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A COMPARISON OF PHYSIOLOGICAL CORRELATES ACCOMPANYING TRANSCENDENTAL MEDITATION AND RELAXATION PERIOD

by

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ABSTRACT

Heart rate, respiration, skin conductance, muscle activity, cephalic vasomotor activity and electroencephalograph measurements were obtained from twenty-four subjects in order to test the hypothesis that the practice of Transcendental Meditation is associated with a hypometabolic state. Sixteen of the subjects were experienced practitioners of Transcendental Meditation and were randomly divided into two groups; one was asked to meditate during the test period and the other was not. The other eight subjects were non-meditating controls who sat for a relaxation period. Decreases in heart rate were evident in all three groups while no change was observed in respiration across the test period. During meditation meditators showed significantly greater decreases in skin conductance than did the meditators and non-meditators during relaxation. None of the groups showed any appreciable changes in cephalic vasomotor activity throughout the experiment. No particular changes in muscle activity were observed in most subjects; however, several meditators appeared to experience an 'active' meditation in which increased muscle activity was observed. The electroencephalogram distinguished the meditators from the non-meditators in that the former showed a predominance of alpha wave activity.

It would appear that Transcendental Meditation is accompanied by a variety of physiological changes, although not to the extent implied by the term, hypometabolic state. The extent to which these changes occur, both during meditation and other processes, requires further investigation including the use of longitudinal research.

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Introduction

Recently great interest has been displayed in the objective examination of the physiological patterns accompanying the practice of meditation. Particular attention has been given to Transcendental Meditation (T.M.), a technique widely practised in Western society and which forms the topic of investigation in this study. Initially this introduction will review some of the earlier research done on other meditation techniques and then consider some of the work which has dealt specifically with T.M.

Physiological Research on Meditation Techniques Other than T.M.

Prior to the recent upsurge in interest, most physiological research on meditative techniques involved subjects with extensive experience in their own particular techniques. The claims investigated were often unusual e.g., the stopping or controlling of the heart, pit burials for long periods of time, voluntary control of body temperature, etc.

One of the pioneers in this field was Therese Brosse who in 1935 used a portable polygraph in India to monitor the heart activity of several Indian yogis. One of her published records, involving one electrocardiographic lead, a pneumogram, and a pulse wave recording from the radial artery, shows the heart potentials and pulse wave decreasing to approximately zero and remaining there for several seconds. In 1957 Wenger, Bagchi and Anand conducted more sophisticated research in India investigating three yogis who claimed to be able to stop their heart beat and one who claimed to be able to slow it. Among these four was the subject Brosse had studied in 1935. It is obvious from their results that these subjects did not voluntarily control the heart directly but that striate muscle activity was used to produce changes in circulatory patterns. For three subjects the means to produce these changes appeared to be a technique called the Valsalva maneuver, which involves the production of increased tension in the abdominal and thoracic muscles, closure of the glottis, and the development of intrathoracic pressure, interfering with venous return to the heart. Heart sounds in these subjects were masked by muscle activity and the radial pulse appeared to disappear. However, high amplitude finger plethysmography continued to show pulse waves and the electrocardiograph showed continued heart contractions. It seems that Brosse obtained the results she did because she used only one lead configuration and did not take into consideration the nature of the Valsalva maneuver. The subject who claimed only to slow his heart rate did so markedly and it is postulated that through striate muscle mechanisms he stimulated vagus output to the sinoatrial node, causing interruptions in regular cardiac cycles and the brief establishment of nodal rhythms.

Anand and Chhina (1960) conducted a similar investigation with three yogis who claimed to be able to voluntarily stop their heart beat. They found that they could not actually do so; in fact, during the forced holding of the breath and for a short period immediately after it, there was an increase in heart rate, although slowing occurred for some time following this period.

Several accounts have been given of the recent research done by

Green on Swami Rama and his attempts to control his heart activity. When the Swami 'stopped' his heart the polygraph showed a reading of 300 beats per minute -- a sudden atrial fibrillation, which would for most be a dangerous cardiac condition preventing blood from being pumped throughout the body. It was also reported that he was able to produce a temperature difference of ten degrees Fahrenheit between two adjacent areas of his right hand.

Testing Yoga students in India, Wenger and Bagchi (1957) reported slightly higher heart rate, greater palmar skin conductance, higher systolic and diastolic blood pressure, and lower respiration during meditation, than during a relaxation period. It was hypothesized that these physiological differences were in part attributable to the different positions maintained by the subjects during the two procedures -- a reclined savasana pose for relaxation and an erect legs crossed position for meditation.

The results obtained for these students were compared to those obtained from five experienced yogis. However, some of the second group were apparently bothered by the experimental apparatus, and none felt he had attained his deepest state of meditation. Also, some subjects displayed both marked increases and decreases in autonomic functioning, indicating that repeated recording sessions may have been necessary to obtain more meaningful results. Compared with the students, the older yogis displayed faster heart rates, greater palmar skin conductance, and higher blood pressure, suggesting increased sympathetic arousal and perhaps a more active meditative process than that observed in the students. With respect to these results and the possible long-term effects of Yoga the authors commented that ". . . controlled longitudinal research perhaps offers the best approach for investigating the effects of Yogic practice." (Wenger and Bagchi, 1961, p. 321).

Wenger and Bagchi (1957) report elsewhere on results obtained from 13 advanced yogis studied in different locations, including mountain caves. These subjects exhibited a stabilization or lowering of heart rate, respiration and, particularly, skin conductance, during meditation. Well-modulated alpha wave activity was present in the electroencephalograph (EEG) with low intensity stimuli not appearing to reach consciousness. However, the authors state that these physiological trends showed variability and independence in terms of extent, timing and direction.

Anand, Chhina and Singh (1960) conducted experiments on Shri Ramanand Yogi while he was sealed in an air-tight box on two occasions, once for ten hours and once for eight hours. The data would indicate that he was able to reduce his oxygen intake and carbon dioxide output over the levels under basal conditions. His average oxygen utilization while in the box was 13.3 liters/hour as compared to basal requirements of 19.5 liters/hour. Even when breathing air with a decreased oxygen content and increased carbon dioxide content the yogi did not develop and hyperpnoea or tachycardia. The EEG changed from alpha to low voltage fast waves resembling those of the early stages of sleep; these waves were present for most of his time in the box without passing into typical sleep patterns.

One of the earlier studies done on the EEG patterns of yogis is that of Das and Gastaut (1957). The first issue which they considered in this study, and it may be the most important one, is the necessity of obtaining genuine yogis to study. They state, perhaps a little over-zealously, that the problem is "... the absolute impossibility of meeting a true yogi outside India, an obstacle that the Western researcher finds even in India, since one of the ironclad rules of a yogi is never to exhibit his powers in public. If we now report a study on this subject, it is due to the one of us who lived in India in the faith of his fathers, who frequented a community of yogis since his youth, and who managed to get his fellow Hindus to lend themselves to a true study in his presence only." (Das and Gastaut, 1957, p. 211).

Recordings were obtained from seven subjects with 2 - 15 years involvement in yogic techniques. Only one subject reported that he attained samahdi, the deepest state of meditation, during testing, while the others had less extreme experiences. There was no evidence of any recordable muscle activity (EMG) during meditation. A most interesting observance was that the EKG appeared to follow a pattern that paralleled the changes in EEG. For the one subject who reportedly attained samahdi the EKG pattern was as follows: 85 beats/min before meditation; 90 beats/min during light meditation; 95 beats/min during profound meditation and samahdi; 70 beats/min after meditation.

The EEG showed several modifications of the basic alpha rhythm displayed by all subjects. The first was an acceleration of the alpha rhythm by 1-3 Hz, a diminuation of amplitude and the appearance of high frequency low voltage waves of 15, 20 Hz. Beta rhythms of 16-20 Hz appeared in the rolandic area or if already present they increased in amplitude. These were followed by high frequency low voltage waves in both hemispheres of 20-30 Hz. and as high as 40 Hz which increased in amplitude during states of profound meditation. At the completion of meditation alpha wave activity reappeared with a frequency as slow as 7 Hz.

During meditation stimuli were presented to the subjects. The authors report that, ". . . all auditory, photic, tactile and noxious stimuli applied during profound meditation had no effect on the cerebral electrical activity and these stimuli did not modify the rapid, large-amplitude rhythms described above." (Das and Gastaut, 1957, p. 216). The lack of detail given concerning the nature of the stimulation makes it difficult to interpret the significance of these data. It would be of particular interest to have more information concerning the tactile and noxious stimulation.

In an attempt to account for the neurological mechanisms producing the changes observed during meditation the authors, ". . . postulate that yogic meditation represents an extreme concentration of attention on the object of meditation accompanied by intense reticular excitation with desynchronisation or rapid synchronisation of the cortical electrical activity, cardiac acceleration and physiological sensory deafferentiation." (Das and Gastaut, 1957, p. 219).

In the studies cited so far it can be seen that the physiological patterns observed by various researchers studying meditation are often somewhat contradictory. This may be explained by the fact that there are many different techniques of meditation subsumed under the title Yoga with some of them producing a hypometabolic state and others a hypermetabolic state. However it would seem that the deepest state of meditation, samahdi, should be similar across studies regardless of the technique employed to attain that state.

Anand, Chhina and Singh (1960) obtained EEG data from four highly experienced yogis in order to further assess the statement that during deep meditation they appear oblivious to environmental stimuli. Two of the yogis were exposed to visual, auditory, thermal, and vibrational stimulation. One of these practised what is described as "pin-pointing of consciousness" on different points on the vault of the skull. The other two yogis were reported to have increased pain thresholds to cold water and were able to keep their hand in 4 degree Centigrade water for 45-55 minutes without discomfort.

While at rest all four subjects displayed prominant alpha activity; during meditation there was persistent alpha activity with increased amplitude modulation. In the two who received the stimulation, alpha activity during the resting period showed consistent blocking without any habituation to the stimuli, whereas in meditation no alpha blocking occurred. The attempts at pinpointing of consciousness were accompanied by eye-blink responses in the frontal EEG channels. The two who immersed their hands in water showed persistent alpha activity before and during the period of immersion.

An interesting aspect of this research but one that is not elaborated on is the authors' report that they examined the EEG activity of beginners in yogic practices and found that those who showed well marked alpha activity in a resting period displayed a greater aptitude and enthusiasm for Yoga. If this were a consistent finding it could have important implications for physiological research on meditation. It may be possible to determine in advance whether a person is more or less suited to involvement in Yoga.

