | 37.82 \pm 16.58* | 37.48 \pm 16.52 | 36.76 \pm 17.03* | 36.85 \pm 17.26* |
| % Change | | -19.23 | -16.15 | -16.19 | -18.5 | -18.31 |
| <i>Dhāraṇā</i> | 40.55 \pm 15.56 | 45.03 \pm 19.79 | 40.77 \pm 17.69 | 40.36 \pm 17.24 | 47.25 \pm 17.43 | 41.46 \pm 15.43 |
| % Change | | 11.05 | 0.54 | -0.46 | 16.51 | 2.24 |
| <i>Dhyāna</i> | 39.58 \pm 15.57 | 53.80 \pm 20.15*** | 48.90 \pm 19.54* | 49.53 \pm 16.40* | 54.53 \pm 13.57 *** | 50.50 \pm 17.07* |

| | | | | | | |
|----------|--|-------|-------|-------|-------|-------|
| % Change | | 35.92 | 23.55 | 25.12 | 37.76 | 27.57 |
|----------|--|-------|-------|-------|-------|-------|

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was a decrease of 18.39% to 24.16% in *Cañcalatā*, *Ekāgratā* showed 16.15% to 19.23%, *Dhāraṇā* showed 0.46% to 16.51%, *Dhyāna* showed 23.55% to 37.76% in HF.

6.2.6C Low frequency and high frequency ratio

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions ($F=5.55$, $p<0.01$, Huynh-Feldt epsilon $\epsilon=0.618$) whereas no significant change was observed between States ($F=1.64$, $p=0.18$, Huynh-Feldt epsilon $\epsilon=0.661$). Also no significant interaction between Sessions and States ($F=1.85$, $p=0.12$, Huynh-Feldt epsilon $\epsilon=0.286$) was observed.

Post-hoc analysis with Bonferroni adjustment showed a significant increase in low and frequency ratio as well as in *ekāgratā* session (Pre versus During 1; $p<0.05$, During 2; $p<0.05$, During 4; $p<0.05$ and Post; $p<0.05$). No significant changes were noticed in other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6C**.

Table 6.2.6C

Group mean values \pm S.D of the LF/HF reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|---------------|----------------|-----------------|----------------|-----------------|----------------|
| <i>Cañcalatā</i> | 1.85 ±2.03 | 2.81 ± 4.66 | 3.19 ± 4.79 | 3.18 ± 3.34 | 2.91 ± 3.98 | 2.98 ± 3.52 |
| % Change | | 51.72 | 71.95 | 71.43 | 56.75 | 60.79 |
| <i>Ekāgratā</i> | 1.65 ±1.45 | 3.04 ±3.37* | 2.36 ± 2.03* | 2.34 ± 1.78 | 2.51 ± 1.92* | 2.79 ±2.73* |
| % Change | | 83.67 | 43.02 | 41.44 | 51.60 | 68.73 |
| <i>Dhāraṇā</i> | 1.86 ±1.19 | 1.96 ± 2.03 | 2.05 ± 1.75 | 2.15 ± 1.87 | 1.66 ± 1.65 | 1.96 ± 1.75 |
| % Change | | 5.06 | 10.21 | 15.25 | -11.01 | 5.11 |
| <i>Dhyāna</i> | 2.30 ±2.52 | 1.62 ± 3.03 | 1.53 ± 1.42 | 1.35 ± 1.17 | 0.98 ± 0.73 | 1.31 ± 1.11 |
| % Change | | -29.66 | -33.46 | -41.22 | -57.22 | -42.93 |

* $p < 0.05$, RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post).

Minus sign indicate a decrease with respect pre data. While there was an increase of 51.72% to 71.95% in *Cañcalatā*, *Ekāgratā* showed increase of 41.44% to 83.67%, *Dhāraṇā* showed decrease of 5.06% to 11.01%, *Dhyāna* showed 29.66% to 57.22% in LF/HF.

6.2.6D Mean RR

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=0.47$, $p=0.68$, Huynh-Feldt epsilon $\epsilon=0.880$)

whereas a significant change was observed between States ($F=2.75$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.695$), while significant interaction between Sessions and States ($F=2.07$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.319$) was observed.

Post-hoc analysis with Bonferroni adjustment for *ekāgratā* session showed a significant increase in mean RR (Pre versus During 2; $p<0.05$, During 3; $p<0.05$, and During 4; $p<0.05$), while there was no significant change in mean RR in other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in

Table 7.2.6.4.

Table 6.2.6D.

Group mean values \pm S.D of the Mean RR reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|--------------------|--------------------|---------------------|----------------------|---------------------|--------------------|
| <i>Cañcalatā</i> | 0.90 \pm 0.13 | 0.89 \pm 0.13 | 0.89 \pm 0.13 | 0.89 \pm 0.13 | 0.87 \pm 0.12 | 0.90 \pm 0.13 |
| % Change | | -0.27 | -0.35 | -1.04 | -2.93 | 0.46 |
| <i>Ekāgratā</i> | 0.88 \pm 0.11 | 0.85 \pm 0.19 | 0.91 \pm 0.12* | 0.92 \pm 0.12** | 0.91 \pm 0.12* | 0.90 \pm 0.12 |

| | | | | | | |
|----------------|----------------|----------------|----------------|-----------------|----------------|----------------|
| % Change | | -2.74 | 3.56 | 4.52 | 3.69 | 1.93 |
| <i>Dhāraṇā</i> | 0.87 ± 0.12 | 0.89 ± 0.13 | 0.90 ± 0.15 | 0.89 ± 0.13 | 0.90 ± 0.12 | 0.88 ± 0.12 |
| % Change | | 2.12 | 3.85 | 2.79 | 3.01 | 1.72 |
| <i>Dhyāna</i> | 0.89 ± 0.10 | 0.91 ± 0.12 | 0.92 ± 0.13 | 0.93 ± 0.12* | 0.88 ± 0.16 | 0.89 ± 0.17 |
| % Change | | 1.98 | 3.64 | 3.95 | -1.08 | -0.30 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was a decrease of 0.27% to 2.93% in *Cañcalatā*, *Ekāgratā* showed 1.93% to 4.52%, *Dhāraṇā* showed 1.72% to 3.85%, *Dhyāna* showed 0.3% to 3.95% mean RR.

