The wave V peak latency was significantly increased during caïcalatä by 0.9 percent and ekägratä by 1.4 percent, but there was no change during dhāraëä 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 (dhāraëä and dhyāna) while an increase in wave V peak latency was found in caïcalatä and ekägratä 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 caïcalatä and ekägratä 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 dhāraëä and dhyāna states have been described in an ancient yoga text, namely Pataïjali’s yoga Sūtras. In this text, dhāraëä literally means ‘fixing the mind on a specific object’ (Pataïjali’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 (caïcalatā and ekāgratā) are described in another ancient text, the Bhagavad Gētā (Bhaktivedanta Svāmē Prabhupada, 1988). The caïcalatā 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 (caïcalatā) 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 was 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 dhāraëā and dhāyāna 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 dhāraëā and dhāyāna 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: caïcalatā, ekāgratā, dhāraëā and dhāyāna. 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., dhāraëā and dhāyāna) and two control sessions (i.e. caïcalatā 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 dhāyāna sessions. The high frequency (HF) power was higher during the dhāyāna practice. The LF/HF ratio was higher during the ekāgratā practice. The
changes in LF power suggest that there was increased sympathetic activity in caïcalatä and ekägratâ sessions. In the time domain analysis of heart rate variability RMSSD was higher during all sessions except caïcalatä. NN50 was also higher during ekägratâ, dhäraëä and dhyäna. The pNN50 was higher during all three sessions except caïcalatä.

The breath rate was significantly lower during dhyäna sessions while there was significantly increased during caïcalatä. The lowering of breath rate was consistent during and after the practice of dhyäna session. The heart rate too was lower during dhyana in the present study. All four session viz., caïcalatä, ekägratâ, dhäraëä and dhyäna showed an increase in skin resistance during the practices.

Following meditative defocusing dhyäna, 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, 1993b). 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 Saāskāta; Patañjali’s Yoga Sūtras 3:1) and a meditative state characterized by no effort and by ‘de-focusing’ (called dhyāna in Saāskāta; 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: caīcalatā, 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 caīcalatā and ekāgratā sessions. Hence dhāraēā did not influence the HRV in the same way.

An increase in finger plethysmogram amplitude is correlated with decreased nor adrenergic 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., caīcalatā, ekāgratā, dhāraēā 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 dhāraēā (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 caicalatē (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 dhāraēā 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 caïcalatä. NN50 was also higher during ekägratä, dhäraëä and dhyäna. The pNN50 was higher during all three sessions except caïcalatä. 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 ekägratä, dhäraëä and dhyäna 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 dhyäna, while lowest change occurred during dhäraëä.

7. 3 SIX LETTER CANCELLATION TASK

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

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, & Wnter 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). 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) and changes in the heart rate
variability suggestive of vagal dominance and/or sympathetic withdrawal (Sarang & Telles, 2006). 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 (dhāraēā) 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., caïcalatā (random thought), ekāgrata (concentration), dhāraēā (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 Pataïjali’s Yoga Sūtras (Taimini, 1961) and Bhāgavad Gētā (Bhaktttivedānta Svāmi Prabhupāda, 1998)] it has been described that when awake and in the absence of a specific task the mind is very distractible (caïcalatā), and has to be taken through the stages of ‘streamlining the thoughts’ (concentration or ekāgratā), followed by one-
pointed concentration (focusing or *dhāraṇa*), 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 caïcalatā session (Pre versus During, 0.4%), ekāgratā session (Pre versus During & post, 0.9% and 1.56%) and following the dhāraēā 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 caïcalatā (7.3% to 10.28%), ekāgratā (7.43% to 11.36%), and dhāraēā (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 caïcalatā 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 caïcalatatā and ekägratā sessions caïcalatatā (Pre versus During & post 15.95% to 22.67%), ekägratā (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 ekägratā 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 ekägratā 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 dhārarāēa session (16.21% and 13.31%) compared to the pre scores, whereas after the caïcalatatā 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
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, dhāraēā and dhyāna appeared to be related to changes in vagal tone, the present results suggest that meditative focusing (dhāraēā) may be the phase during which attention improves.

8.2 CONCLUSIONS
These results showed that information transmission along the auditory pathway is delayed during caïcalatā and ekāgratā with no change during dhāraēā 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 (dhāraēā) may improve attention by 13% in net score.

Hence the null Hypothesis: (1) the information transmission in auditory pathway will not be delayed in caīcalatā, ekāgratā, and dhāraēā 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 dhāraēā (3) there will be no increased attention in all phases ekāgratā, dhāraēā and dhyāna with no higher increase in dhyāna is disproved. It appears that separating meditation as dhāraēā and dhyāna and comparing these phases with caīcalatā, 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 Pataïjali (Circa 900 B.C.), dhāraēā and dhyāna, resulted in group significant and distinct changes showing that the phase of dhāraēā 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 on other Dhāraṇā and Dhyāna components in them.