Swami Rama while being tested by the Greens experimented with feedback of EEG activity and is reported to have produced alpha and theta wave activity at will (Luce and Peper, 1971, p. 43). He also displayed 25 minutes of EEG activity associated usually with deep sleep, following which he gave a highly accurate account of verbal statements that had been made in his presence during this period.

A thorough investigation of EEG activity during Zen meditation was carried out by Kasamatsu and Hirai (1966). An important distinction between Yogic meditation and Zen meditation, called Zazen, is that the latter is performed with the eyes half open, focused in a downward direction about two feet in front of the meditator. Included in this study were subjects of in excess of 20 years practice of Zen and a control group who had no training in the technique. The EEG changes during Zazen can be summarized in four stages: the appearance of alpha waves; an increase in the amplitude of persistent alpha waves; a decrease in the alpha wave frequency; and sometimes the appearance of theta waves. For the control subjects no changes in EEG were observed, with a predominance of beta wave activity and short bursts of alpha waves prevailing throughout. The results indicated that the greater the experience in

Zen the more extensive the EEG changes. An interesting aspect of this research is that the Zen master's rating of the development of his students' mental state was correlated with the extent of the EEG changes, indicating, perhaps, that increased proficiency in Zen training is accompanied by changes in the EEG.

Kasamatsu and Hirai distinguish the EEG patterns observed in Zazen from those accompanying hypnosis and sleep. The EEG record of the former shows few alpha waves and an abundance of beta wave activity. In the drowsy sleep state the reaction to click stimuli is alpha activity and the typical arousal reaction, whereas in Zen meditation click stimuli block the theta waves, but they spontaneously reappear after several seconds.

The response to repeated click stimuli presented during Zen meditation was very different from the response obtained with practitioners of Yoga, where habituation of the alpha blocking response is consistently observed. In experienced Zen meditators the following pattern was observed: with the first stimulus the alpha blocking occurred for two seconds; although the stimulus was presented 20 times at regular intervals of 15 seconds the blocking always occurred for 2-3 seconds. For the control group the longer the stimuli were presented the greater the habituation.

These EEG differences between the Zen and Yogic meditation respones to stimuli may be explicable on the basis of important differences in the philosophies of the two techniques. In the Yogic meditation, an attempt is usually made to minimize one's awareness of body and surroundings, so that a centering device such as a mantra or euphonic sound is often employed. The studies cited earlier indicate that habituation of alpha blocking occurs to repeated stimulation with Yogic meditators and that many subjects appear oblivious of the stimulation. In Zen meditation the effort is more towards adopting a stance of passive, unattached observance of events, each stimulus being accepted as stimulus itself.

<u>The Physiology of Transcendental Meditation</u>

Transcendental Meditation was first introduced to Western society by Maharishi Mahesh Yogi in 1958 and is considered by him to be a meditation technique particularly suited to Western life styles. The initiate is given a mantra and instructed in the technique by a qualified teacher. Maharishi has defined the process as, "turning the attention inwards towards the subtle levels of thought until the mind transcends the experience of the subtlest state of the thought and arrives at the source of the thought."

The philosophical goals of meditation are somewhat difficult to define and vary in name with different traditions -- samahdi, nirvana, self-realization, satori, enlightenment, different names for essentially the same experience. With reference to the somewhat elusive subjective descriptions of these meditative experiences Maharishi has asserted that just as there are distinct physiological states accompanying waking, dreaming and deep sleep, there are distinct and objectively verifiable physiological patterns accompanying T.M. It is this encouragement which has in part resulted in the tremendous output of scientific research on T.M. evident during the past several years.

The purpose of this review is not to examine all of the research in this area but rather to present a representative sample of the type of work which is being done and to acquaint one with the types of designs being used so as to provide a basis for the hypothesis of this thesis.

Since its introduction to Western society there have been many informal, subjective reports that T.M. is associated with a hypometabolic state, that is, with a reduction in the rate at which the body uses its energy resources. One of the first empirical studies in this area is that of Wallace (1970). Twenty-seven subjects of varying years involvement in T.M. served as their own controls in this study, sitting for a period prior to meditation with their eyes closed but with the instructions to not meditate until told to do so. Not all of the physiological variables were measured in all subjects but on the basis of the data obtained, Wallace reports that: 1) within 5-10 minutes of beginning meditation there were significant decreases in oxygen consumption and carbon dioxide elimination, although the respiratory quotient remained relatively the same throughout the testing; 2) respiratory rate decreased by about three breaths/minute on the average, with the largest decrease being seven breaths/minute; 3) after 15 minutes of meditation the mean decrease in cardiac output was approximately 25 percent below the control period; 4) there was a mean decrease of five beats/minute in heart rate; 5) there was a decrease in arterial blood pressure; 6) arterial lactate decreased markedly, a decrease that continued for some time after meditation; 7) large increases in skin resistance were obtained for all subjects; 8) the most characteristic change in the EEG was an increase in the intensity of the 8-9 Hz waves in the centrol and frontal regions. In some subjects this increase was accompanied by trains of 5-7 Hz theta waves in the frontal areas.

In a similar study Wallace (1970a) examined physiological changes accompanying T.M. with 15 college students. Although the design was similar to the previously cited study several subjects in this research received auditory and visual stimulation at irregular intervals during the meditation. The results reported are similar to those described earlier, with the alpha blocking to stimulation showing no habituation during meditation for almost all subjects. Wallace concluded that " physiologically, the state produced by T.M. seems to be distinct from commonly encountered states of consciousness such as wakefulness, sleep and dreaming and from altered states of consciousness such as hypnosis and autosuggestion." (Wallace, 1970a, p. 1754).

Recognizing that the apparatus used to measure respiration could interfere somewhat with the meditative process, Allison (1970) used three thermisters placed over the mouth and nostrils; they were comfortable and offered minimal distraction. He reports that, during meditation, the respiration rate dropped as low as four breaths/min about half the resting rate. Wallace, Benson and Wilson (1971), studied 36 practitioners of T.M., again with each subject serving as his own control. The results of this study appear to be similar to those obtained by Wallace in his earlier research, although blood lactate was measured somewhat more extensively and was found to decrease in concentration markedly during meditation, and to continue to drop for ten minutes after meditation. In reporting on this study elsewhere, Wallace and Benson (1972) suggest this sharp decrease in blood lactate may be in part responsible for the highly relaxed, though wakeful, condition present in T.M. They attribute it to an increase in blood flow during meditation caused by a reduction in sympathetic activity, resulting in an absence of vasoconstriction as well as a reduction in norepinephrine secretion which would diminish lactate production. This decrease in blood lactate could be considered beneficial when coupled with the evidence that intravenous injections of lactate may cause anxiety sumptoms, that patients with anxiety neurosis show a rise in blood lactate in stress situations, and that hypertensive patients show high blood lactate levels even in the resting state (Pitts, 1969). They conclude that: "...the hypometabolic state, representing quiescence rather than hyperactivation of the sympathetic nervous system, may indicate a guidepost to better health. It should be worthwhile to investigate the possibilities for clinical applications of this state of wakeful rest and relaxation." (Wallace and Benson, 1972, p. 84).

Further research on decreased blood lactate during T.M. is reported by Wallace, Benson, Wilson and Garrett(1971). As in the earlier research there was a marked decrease in blood lactate during meditation, a decrease which was maintained for a short period following meditation.

One obvious criticism of the research cited so far is the lack of adequate control groups. Meditators served as their own controls prior to the meditation period with no attempt being made to compare the changes occurring in meditators to those which might occur with non-meditating subjects under the same conditions. Other considerations would be to compare the results of T.M. to those obtained from other techniques such as relaxation procedures or other forms of meditation. Wallace mentions that the differences between the precontrol, control and postcontrol periods may have been affected by the fact that some subjects reported that during the precontrol and postcontrol periods, when told to sit quietly with their eyes closed, they had a predisposition to meditate. Any attempt to prevent the subjects from meditating in the pre- or post- periods, such as asking them to engage in some active mental exercise, could not be considered comparable to asking someone to sit in a relaxed, eyes closed state. It may be that for this type of design the comparison should be made between a meditation period with an eyes open pre- and post- control period, and a non-meditator who follows the same procedure except that he would be told to relax in the control period with his eyes closed.

A study using non-meditating controls was conducted by Brown, Stewart and Blodgett (1971) who compared 11 meditators and 11 non-meditators on EKG, EEG, respiration and performance on four perceptual threshold tasks. Precontrol performance measures were followed by a 15 minute period in which the meditators practised T.M. and the control group sat quietly with eyes closed. Following this the performance tasks were repeated.

There were no significant differences between the two groups on perceptual performance measures, with the performance of both groups showing improvement. The EEG of 10 of the 11 meditators showed 8-12 Hz waves in the frontal regions whereas only 3 of the 11 non-meditators showed this pattern. A distinction was made between 8-12 Hz waves of the occipital area and those of the frontal region. The former are usually displayed under eyes closed, relaxed situations and are the familiar alpha waves, whereas the latter fit the definition of kappa rhythms. These are described as EEG rhythms with a frequency of 7-12 Hz which are most prominent with bilateral bipolar recording from the frontal regions and which are present most noticeably during mental tasks. In some meditators these kappa rhythms were present before, during and after meditation. Brown et al, conclude that ". . . a scientific question unanswered to this time has been whether T.M. is a state of consciousness between sleep and wakefulness. Presence of kappa rhythms in all but one of the 11 meditators and only at a low level in three of the 11 non-meditators would tend to suggest it to be something else. Rather, it tends to suggest a higher level of frontal-cortical activity instead. This would be expected if meditation is a higher state of consciousness to which the meditator allegedly transcends." (Brown, Stewart and Blodgett, 1971, p.5).

Preliminary research by Spong, Low and Wada (1970) included both experienced and inexperienced practitioners of T.M. During some sessions intermittant click and flash stimuli were presented to the subjects. All subjects displayed a tendency towards increased alpha wave activity and one inexperienced subject showed substantial increases in the amount of alpha activity over the sessions. Also, a decrease in alpha frequency, and short periods of theta wave activity were observed. Habituation of the alpha blocking response to the stimuli was much greater in in inexperienced than experienced subjects, with all subjects showing greater habituation of alpha blocking to click than to flash stimuli.