6.2.6E Mean HR

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed no significant difference between Sessions ($F=1.21$, $p=0.31$, Huynh-Feldt epsilon $\epsilon=0.981$) whereas a significant change was observed between States ($F=3.34$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.807$). Also significant interaction between Sessions and States ($F=2.17$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.666$) was noticed.

Post-hoc analysis with Bonferroni adjustment for *ekāgratā* session showed a significant decrease in mean HR (Pre versus During 2; $p<0.05$, During 3; $p<0.01$, and During 4; $p<0.05$), while there was no significant change in mean HR in other sessions. The

actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in

Table 6.2.6E.

Table 6.2.6E.

Group mean values \pm S.D of the Mean HR reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|----------------------|------------------------|--------------------------|------------------------|----------------------|
| <i>Cañcalatā</i> | 69.18 ± 11.12 | 69.09 ± 11.31 | 69.18 ± 11.71 | 69.79 ± 11.52 | 71.42 ± 10.68 | 68.84 ± 10.69 |
| % Change | | -0.14 | 0.00 | 0.87 | 3.24 | -0.49 |
| <i>Ekāgratā</i> | 70.07 ± 10.32 | 69.31 ± 10.26 | 67.71 $\pm 10.27^*$ | 67.12 $\pm 9.98^{**}$ | 67.91 $\pm 10.29^*$ | 68.75 ± 10.29 |
| % Change | | -1.09 | -3.37 | -4.21 | -3.08 | -1.88 |
| <i>Dhāraṇā</i> | 71.31 ± 11.53 | 69.91 ± 11.55 | 69.06 ± 12.07 | 69.18 ± 11.97 | 69.02 ± 10.47 | 69.87 ± 10.27 |
| % Change | | -1.97 | -3.16 | -2.99 | -3.21 | -2.02 |
| <i>Dhyāna</i> | 68.62 ± 7.63 | 66.60 ± 11.53 | 66.67 ± 9.20 | 67.08 ± 9.70 | 68.25 ± 8.64 | 67.99 ± 10.50 |
| % Change | | -2.96 | -2.85 | -2.25 | -0.55 | -0.92 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1,

D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was decrease of 0% to 3.24% in *Cañcalatā*,

Ekāgratā showed 1.09% to 4.21%, *Dhāraṇā* showed 1.97% to 3.21%, *Dhyāna* showed 0.55% to 2.96% in mean HR.

6.2.6F pNN50

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions ($F=3.50$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.873$) and between States ($F=4.64$, $p<0.001$, Huynh-Feldt epsilon $\epsilon=0.827$). Also significant interaction between Sessions and States ($F=2.07$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.617$) was observed.

Post-hoc analysis with Bonferroni adjustment for *dhyāna* session showed a significant increase in pNN50 (Pre versus During 2; $p<0.01$, and During 3; $p<0.05$), while no significant change was observed in pNN50 of other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6F**.

Table 6.2.6F.

Group mean values \pm S.D of the pNN50 reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|--------|-----|----|----|----|----|------|
|--------|-----|----|----|----|----|------|

| | | | | | | | | |
|--|------------------|----------------|----------------|------------------|-----------------|----------------|----------------|--|
| *p < 0.05, **p < 0.01, RMANOVA with (within session). states. (i.e. D1, D2, D3, sign indicate a decrease While there was 7.37% in <i>Cañcalatā</i> , | <i>Cañcalatā</i> | 29.9 ± 16.8 | 21.7 ± 19.3 | 23.1 ± 18.8 | 21.1 ± 16.7 | 21.5 ± 16.7 | 24.6 ± 17.6 | ***p < 0.001; Bonferroni adjustment Comparing individual D4, and Post). Minus with respect pre data. decrease of 0.99% to <i>Ekāgratā</i> showed |
| | % Change | | -5.37 | 0.99 | -7.66 | -6.29 | 7.37 | |
| | <i>Ekāgratā</i> | 22.5 ± 18.0 | 23.4 ± 18.0 | 26.4 ± 19.1 | 27.6 ± 19.0 | 27.1 ± 18.6 | 24.5 ± 17.2 | |
| | % Change | | 3.85 | 17.10 | 22.31 | 20.27 | 8.89 | |
| | <i>Dhāraṇā</i> | 24.0 ± 18.2 | 24.3 ± 18.1 | 25.7 ± 20.4 | 25.6 ± 18.7 | 25.8 ± 19.2 | 24.3 ± 17.1 | |
| | % Change | | 1.29 | 7.09 | 6.73 | 7.46 | 1.24 | |
| | <i>Dhyāna</i> | 25.7 ± 19.2 | 28.6 ± 20.6 | 32.8 ± 20.3** | 32.5 ± 20.9* | 29.8 ± 20.8 | 28.5 ± 18.9 | |
| | % Change | | 10.93 | 27.39 | 26.45 | 15.72 | 10.72 | |

increase of 3.85% to 22.31%, *Dhāraṇā* showed increase of 1.24% to 7.46%, *Dhyāna* showed 10.72% to 27.39% in pNN50.

6.2.6G RMSSD

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions ($F=4.53$, $p<0.01$, Huynh-Feldt epsilon $\epsilon=0.950$) and between States ($F=3.18$, $p<0.01$, Huynh-Feldt epsilon $\epsilon=0.941$). While no significant interaction was observed between Sessions and States ($F=1.11$, $p=0.34$, Huynh-Feldt epsilon $\epsilon=0.843$).

Post-hoc analysis with Bonferroni adjustment for *dhyāna* session showed no significant change in RMSSD in any one of the session. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6G**.