The experienced subjects showed no change in their alpha blocking over the sessions and displayed more habituation of alpha blocking in an initial control session without meditation than in subjsequent sessions with meditation. The inexperienced meditators displayed decreased habituation of alpha blocking over the sessions. There was a decrease in muscle tension and inconsistent tendencies for heart rate (mostly decreases) and respiration rate to change. One of the experienced subjects displayed no obvious habituation of visual evoked responses to the 300 flash stimuli presented during a meditation which the subject considered successful. Evoked responses computed for the first and last 50 flash stimuli were very similar, unlike a session without meditation in which the longer latency components of visual evoked responses to the flash stimuli were reduced in amplitude at the end of the session. During a meditation which the meditator considered unsuccessful, the visual evoked responses were lower in amplitude at the end than at the beginning of meditation. It would appear that the variability of habituation of visual evoked responses is related to the success of the meditation, coupled with the experience of the mediator. There also seems to be a relationship between alpha blocking and the evoked responses in that subjects who show greater habituation of alpha blocking during meditation also exhibit greater habituation of evoked responses. This relationship appears to extend to the subject's evaluation of the meditation session -- in those evaluated as successful subjects were less aware of the external stimulation than in sessions evaluated as less successful. The data suggest that T.M. is not accompanied by a lowered cortical responsiveness to sensory stimulation but rather by a high level of response readiness, despite absence of attention to or perception of, the stimulus source.

This study has been extended to include more subjects and has involved data collection over two years. The earlier results were confirmed with respect to evoked potentials. However, Wada comments on an important aspect of the results, namely the degree of inter- and intra-subject variability and the fact that the objective evaluation of the subject's reports on the quality of a meditation session was difficult and often misleading. He states that, ". . . a possibility of a predisposition for 'ideal' meditative states was suggested by the fact that some experienced subjects showed largely incongruous subjective and objective states in spite of the prolonged past expereince while some inexperienced subjects achieved relatively congrous subjective and objective states with relative ease." (Wada, 1973, p. 2).

Computerized spectral analysis was performed by Banquet (1972) on selected channels of the EEG of 12 subjects practising T.M. and a group of 12 control subjects who were about to begin T.M. A push-button apparatus permitted subjects to indicate which one of five psychological events might be occurring during meditation: body sensation; involuntary movement; visual imagery; deep meditation; and transcendence.

The results for the control group can be divided into two groups, an alpha plus and an alpha minus group. The latter displayed beta dominant frequencies throughout the session while the former showed alpha rhythms. In the alpha plus group four subjects alternated posterior alpha patterns with the previously dominant beta activity which was equated with successful relaxation while the other four subjects associated alpha activity with slow theta waves and low voltage delta frequencies with a subjective report of drowsiness.

For the meditators alpha wave activity was present in all subjects during the pre-meditation rest period and became predominant at the beginning of meditation, with amplitude increasing and frequency decreasing. Following this a typical shift from the dominant alpha to slower theta wave activity was observed. In four meditators a third stage was observed which the subjects indicated, via the push-button, to be deep meditation or even transcendence. This period was characterized by a dominant beta rhythm with frequencies of 20 Hz and 40 Hz. The end of meditation was characterized by alpha activity, with advanced meditators showing a persistence of alpha and some theta wave activity into the eyes open period.

Topographically two changes were observed during meditation. There was a tendency towards synchronisation of the anterior and posterior derivations, with alpha rhythms spreading from the occipito-parietal to the anterior channels and theta and beta patterns diffusing posteriorly from the frontal channels. Also, a transient symmetry between right and left hemispheres was observed in the shifting phase from slow to fast frequencies -- beta activity appeared first in the left hemisphere from the frontal to the occipital channels.

Flash and click stimuli were administered to seven subjects at different stages of meditation. During the periods of alpha wave activity there was usually no blocking to the stimuli. The click stimuli blocked the theta wave activity but only for a few seconds; during the faster frequencies associated with deep meditation no changes in brain-wave activity were associated with the stimulation.

Banquet also noted that as the meditation progressed, muscle activity and eye movements disappeared and respiration became slower and shallower. He states that voluntary movement to push the button could be performed at any state of meditation without altering brain wave patterns and that subjects could answer questions readily and accurately.

To distinguish the meditative state from other states of consciousness Banquet discusses some of the unique EEG characteristics of the former state, such as the maintenance of alpha activity after meditation with the eyes open and the diffusion of large amplitude alpha waves to anterior regions. As was reported earlier, the study by Kasamatsu and Hirai (1966) describes how the response to flash and click stimuli distinguishes the slow frequencies of meditation from those of drowsiness and sleep -- stimulation during the latter state produces a typical arousal reaction. Banquet noted the same thing in his research and also that the theta rhythms of meditation are continuous trains of dominant theta activity at a constant frequency as compared to the mixture or alterations of alpha, beta and discontinuous theta activity seen in drowsiness. Another distinction is found in the low voltage beta wave activity of deep meditation and that of the awake subject. The former appears on a background of slow frequencies, has spindle-like amplitude modulation and shows rhythmic fast frequencies around 20 and 40 Hz, while the latter is characterized by dominant fast frequencies without any rhythmicity or regularity.

One aspect of Banquet's research which is difficult to understand from a meditator's point of view is that subjects were apparently able to indicate by push button when they were experiencing the deepest state of meditation or transcendence and even to answer questions in that state. It would seem that if the meditator has indeed transcended, the process of becoming aware of the stimuli and responding to it would serve to remove the individual from that state, i.e., he would be indicating what he had been experiencing not what he was experiencing.

The data obtained by Banquet on alpha blocking would appear to be contradictory to the results obtained by Wallace (1970) and Spong, Low and Wada (1970) in their examinations of EEG patterns during T.M. -- the latter observed little habituation to the stimuli, whereas Banquet reports consistent habituation. These differences may have important implications for the use of stimulation during meditation and this issue will be examined in more detail in the discusssion.

To investigate the effects of T.M. on certain aspects of autonomic functioning related to an individual's response to stress, Orme-Johnson (1971) studied both habituation of GSR to a tone and the frequency of spontaneous GSR fluctuations as a function of meditation. Detailed evidence is presented to suggest that autonomic stability is positively correlated with characteristics beneficial to health and that lability may result in "malfunction".

Two studies were carried out. In the first, a habituation study, the subjects -- both meditators and non-meditators -- received tone presentations until the criterion for habituation was attained. These subjects were also measured for spontaneous GSR several weeks later.

Initial responses to the tone were similar for both groups, with the meditators habituating faster to the tone than the non-meditators. Although the two groups appeared to be equally sensitive to the tone initially, the mean trials to criterion for the meditators was 11.0 as compared with 26.1 for non-meditators. Meditators also showed fewer secondary responses to the tones as well as rapid habituation. On the basis of these results it appears that T.M. may bring about rapid homeostatic stabilization under conditions of auditory stress. The meditators also made significantly fewer spontaneous GSR's over the test period than did the non-meditators. In the second study, subjects planning to begin T.M. were "normal" with respect to spontaneous GSR activity whereas over three different sessions the meditators consistently emitted fewer spontaneous GSR's. Orme-Johnson concluded that, "T.M. may influence autonomic balance by increasing parasympathetic activity, decreasing sympathetic activity or both. The possibility that T.M. reduces sympathetic dominance is consistent with the observation of Wallace, Benson and Wilson (1971) that meditators have low resting levels of blood pressure, and it would explain the present findings of rapid GSR habituation and low levels of spontaneous GSR in meditators, the GSR being a purely sympathetic response." (Orme-Johnson, 1971, p. 17).

Several exploratory studies have been completed by Schwartz (1973) and his co-workers to evaluate the hypothesis that T.M. produces a hypometabolic state. In the first study, an attempt was made to investigate the claim that meditation could be carried out even while riding in a subway. Meditators and non-meditating controls were exposed to recorded subway noises while GSR and occipital alpha were being recorded. During initial eyes closed periods occipital alpha increased in both groups, but over the session there was a decrease in alpha, which was greatest for the controls. As only alpha wave activity was being scored it could not be determined if this decrease was due to increases in beta or theta wave activity. Meditators displayed more alpha activity with their eyes open than did controls at the beginning of the experiment, a situation which was reversed at the end of the session. This was attributed to a post-meditation sensitization effect in which visual stimuli appear more striking. The skin resistance changes differed from those obtained by Wallace et al (1970a;b, 1971, 1972); both groups displayed relatively small increases in skin resistance.

A second study (Schwartz, 1973) was initiated to investigate this failure to obtain large skin resistance changes and to further investigate the EEG sensitization finding. Meditators and non-meditating controls were examined over one extended eyes closed period. The EEG sensitization phenomenon was replicated. Again, large changes in skin resistance were not obtained during the meditation. After meditation a skin resistance level sensitization effect, similar to the EEG effect, occurred.

A third study compared skin resistance changes during T.M. and a relaxation period in anticipation of watching a stressful movie. Rather than displaying the expected increase in skin resistance the meditators showed decreases in skin resistance (i.e., increased electrodermal arousal) which were greater than those for the control group. Concerning these results, Schwartz commented that, ". . . what must be concluded from the data is that transcendental meditation has both trait and state effects, and that situational factors can play an important role in determining both the size and direction of the physiological effects that can be obtained. . . it may be necessary to do long term studies on individual meditators to observe large effects in multi-physiological systems, or even resort to portable, unobtrusive instruments in the field in order to assess changes presumed to take place in natural meditation." (Schwartz, 1973, p. 4).

Purpose of the Present Study

The research cited in the introduction has generally involved the use of subjects with formal training in meditation (e.g., Transcendental Meditation, Zen, Yoga). However, in much of this research adequate control groups against which the obtained results can be compared were not used. Even when non-meditating control groups are employed, several problems still exist. It is unlikely that non-meditators could be obtained who have spent the same amount of time sitting quietly with their eyes closed for extended periods as have the meditators. This situation makes it difficult to separate the effects of the technique from those of the process of sitting quietly with eyes closed over repeated sessions. A within-subjects design with the meditator serving as his own control by sitting with his eyes closed without meditating for some period prior to beginning to meditate is also inadequate. The eyes closed sitting position is most condusive to meditation and the tendency to begin meditation or to actively resist it is undoubtedly experienced by most meditators in spite of intentions to do otherwise. Even with this inadequacy the within subjects design is being used by most researchers in this area with little attention being given to the inappropriatness of this design.

Another factor to consider in comparing meditators to non-meditators is that those who begin meditation may do so by virtue of some special capacity they have for this experience or which causes them to seek this experience. They may differ from non-meditators even before beginning the technique. No attempt has been made to adequately assess any pre-meditation differences that may exist between the two groups.

An important aspect of most meditative techniques is that they usually stress the necessity of a teacher, one who is already involved in the practice and, having attained some degree of advancement or training, is recognized as being capable of imparting the knowledge to others. To what extent this specialized training is necessary is not fully known and it is possible that some of the changes occurring in these techniques may be available to some degree without this specialized instruction.

The present study was designed to investigate some of these issues, in particular: the use of meditating and non-meditating control groups; the predisposition for meditators to begin meditation when sitting with their eyes closed; the extent to which the physiological changes associated with meditation can be achieved by non-meditators; the extent to which meditators during meditation vary from meditators sitting with their eyes closed; the possibility of studying meditation in the laboratory setting and to assess some of the variables that might affect this type of research.

The design involved random assignment of Transcendental Meditators to two groups, one of which was asked to meditate for part of the test period, and the other to sit with eyes closed without meditating for part of the test period. A third group composed of individuals not involved in T.M. was asked to follow the same procedure as the second group of meditators. This latter group could be considered a control group like that used in most of the previous research; however, it would also be of interest to compare them with the second group of non-meditating meditators.

Using this design it should be possible to evaluate some of the physiological changes occurring in meditation, to examine to what extent these changes are unique to meditation and to what extent they occur in relaxed meditators or are available to individuals without training in meditation. It should be possible to determine whether the non-meditating meditators are able to resist meditating when sitting in the upright, eyes-closed position and if the laboratory situation affects the three groups differentially (i.e., is the balance necessary in meditation upset more by the environment than that required for relaxation).

Method

Subjects

The subjects were 24 male volunteers, most of whom were obtained through the cooperation of the Students International Meditation Society. The specific nature of the research was not revealed to the subjects prior to their coming to the laboratory; they were told only that they would be involved in a physiological experiment. The subjects ranged in age from 20 to 30 years with a median of 24.5 years. Sixteen of the subjects were practitioners of T.M. with a range of 19 to 90 months experience with the technique. These subjects were randomly divided into two groups. A third group was composed of 8 non-meditators, four of whom had made appointments to begin T.M. and the other four having not expressed any interest in beginning T.M.

One of the original subjects assigned to the meditation group had to be replaced since excessive body movements during the experiment made his record unscorable.

Apparatus

A Beckman Type R Polygraph was used to record respiration, palmar skin conductance, heart rate, cephalic vasomotor activity, electromyoghic activity (EMG) from the neck, and EEG.

Skin conductance was measured directly by putting a constant voltage of 0.5 V across two Beckman biopotential electrodes attached to the first and third fingers of the left hand; a 0.5 percent NaCl paste was used as the contact medium. Heart rate was obtained from a standard lead I configuration and a cardiotachometer coupler which expressed the output in beats per minute (bpm). Cephalic vasomotor activity was measured by placing a photocell plethysmograph (with a light-emitting diode as the light source) in the middle of the forehead; the signal was AC coupled with a time constant of .03 seconds. A strain gauge recorded respiratory activity. Integrated EMG activity was recorded from the neck, using the leads described by Lippold (1967). Occipital EEG recordings were made using a single electrode placed approximately 2-3 cm. anterior to the inion on the midline, roughly corresponding to electrode placement O_2 according to the 10-20 system. A reference electrode was clipped to the right ear. The signal was AC coupled with a time constant of .03 seconds. Chart speed was 10 mm per second.

Procedure

Subjects first filled out a brief life history questionnaire and then sat in a comfortable chair in an air conditioned, dimly lit IAC acoustical chamber. The recording equipment was situated outside the chamber.

While the electrodes and transducers were being attached the nature of the acoustical chamber was explained to the subject and he was told that once the experiment began all communication between him and the experimenter would take place through an intercom. The hook-up time was approximately 15 minutes.

After the hook-up had been completed the subject was asked to sit quietly with his eyes open until given further instructions. Subjects in Groups I and II, comprised of trained meditators, were also told at this time that it was important that they not meditate until given instructions to do so.

After approximately five minutes the subject was told that the experiment would begin and that he should sit quietly with his eyes open.

Following another five minute period the subject was told to sit quietly with his eyes closed.

After ten minutes subjects in Group I were asked to begin meditation and those in Groups II and III were asked to continue sitting quietly with their eyes closed.

After 15 minutes subjects in Group I were asked to stop meditating and to continue sitting quietly with their eyes closed; those in Groups II and III were asked to continue sitting quietly with their eyes closed.

After five minutes all subjects were asked to open their eyes and to continue sitting quietly.

Following another five minute period all subjects were told that the experiment was finished.

The subject then was asked to fill out a short questionnaire and also to write a short paragraph summarizing his subjective impression of the session (see Table I for summary of procedure).

Analyses

The data were scored in the same manner for all three groups. Heart rate, respiration and skin conductance were scored as follows: for the minute prior to the initial instruction; for the first two 30 second periods and then for each minute of the five minute eyes open session; for the first 30 seconds and four other one minute periods throughout the ten minute eyes closed session; for the first 30 seconds and six other

Table I

Experimental Procedure

	5 min	10 min	15 min	5 min	5 min
Group I	eyes open	eyes closed	meditation	eyes closed	eyes open
Group II	eyes open	eyes closed	eyes closed	eyes closed	eyes open
Group III	eyes open	eyes closed	eyes closed	eyes closed	eyes open

one minute periods throughout the 15 minute meditation or relaxation session; for the first two 30 second periods and then for each minute of the five minute eyes closed session; and for the first two 30 second periods and then for each minute of the five minute eyes open period.

Vasomotor activity was scored by averaging the first and last ten peak-to-trough amplitudes for each of the selected time periods, which were: the second 30 second period and the last minute of the five minute eyes open session; for one minute following the first 30 second period and the last minute of the ten minute eyes closed session; for one minute following the first 30 second period and for two one minute periods during the 15 minute meditation-relaxation session; for the second 30 second period and the final minute of the five minute eyes closed session; and the second 30 second period and final minute of the five minute eyes open session.

The EEG was scored for the production of alpha waves over the entire ten minutes of the eyes closed session, the 15 minutes of the meditation-relaxation session, and the five minutes of the eyes closed session. The criterion for alpha activity was 8-13 c.p.s. regular waves of greater amplitude than the surrounding irregular waves with a duration of at least one second.

The first five minute eyes open period served as a baseline for the succeeding periods and the results are expressed as changes from this initial period. For certain measures further analysis was performed within the individual periods.

The scores obtained, excluding the EEG, were analyzed according to a repeated measures analysis of variance design, comparing the three groups across the periods and expressing them as a change from the initial eyes open period.

Results

Heart Rate

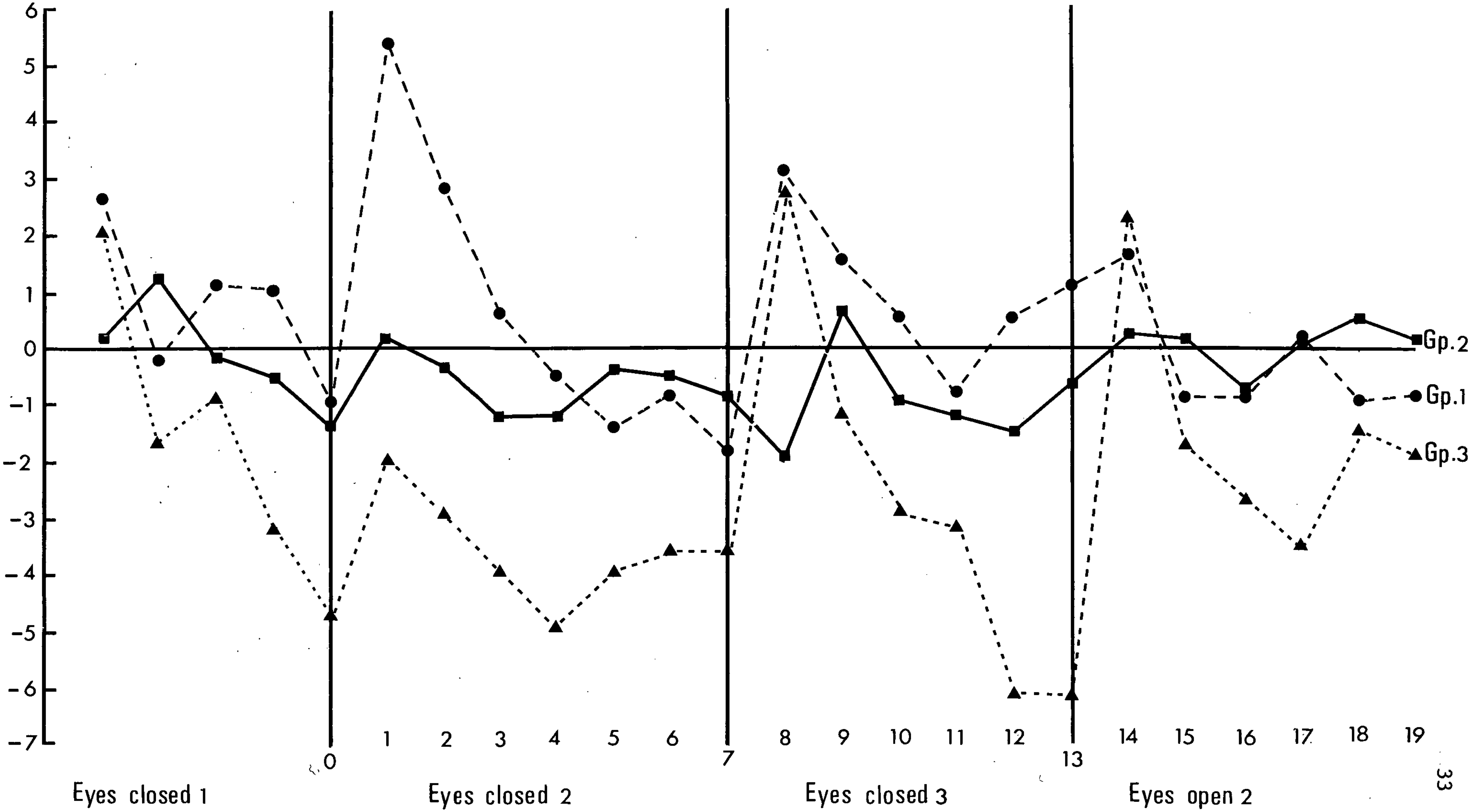
During the initial eyes open control period the means obtained for heart rate were: Group I - 77.4 beats/min; Group II - 78.1 beats/min; Group III - 67.9 beats/min. These differences between the groups were not significant.