Table 6.2.6G

Group mean values \pm S.D of the RMSSD reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| <i>Cañcalatā</i> | 49.35 \pm 16.34 | 46.71 \pm 21.39 | 45.78 \pm 23.08 | 49.87 \pm 24.53 | 48.73 \pm 18.21 | 49.88 \pm 22.28 |
| % Change | | -5.34 | -7.23 | 1.05 | -1.25 | 1.08 |
| <i>Ekāgratā</i> | 54.43 \pm 25.10 | 50.24 \pm 23.06 | 51.73 \pm 25.95 | 55.15 \pm 25.88 | 61.04 \pm 28.57 | 53.79 \pm 23.89 |
| % Change | | -7.70 | -4.95 | 1.32 | 12.14 | -1.17 |
| <i>Dhāraṇā</i> | 52.00 \pm 22.01 | 54.95 \pm 27.07 | 50.69 \pm 24.29 | 54.70 \pm 27.14 | 57.50 \pm 23.78 | 53.90 \pm 22.77 |
| % Change | | 5.66 | -2.53 | 5.19 | 10.57 | 3.65 |
| <i>Dhyāna</i> | 54.17 \pm 26.78 | 62.28 \pm 31.76 | 61.87 \pm 32.65 | 63.49 \pm 33.32 | 65.61 \pm 31.26 | 64.34 \pm 36.38 |
| % Change | | 14.96 | 14.21 | 17.20 | 21.11 | 18.77 |

RMANOVA with Bonferroni adjustment (within session). Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was decrease of 1.05% to 7.23% in *Cañcalatā*, *Ekāgratā* showed 1.32% to 12.14%, *Dhāraṇā* showed 2.53% to 10.57%, *Dhyāna* showed increased of 14.21% to 21.11% in RMSSD.

6.2.6H NN50

RMANOVA consisted of two Within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) and (ii) States [Pre, During (D1 to D4) and Post] showed significant difference between Sessions ($F=2.74$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.838$) and between States ($F=3.52$, $p<0.05$, Huynh-Feldt epsilon $\epsilon=0.893$). Also significant interaction between Sessions and States ($F=2.09$, $p<0.02$, Huynh-Feldt epsilon $\epsilon=0.738$) was noticed.

Post-hoc analysis with Bonferroni adjustment for *dhyāna* session showed a significant increase in NN50 (Pre versus During 2; $p<0.001$, and During 3; $p<0.05$), while no significant change was observed in NN50 of other sessions. The actual data of individual subjects in Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) are presented with group mean values \pm SD in **Table 6.2.6H**.

Table 6.2.6H.

Group mean values \pm S.D of the NN50 reordered pre, during and post of two meditation and two control sessions.

| Phases | Pre | D1 | D2 | D3 | D4 | Post |
|------------------|----------------------|----------------------|-------------------------|------------------------|----------------------|----------------------|
| <i>Cañcalatā</i> | 72.53 \pm 49.68 | 67.70 \pm 54.22 | 73.10 \pm 54.56 | 67.80 \pm 48.09 | 69.90 \pm 49.38 | 76.63 \pm 54.70 |
| % Change | | -6.66 | 0.78 | -6.53 | -3.63 | 5.65 |
| <i>Ekāgratā</i> | 74.73 \pm 53.28 | 74.77 \pm 51.97 | 82.47 \pm 54.60 | 85.27 \pm 54.07 | 84.67 \pm 53.03 | 77.60 \pm 49.34 |
| % Change | | 0.04 | 10.35 | 14.09 | 13.29 | 3.84 |
| <i>Dhāraṇā</i> | 75.97 \pm 51.02 | 76.60 \pm 51.38 | 79.13 \pm 57.74 | 78.60 \pm 53.38 | 79.17 \pm 54.45 | 73.73 \pm 47.34 |
| % Change | | 0.83 | 4.17 | 3.47 | 4.21 | -2.94 |
| <i>Dhyāna</i> | 75.97 \pm 51.44 | 85.10 \pm 56.95 | 99.80 \pm 57.14*** | 100.63 \pm 58.06* | 86.06 \pm 61.93 | 85.87 \pm 58.82 |
| % Change | | 12.02 | 31.37 | 32.46 | 13.28 | 13.03 |

*p < 0.05, ***p < 0.001;
 RMANOVA with
 adjustment (within
 Comparing
 (i.e. D1, D2, D3,
 Minus sign indicate
 respect pre data.

0.001;
 Bonferroni
 session).
 individual states.
 D4, and Post).
 a decrease with
 While there was

decrease of 0.78% to 6.53% in *Cañcalatā*, *Ekāgratā* showed increased of 0.04% to 14.09%, *Dhāraṇā* showed decreased of 0.83% to 4.21%, *Dhyāna* showed increased of 13.03% to 32.46% in NN50.

6.3. SIX LETTER CANCELLATION TEST

6.3.1. RECAPITULATION

Performance in letter cancellation task were assessed in 35 practitioners in four sessions i.e. *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. RANOVA were performed with two ‘Within Subjects’ factors, i.e., Factor 1: Sessions; *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*, and Factor 2: States; Pre and Post. This was followed by a Post-hoc analysis with Bonferroni adjustment for multiple comparisons between the mean values of different states (Pre and Post). The groups mean values and standard deviations for total scores, scores for wrong cancellations and net scores before and after *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions are given in **Table 6.3.1**.

Six-letter cancellation task

Repeated measures analysis of variance (ANOVA).

The RMANOVA showed a significant interaction between Groups and States for total scores in all the sessions ($F=9.795$, $df=3, 36$, $p<.001$, Huynh-Feldt epsilon=0.900), net scores ($F=10.198$, $df=3, 34$, $p<0.001$, Huynh-Feldt epsilon=0.821) and wrong

scores in sessions and states ($F=3.207$, $df=3, 36$, $p<.05$, Huynh-Feldt epsilon=0.897). This suggested that for all three scores, Groups and States were not independent of each other (Zar, 2005).

Post hoc tests with *Bonferroni* adjustment.

Total and net scores were significantly higher after the *dhāraṇā* session compared to the pre scores ($p<.02$), whereas after the *cañcalatā* session they were significantly lower ($p<.001$). No significant change was observed in other sessions for the letter cancellation task.

Table 6.3.1.

Total scores, net scores and scores for letters wrongly cancelled in a six letter cancellation task before and after separate sessions of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*.

| States | Total Scores | | | Net Scores | | | Score for Wrong Cancellation | | |
|------------------|----------------|-------------------|----------|-----------------|-------------------|----------|------------------------------|----------------|----------|
| | Pre | Post | % change | Pre | Post | % change | Pre | Post | % change |
| <i>Cañcalatā</i> | 35.26 ±9.87 | 26.60 ±6.72*** | -24.65 | 34.11 ±10.29 | 26.17 ±6.76*** | -23.28 | 1.14 ±2.02 | 0.40 ±0.60* | -64.91 |
| <i>Ekāgratā</i> | 31.54 ±9.20 | 31.69 ±9.39 | 0.48 | 30.97 ±8.71 | 31.23 ±9.54 | 0.84 | 0.57 ±1.44 | 0.46 ±1.15 | -19.3 |
| <i>Dhāraṇā</i> | 32.26 ±8.90 | 37.49 ±11.78* | 16.21 | 32.60 ±8.79 | 36.94 ±12.32* | 13.31 | 0.23 ±0.60 | 0.29 ±0.79 | 26.09 |
| <i>Dhyāna</i> | 36.96 | 35.11 | -5.01 | 36.46 | 34.51 | -5.35 | 0.23 | 0.60 | 160.87 |

| | | | | | | | | | |
|--|--------|-------|--|--------|-------|--|-------|-------|--|
| | ±11.43 | ±9.23 | | ±11.46 | ±9.55 | | ±0.60 | ±1.58 | |
|--|--------|-------|--|--------|-------|--|-------|-------|--|

* $p < 0.05$, *** $p < 0.001$; RMANOVA with Bonferroni adjustment (within session).

Comparing individual states. (i.e. D1, D2, D3, D4, and Post). Minus sign indicate a decrease with respect pre data. While there was a decrease of 24.65% in *Cañcalatā*, *Ekāgratā* showed increased of 0.48%, *Dhāraṇā* showed an increase of 16.21%, *Dhyāna* showed decrease of 5.01% in Total scores.

There was a decrease of 23.28% in *Cañcalatā*, *Ekāgratā* showed an increase of 0.84%, *Dhāraṇā* showed an increase of 13.31%, *Dhyāna* showed decrease of 5.35% in Net scores.

There was a decrease of 64.91% in *Cañcalatā*, *Ekāgratā* showed decreased of 19.30%; *Dhāraṇā* showed an increase of 26.09%, *Dhyāna* showed an increase of 160.87% in scores for Wrong Cancellation task.

6.4 SUMMARY OF RESULTS

Trend Table: 6.4.1

The trend in arrows and percentage change shown for peak latencies in during States for wave I, wave III and wave V

| Sl. No. | Variables | During | | | |
|---------|-----------|--------|------|------|------|
| | | C | E | Dh | Dhy |
| 1. | Wave I | ~ | ~ | ~ | ~ |
| 2. | % change | 2.32 | 1.22 | 0.40 | 0.54 |
| 3. | Wave III | ~ | ↑ | ↑ | ~ |
| 4. | % change | 1.28 | 0.89 | 0.51 | 0.32 |
| 5. | Wave V | ↑ | ↑ | ~ | ~ |
| 6. | % change | 0.95 | 1.39 | 0.5 | 0.39 |

Note: C = *Cañcalatā*., E = *Ekāgratā* ., Dh = *Dhāraṇā*., Dhy = *Dhyāna*.

~ = no significant change.

Trend Table: 6.4.2

The trend in arrows and percentage change shown in autonomic & respiratory variables reordered during phases of two meditation and two control sessions

| Variables | During | | | |
|-----------|--------|-------|-------|--------|
| | C | E | Dh | Dhy |
| RR | ↓ | ↓ | ~ | ↓ |
| % change | 16.07 | 6.67 | -5 | -18.75 |
| HR | ~ | ~ | ~ | ↓ |
| % change | 1.81 | -1.79 | -2.86 | -6.16 |
| PLT | ~ | ~ | ~ | ↑ |
| % change | -12.24 | -9.23 | 8.60 | 10.39 |
| GSR | ↑ | ↑ | ↑ | ↑ |
| % change | 8.15 | 10.25 | 8.09 | 13.95 |

Note: C = *Cañcalatā*., E = *Ekāgratā*., Dh = *Dhāraṇā*., Dhy = *Dhyāna*.

~ = no significant change.

Trend Table: 6.4.3

The trend in arrows and percentage change shown in frequency domain measures of heart rate variability spectrum reordered during phases of two meditation and two control sessions

| Variables | During | | | |
|-----------|--------|---|----|-----|
| | C | E | Dh | Dhy |

| | | | | |
|----------|--------|--------|-------|--------|
| LF | ↓ | ↓ | ~ | ↓ |
| % change | 18.75 | 14.53 | -3.88 | -29.24 |
| HF | ~ | ↑ | ~ | ↓ |
| % change | -19.76 | -17.68 | 6.91 | 30.60 |
| LF/HF | ~ | ↑ | ~ | ~ |
| % change | 63.38 | 55.30 | 5.11 | -40.43 |

Note: **C** = *Cañcalatā*., **E** = *Ekāgratā*., **Dh** = *Dhāraṇā*., **Dhy** = *Dhyāna*.

~ = no significant change.

Trend Table: 6.4.4

The trend in arrows and percentage change shown in time domain measures of heart rate variability spectrum reordered during phases of two meditation and two control sessions

| Variables | During | | | |
|-----------|----------|----------|-----------|------------|
| | C | E | Dh | Dhy |
| Mean RR | ↓ | ↑ | ↑ | ↑ |
| % Change | -1.15 | 2.26 | 2.94 | 2.12 |
| Mean HR | ↑ | ↓ | ↓ | ↓ |
| % Change | 0.18 | -2.17 | -2.03 | -2.01 |
| RMSSD | ↓ | ↑ | ↑ | ↑ |
| % Change | -2.88 | -2.83 | 2.08 | 11.59 |
| NN50 | ↓ | ↑ | ↑ | ↑ |
| % Change | -3.10 | 6.12 | 2.12 | 18.96 |
| pNN50 | ↓ | ↑ | ↑ | ↑ |
| % Change | -3.01 | 10.81 | 3.78 | 16.19 |

Note: **C** = *Cañcalatā*., **E** = *Ekāgratā* ., **Dh** = *Dhāraṇā*., **Dhy** = *Dhyāna*.

~ = no significant change.