The first eyes closed period resulted in significant decreases in heart rate across all groups ($F = 6.69$, $df = 5/105$, $p < .0001$). However, the groups effect and the groups X measures interaction were not significant.

During the second eyes closed period (the meditation or relaxation period) a significant measures effect ($F = 2.55$, $df = 6/126$, $p < .025$) was obtained, indicating an overall deceleration in heart rate. The groups effect approached significance. Figure 1 shows that initially heart rate accelerated, probably in response to the instructions given at the beginning of the period. A further analysis of variance was conducted within this period to investigate these effects. From point 0 - 1 (see Figure 1) a significant periods effect ($F = 5.55$, $df = 1/21$, $p < .03$) was observed; however the groups effect only approached significance ($F = 3.20$, $df = 2/21$, $p < .06$). From points 1-7 only the periods effect approached significance ($F = 3.62$, $df = 1/21$, $p < .07$).

In the third eyes closed period a significant measures effect ($F = 4.32$, $df = 5/105$, $p < .001$), indicating a deceleration in heart rate was observed. A significant groups X measures effect ($F = 2.58$, $df = 10/105$, $p < .008$)

Figure 1. Heart Rate Response



Resting means: 1 Group – 77.35 bpm
2 Group – 78.11 bpm
3 Group – 67.94 bpm

was also present indicating that the greatest deceleration was shown by Group III. Further analysis was conducted within this period (see Figure 1). From points 7-8 a significant periods effect ($F = 6.53$, $df = 1/21$, $p < .02$) was observed, indicating an acceleration in heart rate during the minute in which the instructions for the period were given. The groups X periods interaction approached significance ($F = 2.83$, $df = 2/21$, $p < .08$) due to the deceleration in heart rate of Group II in contrast to the sharp acceleration observed in Groups I and III. From points 8-13, a periods effect ($F = 4.92$, $df = 1/21$, $p < .04$) was observed due to the deceleration in heart rate which occurred following the initial acceleration at the beginning of the period. However, a significant groups X periods interaction ($F = 4.26$, $df = 2/21$, $p < .03$) emphasized the pronounced deceleration observed in Group III as compared to Groups I and II.

During the second eyes open period only the measures effect approached significance. From points 13-14 a significant periods effect ($F = 7.18$, $df = 1/21$, $p < .01$) was observed, again due to the acceleration in heart rate which accompanied the verbal instructions at the beginning of the period. However, the deceleration which accompanied the eyes closed periods did not occur in this eyes open period to a significant extent.

Skin Conductance

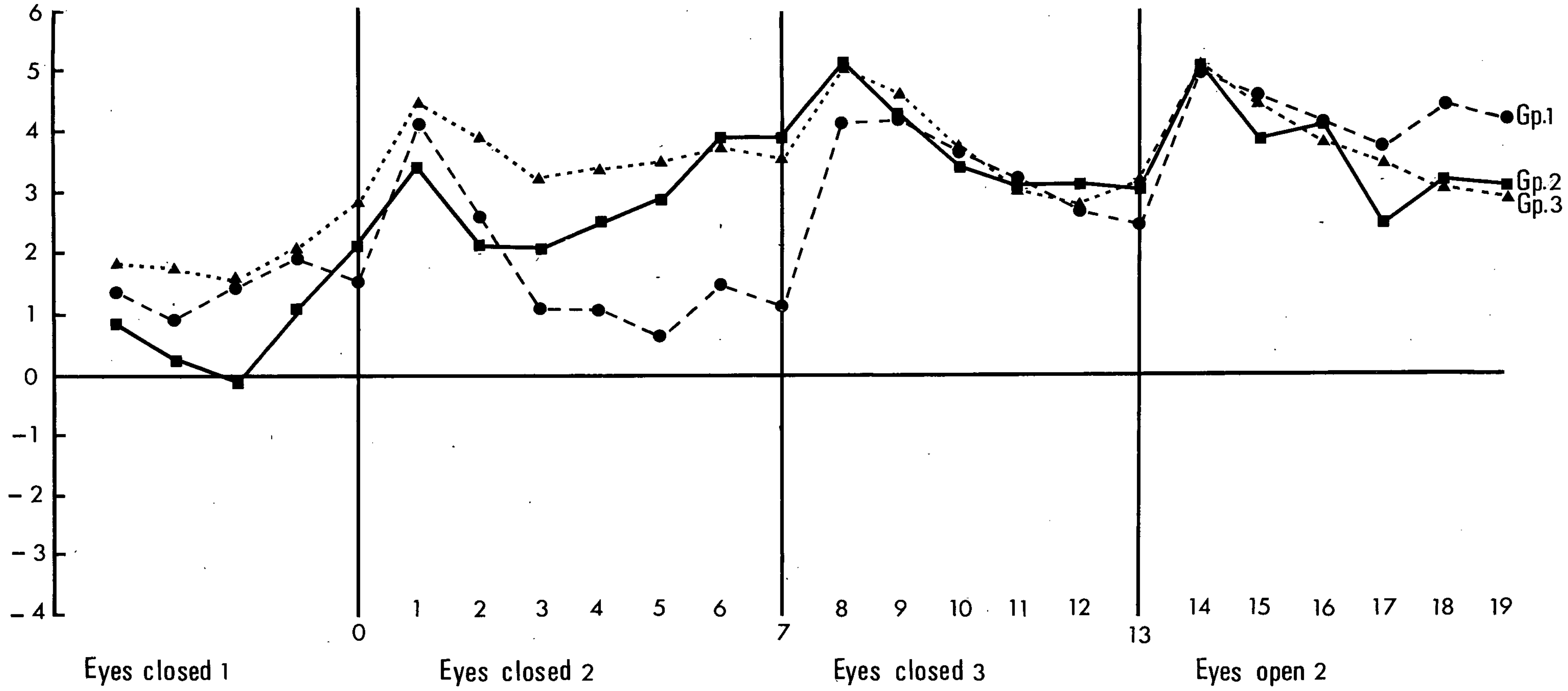
During the initial eyes open control period the means obtained for skin conductance were: Group I - 13.8 umhos; Group II - 10.6 umhos; Group III - 7.7 umhos. These differences between the groups were not significant.

In comparison to the control period the first eyes closed period produced a significant measures effect ($F = 2.50$, $df = 4/84$, $p < .05$), reflecting an increase in skin conductance in all three groups.

When the meditation or relaxation period was compared to the control period, a significant measures effect ($F = 7.72$, $df = 6/126$, $p < .0003$) was obtained, indicating a decrease in skin conductance in the three groups during this period. The significant groups X measures interaction ($F = 2.17$, $df = 12/126$, $p < .017$) may be attributed to the sharp decrease in skin conductance which occurred in Group I, as compared to the smaller decreases in Groups II and III.

As can be seen in Figure 2, the trend, throughout the experiment is for skin conductance to increase, and yet within several periods there is a significant decrease in this measure. At the beginning of each period an increase in skin conductance is usually observed, a response attributable to the effect of the instructions given at the beginning of the period. From this point a decrease in skin conductance is observed during the three periods. To emphasize this point, further analysis was conducted within these periods (similar to that done with heart rate). From points 0 — 1 (see Figure 2) a significant periods effect ($F = 21.88$, $df = 1/21$, $p < .0002$) was observed indicating an increase in skin conductance over this time period. From points 1-7 a significant periods effect ($F = 5.04$, $df = 1/21$, $p < .03$) indicated a decrease in skin conductance following the initial rise; a significant groups X period interaction ($F = 4.23$, $df = 2/21$, $p < .03$) emphasized the larger decrease observed in Group I.

Figure 2. Skin Conductance Response



Resting means: 1 Group – 13.79 μmhos
2 Group – 10.64 μmhos
3 Group – 7.70 μmhos

Skin conductance during the third eyes closed period was significantly greater than it was during the initial control period ($F = 10.09$, df = 5/105, $p < .00001$). Within this period analysis on points 7-9 indicated a significant measures effect ($F = 15.23$, df = 1/21, $p < .0009$) due to an initial sharp increase in skin conductance; this increase was followed by a significant decrease ($F = 12.47$, df = 1/21, $p < .002$) from points 8-13.

In the second eyes open period a significant measures effect ($F = 5.49$, df = 5/105, $p < .0002$) was observed, indicating a decrease in skin conductance. However, when the analysis was conducted on points within the period a significant initial increase was found from points 13-14 ($F = 12.03$, df = 1/21, $p < .013$).