Trend Table: 6.4.5

The trend in arrows and percentage change shown for total scores, net scores and scores for letters wrongly cancelled in a six letter cancellation task before and after separate sessions of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*

| variables | sessions | | | |
|-----------|---------------|--------------|--------------|---------------|
| | C | E | Dh | Dhy |
| Ts | ↓*** | ~ | ↑* | ~ |
| % change | -24.56 | 0.48 | 16.21 | -5.01 |
| Ns | ↓*** | ~ | ↑* | ~ |
| % change | -23.28 | 0.84 | 13.31 | -5.35 |
| Ws | ↓* | ~ | ~ | ~ |
| % change | -64.91 | -19.3 | 26.09 | 160.87 |

Note: **C** = *Cañcalatā*., **E** = *Ekāgratā* ., **Dh** = *Dhāraṇā*., **Dhy** = *Dhyāna*.

~ = no significant change.

The present study does demonstrate a difference between *dhāraṇā* and *dhyāna* states of meditation based on the most pertinent results detailed in the previous section are discussed under the three main categories of variables (i) measures of sensory information processing, measured throughout (pre, during and post states) the recording sessions, (ii) measures of reduction in psychophysiological arousal entails and (iii) performance in a letter cancellation task measured before and after the sessions.

7.1 BRAINSTEM AUDITORY EVOKED POTENTIALS (BAEPs)

The wave V peak latency was significantly increased during *cañcalatā* by 0.9 percent and *ekāgratā* by 1.4 percent, but there was no change during *dhāraṇā* and *dhyāna* sessions. In the literature there is only one previous study of short latency auditory evoked potentials in TM practitioners. In this study, at moderate stimulus intensities (40 to 50 dB) the wave V latency increased following meditation (McEvoy, et al. 1980). In contrast, at higher stimulus intensities the wave V latency was slightly decreased by a comparison of slopes and intercepts of stimulus intensity-latency functions. The authors suggested a possible effect of Transcendental Meditation on brainstem activity. In the present study there was no attempt to vary the stimulus intensity which was kept at 80 dB normal hearing level. This would fit in the category of a higher intensity stimulus based on the categorization in the earlier study (McEvoy, et al. 1980). Compared to that study, even at this high stimulus intensity the latency of wave V did not decrease during either of the two meditation sessions (*dhāraṇā* and *dhyāna*) while an increase in wave V peak latency was found in *cañcalatā* and *ekāgratā* sessions.

An increase in latency of an evoked potential component is taken to suggest that sensory information processing at the level of the underlying neural generator is delayed (Telles, & Desiraju, 1993). This suggests that in *cañcalatā* and *ekāgratā* mental states, sensory processing at the midbrain level was delayed. Another feature of the present study is that a difference was seen in the nature of results in the two meditation sessions.

In the introduction it was already mentioned that *dhāraṇā* and *dhyāna* states have been described in an ancient yoga text, namely Patañjali's yoga *Sūtras*. In this text, *dhāraṇā* literally means 'fixing the mind on a specific object' (Patañjali's yoga *Sūtras* Chapter 5 verse 1). The mind could be fixed on any point and as long as disturbances from any source are warded off this mental state is called *dhāraṇā*. When *dhāraṇā* becomes effortless it takes the form of *dhyāna* which is defined as the uninterrupted spontaneous flow of the mind towards the chosen object.

In contrast to this the two control sessions (*cañcalatā* and *ekāgratā*) are described in another ancient text, the Bhagavad *Gītā* (Bhaktivedanta *Svāmī* Prabhupada, 1988). The *cañcalatā* state is characterized by constant shifting of thoughts from one object to another. The *ekāgratā* state is quite different from this and is similar to concentration. When haphazard thoughts are streamlined in a single direction it is called *ekāgratā*.

Hence irrespective of whether meditators were in a state of random thinking (*cañcalatā*) or channelized thinking in concentration (*ekāgratā*) there was a delay in sensory information processing, as mentioned above at the mid-brain level, (possibly the inferior colliculus) level. The mental state was characterized by a lack of effort during *dhyāna* session whereas, there is an effort involved during *dhāraṇā* session. In both the sessions, the latency of wave V did not show any significant change in sensory information

processing. In contrast, there was a significant delay seen post *dhāraṇā* session, while no such changes were observed post *dhyāna* session. During *dhyāna* compared to before there was a relative increase in wave V amplitude (relative to wave III) suggesting recruitment of more neurons at the inferior collicular level.

Further studies are required to understand whether neural relay centers further along the auditory pathway would also change differently in *dhāraṇā* and *dhyāna* states. The main limitation of the present study is the fact that there was no attempt to vary stimulus intensities and hence the earlier findings of McEvoy, Frumkin and Harkins (1980), could not be examined. Despite these limitations the present study does demonstrate a difference between *dhāraṇā* and *dhyāna* states of meditation based on brainstem auditory evoked potentials.

7.2 AUTONOMIC AND RESPIRATORY VARIABLES

In the present study, changes in autonomic and respiratory variables were evaluated in four mental states. These were: *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. The study assessed the autonomic and respiratory variables on normal healthy volunteers who were experienced in practicing meditation on the syllable 'OM' in two meditation (i.e., *dhāraṇā* and *dhyāna*) and two control sessions (i.e.

cañcalatā and *ekāgratā* sessions) in four mental states. Several changes of different autonomic and respiratory variables were observed at each of these four stages.

In this study the low frequency (LF) power of Heart rate variability (HRV) was lower during *dhyāna* sessions. The high frequency (HF) power was higher during the *dhyāna* practice. The LF/HF ratio was higher during the *ekāgratā* practice. The changes in LF power suggest that there was increased sympathetic activity in *cañcalatā* and *ekāgratā* sessions. In the time domain analysis of heart rate variability RMSSD was higher during all sessions except *cañcalatā*. NN50 was also higher during *ekāgratā*, *dhāraṇā* and *dhyāna*. The pNN50 was higher during all three sessions except *cañcalatā*.

The breath rate was significantly lower during *dhyāna* sessions while there was significantly increased during *cañcalatā*. The lowering of breath rate was consistent during and after the practice of *dhyāna* session. The heart rate too was lower during *dhyāna* in the present study. All four session viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* showed an increase in skin resistance during the practices. Following meditative defocusing *dhyāna*, there was significant change in mention above variables which suggests a physiological relaxed state, while there were no such changes seen following other sessions.

From the late 1960s there have been several studies on the effects of practicing meditation in both inexperienced as well as experienced meditators (Wallace, et al. 1971; Wallace, 1970). These studies did not support a single idea of meditation and showed varied results. However majority of these studies showed a parasympathetic dominance and reduced sympathetic activity, there were few studies (Corby, et al. 1978) which showed contradictory results challenging the relaxation model of meditation.

Hence these early studies did not support a single model of meditation as being either activating or relaxing. A subsequent study which used a self-as-control design assessed each individual in both meditation and non meditation sessions, each of which was repeated thrice (Telles & Desiraju, 1993^b). Here, differences between subjects and differences in the repeat sessions of an individual were attributed to inherent individual differences between individuals. It was considered that this could definitely influence the individual's physical response to yoga. Another factor which was considered important is the fact that an individual's mental state varies from one day to another, or even within shorter time periods.

However it was considered worth examining the description of meditation in ancient yoga texts and understanding whether this description would influence the effects observed experimentally.

In Patañjali's *Yoga Sūtras* (circa 900 B.C.) there are two meditative states described (Taimni, 1986). These are focusing on the object of meditation (called *dhāraṇā* in *Saṃskṛta*; Patañjali's *Yoga Sūtras* 3:1) and a meditative state characterized by no effort and by 'de-focusing' (called *dhyāna* in *Saṃskṛta*; Patañjali's *Yoga Sūtras* 3.2). The two are supposed to follow one another, in sequence.

With this separation of meditation, as *dhāraṇā* and *dhyāna* sessions, *dhāraṇā* may be suspected to be more physiologically activating whereas *dhyāna* would suggest more of physiological relaxation.

In the present study changes in autonomic and respiratory variables were evaluated in four mental states. These were: *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. The change of different autonomic and respiratory variables in each of these four stages is given below.

Heart rate variability has been found to be valuable in describing the role of the two divisions of autonomic system in cardio-circulatory regulation. Some of the autonomic variables which were assessed in the present study directly indicate the level of activity in different subdivisions of the sympathetic nervous system whereas others indicate autonomic balance. The heart rate for example, is regulated by dual innervations (sympathetic and vagal) as well as humoral factors (Andreassi, 2000). This also applies to the heart rate variability (HRV) components. The low frequency (LF) band of the HRV is mainly related to sympathetic modulation when expressed in normalized units (Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996), while the efferent vagal activity is a major contributor to the high frequency (HF) band. The LF/HF ratio is correlated with the sympathovagal balance (Malliani et al., 1991). In the present study the LF power was lower during *dhyāna* sessions. The HF power was higher during the *dhyāna* practice. The LF/HF ratio was higher during the *ekāgratā* practice. The changes

in LF power suggest that there was increased sympathetic activity in *cañcalatā* and *ekāgratā* sessions. Hence *dhāraṇā* did not influence the HRV in the same way.

An increase in finger plethysmogram amplitude is correlated with decreased noradrenergic vasomotor sympathetic control of the cutaneous blood vessels (Telles, 1995). The skin conductance level is an indicator of the level of activity in the cholinergic sudomotor sympathetic nerves supplying the eccrine sweat glands (Shields et al., 1987), which is believed to be the major contributor to changes in the spontaneous electrodermal activity (Fowles, 1986). In the present study there was increase in skin resistance during all four session viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. An increased skin resistance is well recognized as marker of reduced psychophysiological arousal in meditation (Orme-Johnson, 1973). It is also to be noted that the highest percent increase was during *dhyāna* (14.0 percent) compared to the lowest percent increase during *dhāraṇā* (8.1 percent).

Unlike these variables it is well established that the breath rate depends upon numerous factors ranging from physical activity to psychological stressors (Stevenson and Ripley, 1952).

The breath rate was significantly lower during *dhyāna* sessions (18.75) while there was significantly increased during *cañcalatā* (16.07 percent). The lowering of breath rate was consistent during and after the practice of *dhyāna* session. The rate of breathing is known to

vary directly with the level of anxiety (Srinivas & Telles, 1999). A decreased breath rate is a well recognized correlate of reduced psychophysiological arousal. Hence for this variable also there were difference between *dhāraṇā* and *dhyāna*.

The heart rate was also lower during *dhyāna* in the present study there was a lowering of both breathing rate and heart rate during *dhyāna* suggestive of physiological relaxation.

In the time domain analysis of heart rate variability the most commonly used measures derived from interval differences include RMSSD, which is the square root of the mean squared differences of successive NN intervals; NN50, the number of interval differences of successive NN intervals greater than 50 ms; and pNN50, the proportion derived by dividing NN50 by the total number of NN intervals. All of these measurements of short-term variation assess high-frequency variations in heart rate and thus are highly correlated. It is also believed that both the RMSSD and pNN50 indices sensitive to changes in the high frequency components. They select the changes that occur from one QRS cycle to the very next. Some evidence suggests that these time domain are the best predictors of parasympathetic activity (Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

In the present results RMSSD was higher during all sessions except *cañcalatā*. NN50 was also higher during *ekāgratā*, *dhāraṇā* and *dhyāna*. The pNN50 was higher during all three sessions except *cañcalatā*. The RMSSD (along with the pNN50) are time domain measures which are highly correlated with frequency domain measures and recognized to be strongly dependent on vagal tone (Massin

et al., 1999). Hence *ekāgratā*, *dhāraṇā* and *dhyāna* appeared to be related to changes in vagal tone, with percentage changes (in pNN50, for example) of 10.9 percent, 3.8 percent, and 16.2 percent. Hence here also, the highest magnitude of change occurred during *dhyāna*, while lowest change occurred during *dhāraṇā*.

7. 3 SIX LETTER CANCELLATION TASK

The present study assessed the effects of meditation focusing (*dhāraṇā*) and meditative defocusing (*dhyāna*) (as well as two ‘control’ conditions) on the performance in a letter cancellation task. The net scores improved following meditative focusing (*dhāraṇā*), alone, while they were lower after non targeted thinking (*cañcalatā*).