<u>Respiration</u>

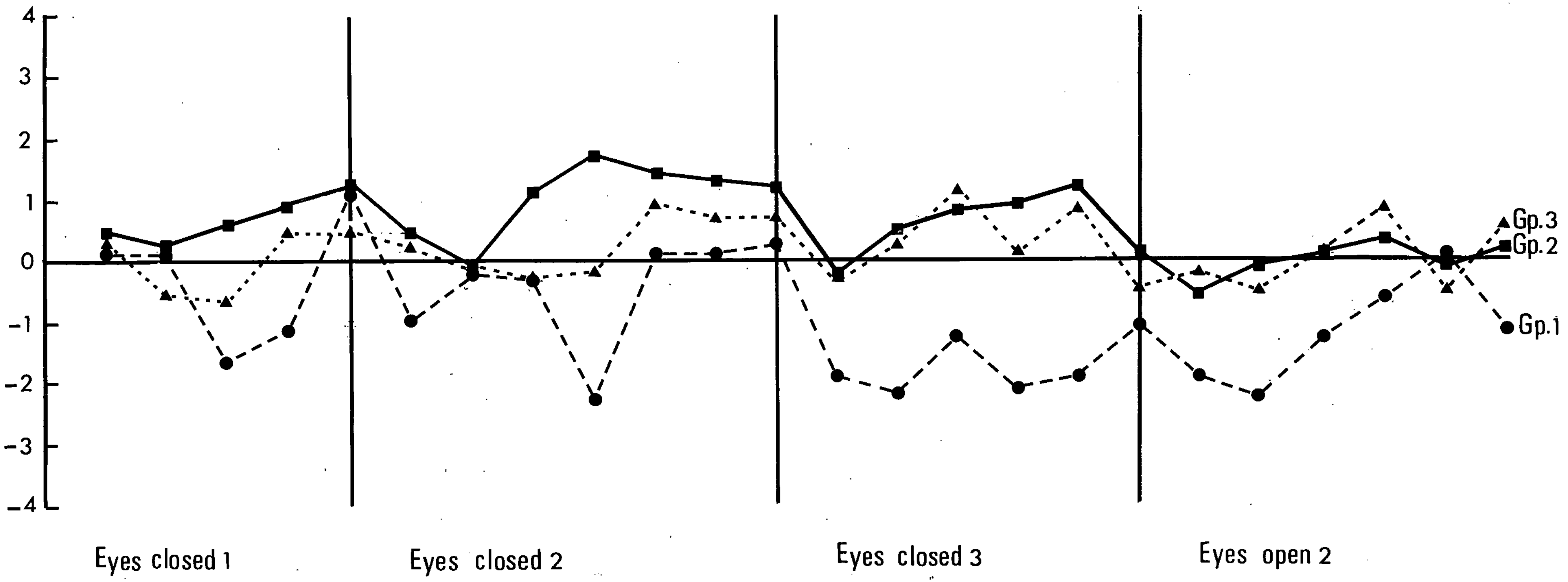
In the initial eyes open control period the mean respiration rates were: Group I - 13.49 cycles/min; Group II - 15.01 cycles /min; and Group III 15.2 cycles/min. These differences between the groups were not significant.

As compared to the control period no significant changes occurred in respiration during the first and second eyes closed periods.

During the third eyes closed period the groups effect approached significance ($F = 3.00$, df = 2/21, $p < .08$); this would appear to be due to the larger decrease in respiration observed in Group I as compared to Groups II and III (see Figure 3).

In the second eyes open period the groups effect again approached significance ($F = 2.65$, df = 2/21, $p < .10$); again this would appear

Figure 3. Respiration Rate



Resting means: 1 Group – 13.49 cycles/min.
2 Group – 15.01 cycles/min.
3 Group – 15.20 cycles/min.

to be due to the greater decrease in Group I as compared to Groups II and III.

Cephalic Vasomotor Activity

Cephalic vasomotor activity was computed for only three subjects in each group due to difficulties in scoring the records. In the five minute eyes open control period the mean pulse amplitude, expressed in milimeters, was : Group I - 6.73; Group II - 10.10; Group III - 9.37. These differences between the groups were not significant.

During the three eyes closed periods no significant differences in cephalic vasomotor activity were observed. In the second eyes closed period a significant measures effect ($F = 6.58$, $df = 1/6$, $p < .04$) was observed, indicating that vasocondilation occurred in this last period (see Figure 4).

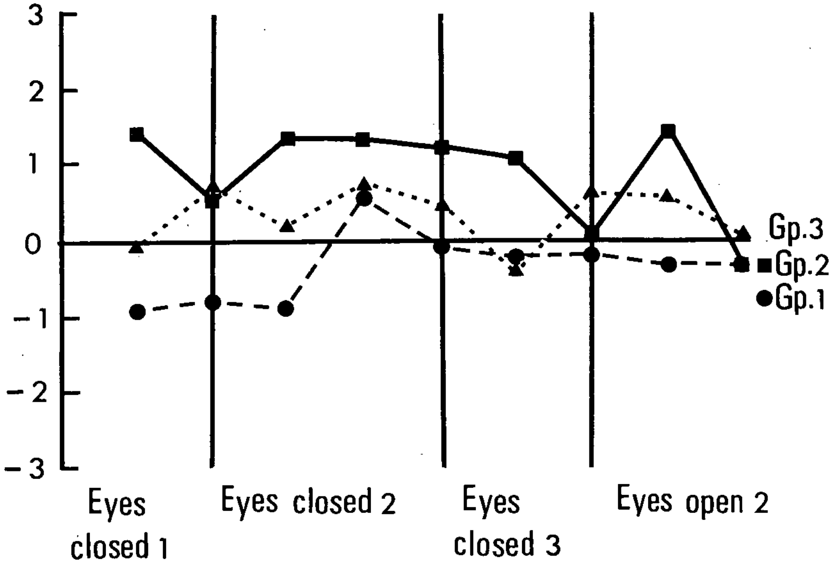
EEG Activity

The EEG activity of two subjects from each group was scored during the three eyes closed periods with alpha wave activity being the criterion measure. The particular records were selected because they were the most scorable by hand, displaying few artifacts and clearly defineable brain wave patterns. Due to the small number of records scored, no statistical analysis was performed on the data. The alpha wave percentages are presented below in Table II.

EMG Activity

Muscle tension in the neck was not quantified as in most subjects there was little apparent change in muscle activity over the session. However, in a few subjects, pronounced muscle movements were observed

Figure 4. Vasomotor Activity



Resting means: 1 Group- 6.73 mm.
2 Group- 10.10 mm.
3 Group- 9.37 mm.

Table II

Percent Alpha For Eyes Closed Periods

		eyes closed (10 min) relaxation	eyes closed (15 min) meditation or relaxation	eyes closed (5 min) relaxation
Group I	Subject 1	94.6	97.9	97.7
	Subject 2	80.0	98.1	86.7
Group II	Subject 1	95.8	97.4	98.9
	Subject 2	97.2	97.1	97.4
Group II	Subject 1	75.0	70.8	53.2
	Subject 2	32.2	36.1	48.8

and their significance will be commented on in the discussion.

Subjective Report

None of the subjects reported any extreme discomfort with the physiological apparatus or the room in which they sat. Some subjects reported feeling drowsy but none indicated that they fell asleep. Perhaps the most important observation is that all of the eight meditators in Group II (those asked not to meditate during the session) reported extreme difficulty in preventing themselves from beginning to meditate during the eyes closed periods. In fact all of them stated that at some point over this time they felt they had slipped into meditation and that they had to consciously halt this process.

Discussion

Physiological Data

It is obvious that the physiological data obtained in this study differ somewhat from the results of some earlier research (Wallace, 1970a, 1970b; Wallace, Benson and Wilson, 1971; Wallace and Benson, 1972; Allison, 1970) in which fairly extravagant claims have been made for the physiological effects of T.M. The present results seem to be in accordance with the trends observed in the research of Brown, Stewart and Blodgett (1971) and Schwartz (1973).

Heart Rate. The changes in heart rate were interesting in that non-meditators showed the lowest initial levels and also attained the lowest levels over the different periods, although the differences between the groups were not significant. A general decrease in heart rate was observed in the three groups across the session; however, an increase was observed at the beginning of each period, presumably as a response to the instructions given to the subjects via the intercom. Although there was a decrease in heart rate it would appear to occur to the same degree in meditators during meditation and relaxation, and in non-meditators during relaxation.

Skin Conductance. Unexpectedly, skin conductance showed a gradual increase across the session in all groups, although significant decreases occurred within the periods following an initial rise (presumably due to the effect of the instructions). However, during meditation the meditators showed a significantly greater decrease in skin conductance than did the other two groups.

Respiration. Although the meditators exhibited slightly lowered respiration rates the changes observed did not reach significance levels. The decreases attained were not close to those reported by most other researchers (Allison, 1970; Wallace et al, 1970, 1971, 1972) and, again, it would appear that the changes were equally available to both meditators and non-meditators.

EEG Activity. On the basis of the records scored the meditators differed greatly from non-meditators in the production of alpha waves whereas meditators in the condition of meditation and relaxation did not differ noticeably. These results are similar to those obtained in the earlier Yogic studies (Das and Gastaut, 1957; Anand, Chhina and Singh, 1960), the Zen studies (Kasamatsu and Hirai, 1966) and T.M. (Wallace et al, 1970, 1971, 1972; Wada, 1972; Banquet, 1972). That the meditating and relaxing meditators did not differ would indicate that during the latter condition either the meditators began meditation or that practice in sitting with the eyes closed over extended sessions brings about increases in alpha activity possibly as a function of time of practice. On the basis of the physiological variables obtained, EEG activity most clearly discriminates between meditators and non-meditators, but it is impossible to know if this difference is the result of the meditative process or, as stated, practice in sitting in the relaxed pose.

On the basis of the results of this study and those obtained by Schwartz et al (1973) and Brown et al (1971) it would seem that the use of the word hypometabolic to describe the physiological state produced during T.M. should be re-evaluated. If this term implies an abnormally low metabolic rate it may be that although meditation produces a state of profound relaxation or quiescence the metabolic rate may not be "abnormally" low. This is not to imply that this is not the case but rather that further research employing the appropriate controls is necessary to assess the physiology of meditationand the appropriateness of the term "a hypometabolic state" in a general sense.

Implications for Future Research

Although the physiological results of this study are of interest in themselves, what is of more importance are some of the conclusions and opinions that can be made concerning research on meditation.

One consideration is that meditation does not always appear to produce the hypometabolic state that has been associated with it. One of the subjects, a meditator of seven years experience, exhibited such frequent and pronounced body movements that the polygraph record was unscorable. This body movement was displayed to a lesser extent in several other subjects and appeared to be part of an extremely active meditation. The nature of this movement, as observed through a window in the chamber, was frequently a jerking movement over the back or sideways at the neck. It is the investigator's experience that this movement within meditation is often termed "unstressing" presumably associated with the "release of stress" within the individual brought about by the "hypometabolic state" experienced during meditation. This phenomenon is usually seen more in experienced meditators and those who have been on extended meditation courses where the meditative state is experienced for longer periods. This experience is by no means considered harmful and is viewed as one aspect of successful meditation.

This factor may account for the discrepancy acknowledged by Wada (1973) in which incongruous subjective and objective states were displayed by some experienced subjects whereas inexperienced subjects usually displayed congruous subjective and objective states. The congruous physiological state would be the hypometabolic one associated with meditation; however, for the experienced meditator this might not always be the case, although it would still be reported as successful meditation. For the inexperienced meditator this active state will probably consitute less of his meditation experience and he would exhibit the expected patterns of quiescence to a greater extent that would the experienced meditator.