Several studies have shown an improvement in the efficiency of executive or orientational processing following meditation (Chan & Woollacott, 2007). There are also reports of changes associated with increased concentration and attention. For example, a study on Zen meditators reported an increase in both sympathetic and parasympathetic indices during the appearance of frontal midline theta rhythm (Fm theta) compared to control periods (Kubota, Sato, Toichi, Murai, Okada, Hayashi, & Sengoku, 2001). The Fm theta rhythm is recognized as distinct theta activity which reflects mental concentration associated with a low anxiety state. This suggested that meditation brought about a relaxed state with heightened internalized attention and concentration.

A study of the contingent negative variation amplitude was the basis of assessing the effect of meditation on attention to external objects (Travis, Tecce, Arenander, & Wallace, 2002). Here the effects of transcendent experiences occurring during the practice of

transcendental meditation were studied on the contingent negative variation amplitude, rebound and distraction effects. The contingent negative variation is an event-related potential occurring between a warning stimulus and an imperative stimulus requiring a response (Walter, Cooper, Aldridge, Callum, & Winter 1964). The changes in transcendental meditation practitioners suggested that transcendent experiences could enhance cortical responses and executive functioning.

Another event related potential was shown to change following the practice of a meditation technique called cyclic meditation (Sarang & Telles, 2006^c). Cyclic meditation (CM) consists of cycles of 'stimulating' and of 'calming' practices. The P300 peak latency was reduced to a greater extent following CM compared to an equal duration period of supine rest. The P300 latency reflects the speed of stimulus classification and is an index of stimulus processing, rather than response generation (Polich, 2004). The P300 peak latency is negatively correlated with mental function in normal persons; shorter latencies being associated with superior cognitive performance in tasks for attention and immediate memory.

In a separate study, following cyclic meditation there was an improvement in performance in a letter cancellation task (Sarang & Telles, 2007). Since the letter cancellation task assesses selective attention and concentration (Uttl & Pilkenton-Taylor, 2001), these results support the idea of improved attention following cyclic meditation. However, cyclic meditation practice was also associated with a decrease in oxygen consumption (Telles, Reddy, & Nagendra, 2000; Sarang & Telles, 2006^a) and changes in the heart rate variability suggestive of vagal dominance and/or sympathetic withdrawal (Sarang & Telles, 2006^b). Hence CM, as was earlier mentioned for Zen Meditation (Kubota, et al., 2001), was characterized by both relaxation and alertness.

In the present study attention alone was measured. There was no attempt to assess objective indicators of relaxation/arousal simultaneously. The present results suggest that meditative focusing (*dhāraṇā*) may be the phase during which attention improves. We may also speculate that relaxation occurs during the *dhyāna* phase. Further studies using objective measurements would substantiate these findings and help to understand the mechanisms involved.

8. 1 SUMMARY OF THE FINDINGS

1. In the present study thirty subjects were studied in four separate sessions i.e., *cañcalatā* (random thought), *ekāgratā* (concentration), *dhāraṇā* (focused attention) and *dhyāna* (meditation). The sample size was calculated and the effect size obtained, based on reports in an unpublished Ph.D thesis entitled ‘Psychophysiology of meditation including responses to external stimuli’ (Naveen, 2005).
2. In the traditional texts [the Patañjali’s *Yoga Sūtras* (Taimini, 1961) and *Bhāgavad Gītā* (Bhaktivedānta Svāmi Prabhupāda, 1998)] it has been described that when awake and in the absence of a specific task the mind is very distractible (*cañcalatā*), and has to be taken through the stages of ‘streamlining the thoughts’ (concentration or *ekāgratā*), followed by one-pointed concentration (focusing or *dhāraṇā*), then reaching the meditative state (defocused, effortless single thought state or *dhyāna*). Earlier findings

suggest that 'OM' meditation facilitates the neural activity in mesencephalic or diencephalic level as well as psycho-physiological relaxation. Based on these backgrounds, the present study was carried out to understand the psycho-physiological effects of these four states of wakeful mind.

3. The study design consisted of four sessions i.e., two meditation and two control sessions. All four sessions consisted of three states, i.e., 'pre' (5 minutes), 'during' (20 minutes), and 'post' (5 minutes) separately on different days.

4. The following assessments were made:

- Brainstem Auditory Evoked Potentials (BAEPs)
- Autonomic and Respiratory variables (ARV) and
- Six letter cancellation task (SLCT)

5. For each of the variables the data were analyzed separately using repeated measures ANOVA followed by post-hoc analysis.

6. The results have shown the following changes:

(i) Brainstem auditory evoked potential –There was a significant increase in the latency only of Wave V during the *cañcalatā* session (Pre versus During, 0.4%), *ekāgratā* session (Pre versus During & post, 0.9% and 1.56%) and following the *dhāraṇā* session (Pre versus Post, 1.22%). There were no significant changes in amplitude of wave V as well as other waves during all sessions.

(ii) Autonomic and respiratory variables

Galvanic Skin Resistance (GSR): There was a significant increase in the galvanic skin resistance during and after the *dhyāna* session (8.60% to 17.03%) in comparison to *cañcalatā* (7.3% to 10.28%), *ekāgratā* (7.43% to 11.36%), and *dhāraṇā* (5.20% to 11.36%) sessions.

- Finger Plethysmogram Amplitude (FPA): There was a significant increase in the digit pulse volume in *dhyāna* session (Pre versus During 2.28% to 12.26%).
- Electrocardiogram (EKG): There was a significant decrease in the heart rate in *dhyāna* session (Pre versus During & post, 4.93% to 7.73%).
- Respiratory rate: There was a significant increase in the respiratory rate in *cañcalatā* sessions (Pre versus During & post 2.69% to 15.56%). But in session *dhyāna* there was significant decrease in respiratory rate (Pre versus During & post 8.86% to 19.59%).

- HRV LF: There was a significant increase in low frequency in *cañcalatā* and *ekāgratā* sessions *cañcalatā* (Pre versus During & post 15.95% to 22.67%), *ekāgratā* (Pre versus During & post 13.22% to 15.78%). But there was significant decrease in low frequency in *dhyāna* session (Pre versus During & post 15.42% to 25.53%).
- HF: There was a significant decrease in high frequency in *ekāgratā* session (Pre versus During & post 16.15% to 19.23%), while there was significant increase in high frequency in *dhyāna* session (Pre versus During & post 23.55% to 37.76%).
- LF/HF: There was a significant increase in low and high frequency ratio in *ekāgratā* session (Pre versus During & post 41.44% to 83.67%).