This stress release may be so gradual as to be not noticeable or it may intrude into awareness. Goleman (1971) has discussed this phenomenon in depth. He states that the, "process of liberating the nervous system from past stresses is undergone without effort, volition or intention. As the meditator reaches a level of profound relaxation and pure awareness with no thoughts, a wide range of kinesthetic sensations, vague feelings, or any of the array of psychic events can be triggered at random. Autokinesthesia may be accompanied by thoughts or may occur alone; or one may notice only thoughts but no movement . . . If attention is turned to scanning the body when thoughts alone are experienced, underlying proprioceptive kinesthetic sensations invariably will be noticed." (Goleman, 1971, p. 11).

The rejuvenating effect of meditation which results from this process of unstressing and its similarity to the function served by dreaming is emphasized by Goleman. "I propose that unstressing serves the same psychological function for the mediator as do dreams for the dreamer. In keeping with the psychophysiological principle, each movement in unstressing signals the release of a stored mental-emotional state, event or impression, and each such psychic event indicates the release of stress on the level of nerve-and-muscle. That is, the kinesthetic event is paralleled by a psychic one, and each psychic event by a kinesthetic one." (Goleman, 1971, p. 13).

This more active aspect of meditation should be investigated further as it constitutes a most important aspect of the meditative experience. Knowledge of this state must be communicated to the non-meditating researcher so as to prevent a misinterpretation of data obtained. Any attempt by researchers to eliminate from study meditators who are experiencing this physical aspect of meditation, possibly in order to guard against movement artifacts which would affect the recording process, is to, pre-select subjects in a manner which denies the random investigation of the physiological changes occurring in meditation.

Another problem is that a design which involves meditators sitting with their eyes closed with instructions not to meditate is an inadequate control for comparison with the meditation periods. Either the meditator will actively try to not meditate in which case he will be somewhat aroused and the difference between the control and meditation periods will be maximized beyond what they should be, or he may slip into meditation, in which case the differences will be minimized. In this study all eight of the meditators who were not asked to meditate reported after the session that at some point during the eyes closed periods they found themselves beginning to meditate and that it was difficult to prevent this. It would seem that once a person has become involved in meditation and has associated the relaxed eyes closed pose with that experience it is not possible to consider his control period of non-meditation as equivalent to that of a relaxed eyes closed period for a non-meditator.

It was noted that the instructions at the beginning of the period produced large increases in physiological activity, a finding that is routinely obtained in psychophysiological research. Failure to take this pattern into account could mean that pre-meditation values would be greatly elevated if made right up to the point at which meditation actually begins. Subsequent decreases in physiological activity during the period of meditation would then be exaggerated, reflecting, somewhat a return to pre-instruction levels. To take this effect into account would be most important in those studies in which the meditator served as his own control.

Another issue in evaluating physiological research on T.M. is the possibility that not all meditators exhibit the same changes during meditation. Some may be cardiovascular responders, others electrodermal responders, etc., in the same that some individuals tend to respond to different forms of stress with a stereotyped physiological pattern (individual-response specificity, Engel, 1972). If this is so, the simple averaging of data would tend to obscure what may be important trends.

It is most important in research on meditation that the nature of the variables involved be clearly specified so that inferences across studies may be made. Although not related to the present findings an example of the difficulty in interpretation that may arise is the variable results obtained in different studies concerning the effect of stimulation on meditation. The data obtained by Banquet (1973) on alpha blocking during T.M. contradict the earlier results obtained by Wallace (1970) and Spong, Low and Wada (1970). Banquet indicates that there was usually no alpha blocking to flash and click stimuli whereas Spong, Low and Wada, (1970) indicated that alpha blocking occurred during meditation and was greater in experienced that inexperienced subjects. Wallace (1971) also states that in his research almost all subjects showed no habituation of alpha blocking to repeated stimuli during T.M. There are several reasons that might account for these differences. The strength and proximity of the flash and click to the subject may be very different for these three experiments and unfortunately detail on the nature of the stimulation is not given. Banquet notes that his results are similar to those obtained by Anand, Chhina and Singh (1960) and Das and Gastaut (1957) in their investigations of Indian yogis in which habituation of alpha blocking occurs to repeated stimulation. As described earlier the results of Kasamatsu and Hirai (1966), in their study of Zen meditation, are opposite to this in that no habituation of alpha blocking is observed. An attempt was also made to explain these results on the basis of the different approaches to meditation emphasized by the different traditions.

With respect to the results obtained by Spong, Low and Wada (1970) and Wallace (1970) it may be that the stimuli they presented were so intense that it would have been impossible for the subjects to not be "aware" of them. In Banquet's research the stimuli may have been of lesser intensity or different proximity to the subject so that it would be possible for him to phase them out. This may also account for the observation by Spong <u>et al</u>, that experienced meditators showed more alpha blocking than experienced meditators and more blocking in meditation than in rest. They may have actively tried to resist the stimuli, to continue meditation against the stimuli by consciously returning to the mantra each time their meditation was interrupted. The experienced meditator would attempt to remain alert to maintain the meditative state so that he would constantly be orienting to the 'novel' stimuli.

The inexperienced meditators, due to their lack of practice in the technique may have been overwhelmed by the stimuli giving more attention to them and perhaps habituating to them. This would also occur with the experienced meditators when they were not meditating but sitting at rest as there would be no conflict between the mantra and the stimuli.

From this discussion it follows that the intensity and proximity of the stimulation should be specified as there may be a point at which the stimulation becomes disruptive to the meditative process and variable results may be obtained depending on whether the stimulation intensity is above or below this point. The level at which this would occur will vary with subjects depending on variables such as the length of meditative experience or the technique employed. It may be crucial to ascertain this level for each subject individually prior to doing research on the effect of stimulation during meditation.

It would also seem that longitudinal studies are necessary for doing valid research on meditation. The inferences which can be made as the result of testing a meditator in the laboratory once or twice will always be somewhat limited due to the vast differences that will exist between this situation and the usual meditation environment. It appears from this study that the laboratory atmosphere affects individual meditators differently, some finding it unpleasant while others were curious and excited. The attachment of electrodes and recording devices may even hamper the meditative process. Due to the subtle balance required in meditation these environmental variables would probably affect the meditator more than the non-meditator. Only with the habituation of extended testing and the efforts of the researcher to make it so can the laboratory meditation be considered comparable to the daily experience conducted in familiar surroundings.

The laboratory situation may also be somewhat artifcial in that the meditator will have some knowledge of what the researcher is looking for and will want to live up to these expectations. In his desire to 'perform' and to give support to the claims made for meditation the meditator may actually prevent himself from attaining the deeper meditation experiences. In this study it appeared that at the beginning of the meditation period the mediators were more aroused than the two control groups (they displayed higher heart rate and increased conductance). This may be the result of this 'performance' effect. Again it is probable that this effect would not be present in non-meditating controls as their only instructions will be to relax. This would further empahsize the importance of longitudinal research through which this problem may be overcome to some extent.

Conclusion

Following the initial dramatic claims for the physiological effects of T.M. and the production of a hypometabolic state, it now seems necessary to temper some of this enthusiasm with objectivity. Only through a more detached approach to this research will it be possible to evaluate the extent of the meditative experience. Inadequate designs, lacking in sufficient controls, have prevented an adequate assessment of the physiological aspects of this technique. In this study an attempt was made to incorporate some of the possible controls in order to investigate to what extent meditation is actually associated with a hypometabolic state, and to what extent such a state can occur in non-meditators. Consideration of the more active aspects of meditation is seen as a most important observation in this study. Also, of great importance, is the shift in emphasis which should now be occurring towards longitudinal research if meditation is to be properly examined in the laboratory setting.

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APPENDIX I

Instructions to Subjects.

Group I and II:	It is most important that you do not meditate until given instructions to do so. So only meditate when and if you are asked to.
All groups:	Just sit quietly until you receive instructions.
	approximately 5 minutes
	:We are ready to begin and would like you to sit quietly with your eyes open.
	Five minutes
	:Now sit quietly with the eyes closed.
	Ten minutes
Group I :	Would you now begin to meditate
Group II:	Would you continue sitting easily with the eyes closed.
	Fifteen minutes
Group I:	Stop meditating and continue sitting easily with the eyes closed.
Group II:	Would you continue sitting easily with the eyes closed.
	Five minutes
All Groups:	Now open the eyes and continue sitting quietly.
	Five minutes
	:We are now finished and will be in to unhook you.

APPENDIX 2

CONSENT FORM

Name: ______________________________

Age: ___________

Do you understand the nature of this research and that you will be involved in a physiological study? ____________________

Do you understand that you may withdraw from the research if you wish? ____________________

Do you consent to participate in this research project? _________

____

Subject's signature

APPENDIX 3

SUBJECT DATA

Before Session

All information is strictly confidential

Name ______________________________

Age __________ Date of Birth __________________

Weight ________Height ______________

Extent of formal education ______________________

State of Physical Health __________________ Do you exercise regularly ________

How? ______________________

Have you had any extensive use of hallucinogenic drugs? ___________

If so, when was the last time? ________________

Do you smoke? ________ If so, how extensively? _______

Do you drink alcohol? _______ If so, how extensively? __________

Have you every been under psychiatric care ? _________

If so, have you completed that programme? _______

Do you take any medication ? ______________

If so, what kind? __________________

Would you check off which of the following conditions is appropriate to how you feel now:

1) Feeling active and vital; alert; wide awake

2) Functioning at a high level, but not at peak, able to concentrate

3) Relaxed; awake; not at full alertness; responsive

4) A little foggy; not at peak; let down

5) Fogginess; beginning to lose interest in remaining awake; slowed down

6) Sleepiness; prefer to be lying down; fighting sleep; woozy

7) Almost in reverie; sleep onset soon; lost struggle to remain awake

____
Signature

Evaluation of Session

Would you check off which of the following conditions best describes how you feel now:

1. Feeling active and vital; alert, wide awake
2. Functioning at a high level, but not at peak, able to concentrate
3. Relaxed; awake; not at full alertness; responsive
4. A little foggy; not at peak; let down
5. Fogginess; beginning to lose interest in remaining awake; slowed down
6. Sleepiness; prefer to be lying down; fighting sleep; woozy
7. Almost in reverie; sleep onset soon; lost struggle to remain awake

Indicate your general reactions to the session by placing a check mark (√) in the appropriate place on each scale.