(iii) Six letter cancellation task (SLCT): Total and net scores were significantly higher after the *dhāraṇā* session (16.21% and 13.31%) compared to the pre scores, whereas after the *cañcalatā* session they were significantly lower (24.65% and 23.28%). No significant change was observed in other sessions for the letter cancellation task.

7. The possibility that the neural transmission of auditory sensory information is not delayed through the inferior colliculus during *dhyāna* may be considered to be supported by the fact the wave V to wave III (wave V / wave III) amplitude ratio was significantly higher during *dhyāna*. LF power was lower during *dhyāna* sessions. The HF power was higher during the *dhyāna* practice. This may

be due to relaxation component of *dhyāna*. An increased skin resistance is well recognized as marker of reduced psychophysiological arousal in meditation (Orme-Johnson, 1973). It is also to be noted that the highest 13 percent increase was during *dhyāna*. Unlike these variables it is well established that the breath rate depends upon numerous factors ranging from physical activity to psychological stressors (Stevenson and Ripley, 1952). The heart rate was also lower during *dhyāna* in the present study there was a lowering of both breathing rate and heart rate during *dhyāna* suggestive of physiological relaxation. The RMSSD (along with the pNN50) are time domain measures which are highly correlated with frequency domain measures and recognized to be strongly dependent on vagal tone (Massin et al., 1999). Hence *ekāgratā*, *dhāraṇā* and *dhyāna* appeared to be related to changes in vagal tone, the present results suggest that meditative focusing (*dhāraṇā*) may be the phase during which attention improves

8. 2 CONCLUSIONS

These results showed that information transmission along the auditory pathway is delayed during *cañcalatā* and *ekāgratā* with no change during *dhāraṇā* and *dhyāna*. In *dhyāna* there was a relative increase in wave V amplitude (relative to wave III) suggesting recruitment of more neurons at the inferior collicular level during compared to before. This suggests that auditory information transmission was delayed at the inferior collicular level (the tectum) as the wave V corresponds to the tectum. Also, the changes in

autonomic and respiratory variables suggested a higher magnitude of psycho-physiological relaxation during *dhyāna* (decrease by 18% in RR, 6% in HR whereas increase by 10% in PLT, and 13% in GSR) as compared to other sessions. Performance in the six letter cancellation task also suggested that meditative focusing (*dhāraṇā*) may improve attention by 13% in net score.

Hence the null Hypothesis: (1) the information transmission in auditory pathway will not be delayed in *cañcalatā*, *ekāgratā*, and *dhāraṇā* while it will not remain unaltered if not delayed at the brainstem level in *dhyāna* phase (2) *dhyāna* would not induce a state of deep rest with alertness and there will be no autonomic arousal in other phases of *ekāgratā* and *dhāraṇā* (3) there will be no increased attention in all phases *ekāgratā*, *dhāraṇā* and *dhyāna* with no higher increase in *dhyāna* is disproved. It appears that separating meditation as *dhāraṇā* and *dhyāna* and comparing these phases with *cañcalatā*, and with *ekāgratā* as a third, meditative state is useful. The states have different and distinct changes.

8. 3 STRENGTH

The distinction between two phases described by *Patañjali* (Circa 900 B.C.), *dhāraṇā* and *dhyāna*, resulted in group significant and distinct changes showing that the phase of *dhāraṇā* promotes autonomic arousal, increased higher attention, visual scanning and delayed information processing while *dhyāna* decreased the ANS arousal, yet promoting attention as also no delayed information

processing. These conclusions of study would possibly explain the controversial findings of the different techniques of meditation as also in the different phase of meditation.

8.4 LIMITATIONS OF THE PRESENT STUDY

- I. The subjects were volunteers from student community which may make it less possible to generalize the findings.
- II. That there was no attempt to vary stimulus intensities and hence the earlier demonstrated the short latency auditory evoked potentials very with stimulus characteristic (McEvoy, et al. 1980) could not be examined.

8.5 IMPLICATIONS OF THE STUDY

The present findings support the outcomes of the earlier studies on ‘*OM*’ meditation leads to changes at the thalamic/primary cortical areas which is beneficial for attention (Telles & Desiraju, 1993) also a sign of increased mental alertness, even while being physiologically relaxed while chanting “*OM*” (Telles, et al. 1995).

These findings have possible applications in

- I. Education
- II. Health care and

III. Specific occupations described below.

- I. Education: Most systems of education place emphasis on attention, concentration, memory, mental alertness, etc. Since the practice of meditation leads to changes at thalamic/primary cortical areas (Telles & Desiraju, 1993) which are known to facilitate these activities, meditation has an important role to play in education. Also the present day education exposes the student to various stresses especially at the mental levels. Thus mental relaxation has become an essential need, which would be fulfilled by the practice of meditation.
- II. Health care: Stress is a major factor in modern illness (Nagendra & Nagarathna, 2000). Meditation on 'OM' has been found to be effective to reduce stress levels with increasing a higher magnitude of psycho-physiological relaxation coupled with increased mental alertness. For this reason, meditation may be an adjunct in treating several diseases. Hence, meditation acts as a holistic treatment for prevention, promotion of positive health management of disease, and as an important part of complementary and alternative medicine (CAM).
- III. Specific occupations: Certain occupations require immediate decision making (viz., air force pilots, drivers, musicians, artists, scientists, and sports men) which need sharp auditory information processing, higher mental alertness and a mentally relaxed state. 'OM' meditation is found to improve all of these and therefore is of great use to these occupations.

8.6 SUGGESTIONS FOR FUTURE WORK

- I. Larger numbers of subjects are from diverse section of the society.
- II. Analysis of the results found in the different techniques of meditation and different phase of each meditation techniques based other *Dhāraṇā* and *Dhyāna* components in them.
- III. Further studies are required to understand whether neural relay centres further along the auditory pathway would also change in *dhāraṇā* and *dhyāna* stages, using middle and long latency evoked potentials.
- IV. Further studies should include functional magnetic resonance imaging (fMRI) to study which part of the brain is involved during different stages of meditation.

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