Interest	very little:	___:___:___:___:___:___:___:	very much
Boredom	very little:	___:___:___:___:___:___:___:	very much
Uneasiness	very little:	___:___:___:___:___:___:___:	very much
Curiosity	very little:	___:___:___:___:___:___:___:	very much
Physical Discomfort	very little:	___:___:___:___:___:___:___:	very much
Mental Discomfort	very little:	___:___:___:___:___:___:___:	very much

Were you disturbed by any outer noise? __________

Were you disturbed by the physiological apparatus? __________

____

Signature

APPENDIX V

Analysis of Variance for Heart Rate

Mean Heart Rate During Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	513.89	256.94	2.16	0.138
Error	21	2496.3	118.87		
Total	23	3010.2			

Heart Rate During Eyes Closed 1 As Compared to Control Period

Source	dF	SS	MS	F	Prob.
Group 5	2	117.39	58.69	2.26	0.1279
Error Between	21	546.41	26.02		
Measures	4	119.62	49.90	6.69	0.0001
Groups X Measures	8	100.38	12.55	1.68	0.1140
Error	84	626.40	7.46		
Total	119	1590.2			

Heart Rate During Eyes Closed 2 As Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	515.19	257.60	2.76	0.0845
Error Between	21	1957.30	93.20		
Measures	6	208.04	34.67	2.55	0.0230
Groups X Measures	12	166.26	13.83	1.02	0.4358
Error	126	1714.2	13.61		
Total	167	4561.1			

APPENDIX V (cont'd)

Heart Rate During Eyes Closed 3 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	353.46	176.73	1.85	0.1801
Error Between	31	2003.9	95.42		
Measures	5	253.08	50.62	4.32	0.0014
Groups X Measures	10	302.54	30.25	2.58	0.0079
Error	105	1231.4	11.73		
Total	143	4144.3			

Heart Rate During Eyes Open 2 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	59.87	29.93	0.44	0.6531
Error Between	21	1420.1	67.63		
Measures	5	126.81	25.36	2.01	0.0821
Groups X Measures	10	81.63	8.16	0.65	0.7710
Error	105	1323.7	12.61		
Total	143	3012.2			

Heart Rate Change For Points 0 → 1

Source	df	SS	MS	F	Prob.
Groups	2	244.25	122.12	3.20	0.0599
Error Between	21	800.57	38.12		
Period	1	150.52	150.52	5.55	0.0270
Groups X Periods	2	51.29	25.65	0.95	0.4067
Error	21	569.69	27.13		
Total	47	1816.3			

Appendix V (cont'd)

Heart Rate Change For Points 1→7

Source	df	SS	MS	F	Prob.
Groups	2	168.45	84.23	1.97	0.1633
Error Between	21	899.63	42.84		
Period	1	126.75	126.75	3.62	0.0678
Groups X Period	2	90.88	45.44	1.30	0.2938
Error	21	734.37	34.97		
Total	47	2020.1			

Heart Rate Change For Points 7→8

Source	df	SS	MS	F	Prob.
Groups	2	34.472	17.236	0.35	0.7114
Error Between	21	1027.9	48.95	2.28	0.0327
Period	1	140.08	140.08	6.53	0.0176
Groups X Period	2	121.54	60.77	2.83	0.0799
Error	21	450.37	21.45		
Total	47	1774.4			

Heart Rate Change For Points 8→13

Source	df	SS	MS	F	Prob.
Groups	2	1144.2	49.75	1.93	0.0670
Error Between	21	1003.3	47.78		
Period	1	126.75	126.75	4.92	0.0359
Groups X Period	2	219.50	109.75	4.26	0.0275
Error	21	540.75	25.75		
Total	47				

Appendix V (cont'd)

Heart Rate Change For Points 13 → 14

Source	df	SS	MS	F	Prob.
Groups	2	2.86	1.43	0.02	0.9649
Error Between	21	1282.8	61.09		
Period	1	147.0	147.0	7.18	0.0135
Groups X Period	2	42.88	21.44	1.05	0.3703

Heart Rate Change For Points 14 → 17

Source	df	SS	MS	F	Prob.
Groups	2	0.35	0.17	0.00	0.9865
Error Between	21	1031.8	49.13	1.96	0.0655
Period	1	65.33	65.33	2.61	0.1178
Groups X Period	2	28.29	14.15	0.56	0.5820
Error	21	526.37	25.07		
Total	47	1652.1			

APPENDIX VI

Analysis of Variance for Skin Conductance

Mean Skin Conductance During Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	148.29	74.15	1.34	0.2840
Error	21	1164.7	55.46		
Total	23	1313.0			

Skin Conductance During Eyes Closed 1 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	28.82	14.41	0.41	0.6728
Error Between	21	735.84	35.04		
Measures	4	24.36	6.09	2.50	0.0481
Groups x Measures	8	10.80	1.35	0.55	0.8136
Error	84	204.75	2.44		
Total	119	1004.6			

Skin Conductance During Eyes Closed 2 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	112.22	56.11	0.47	0.6392
Error Between	21	2531.8	120.56		
Measures	6	57.18	9.53	4.72	0.0003
Groups x Measures	12	52.48	4.37	2.17	0.0172
Error	126	254.44	2.02		
Total	167	3008.1			

Skin Conductance Change for Points 1⟶7

Source	dF	SS	MS	F	Prob.
Groups	2	15.64	7.82	0.20	0.8191
Error Between	21	815.06	38.81		
Period	1	14.19	14.19	5.04	0.0339
Groups x Periods	2	23.79	11.89	4.23	0.0282
Error	21	59.10	2.81		
Total	47	927.77			

Skin Conductance Change for Points 7⟶8

Source	dF	SS	MS	F	Prob.
Groups	2	33.32	16.66	0.35	0.7103
Error Between	21	988.56	47.08		
Period	1	47.80	47.80	15.23	0.0009
Groups x Periods	2	7.01	3.50	1.12	0.3471
Error	21	65.89	3.14		
Total	47	1142.6			

Skin Conductance Change for Points 8⟶13

Source	dF	SS	MS	F	Prob.
Groups	2	6.78	3.39	0.07	0.9262
Error Between	21	1057.6	50.36		
Period	1	47.80	47.80	12.47	0.0020
Groups x Periods	2	0.30	0.15	0.04	0.9510
Error	21	80.49	3.83		
Total	47	1193.0			

Skin Conductance During Eyes Closed 3 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	3.02	1.51	0.01	0.9766
Error Between	21	2700.0	128.57		
Measures	5	82.24	16.45	10.09	0.0000
Groups x Measures	10	6.11	0.61	0.37	0.9546
Error	105	171.11	1.63		
Total	143	2962.5			

Skin Conductance During Eyes Open 2 as Compared to Control Period

Source	dF	SS	MS	F	Prob.
Groups	2	12.22	6.11	0.06	0.9287
Error Between	21	1995.5	95.02		
Measures	5	58.53	11.71	5.49	0.0002
Groups x Measures	10	15.88	1.59	0.75	0.6816
Error	105	223.77	2.1312		
Total	143	2305.9			

Skin Conductance Change for Points 0⟶1

Source	dF	SS	MS	F	Prob.
Groups	2	7.32	3.66	0.10	0.8999
Error Between	21	777.04	37.02		
Period	1	40.33	40.33	21.88	0.0002
Groups x Period	2	4.02	2.01	1.09	0.3559
Error	21	38.72	1.84		
Total	47	867.44			

Skin Conductance Change for Points 13 ⟶ 14

Source	dF	SS	MS	F	Prob.
Groups	2	22.21	11.11	0.25	0.78.05
Error Between	21	920.61	43.84		
Period	1	62.34	62.34	12.03	0.0024
Groups x Periods	2	13.71	6.86	1.32	0.2874
Error	21	108.79	5.18		
Total	47	1127.7			

Skin Conductance Change for Points 14 ⟶ 19

Source	dF	SS	MS	F	Prob.
Groups	2	3.26	1.63	0.04	0.9469
Error Between	21	789.98	37.62		
Period	1	36.05	36.05	7.34	0.0127
Groups x Periods	2	7.39	3.70	0.75	0.4872
Error	21	103.11	4.91		
Total	47	939.79			

APPENDIX VII

Analysis of Variance for Respiration Rate

Mean Respiration Rate During Control Period

Source	df	SS	MS	F	Prob.
Groups	2	14.12	7.06	0.99	0.3907
Error	21	149.94	7.14		
Total	23	164.05			

Respiration Rate During Eyes Closed 1 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Error Between	21	335.31	15.97		
Groups	2	22.39	11.19	0.70	0.5115
Measures	4	27.12	6.78	1.90	0.1173
Groups X Measures	8	21.93	2.74	0.77	0.6337
Error	84	300.15	3.5732		
Total	119	706.90			

Respiration Rate During Eyes Closed 2 as Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	68.52	34.26	1.54	0.2374
Error Between	21	468.14	22.292		
Measures	6	30.64	5.11	1.32	0.2517
Groups X Measures	12	39.79	3.32	0.86	0.5920
Error	126	487.00	3.87		
Total	167	1094.1			

Appendix VII (Cont'd)

Respiration Rate During Eyes Closed 3 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	158.70	79.35	3.00	0.0702
Error Between	21	555.75	26.46		
Measures	5	17.04	3.41	1.25	0.2891
Groups X Measures	10	19.44	1.94	0.72	0.7093
Error	105	285.35	2.7177		
Total	143	1036.3			

Respiration Rate During Eyes Open 2 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	51.38	25.69	2.65	0.0929
Error Between	21	203.89	9.71		
Measures	5	23.64	4.73	1.21	0.3099
Groups X Measures	10	21.99	2.20	0.56	0.8420
Error	105	410.71	3.91		
Total	143	711.61			

APPENDIX VIII

Analysis of Variance For Vasomotor Amplitude

Mean Vasomotor Amplitude During Control Period

Source	df	SS	MS	F	Prob.
Groups	2	18.81	9.40	2.11	0.2021
Error	6	26.75	4.46		
Total	8	45.56			

Vasomotor Amplitude During Eyes Closed 1 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	10.50	5.25	0.51	0.6281
Error Between	6	61.88	10.31		
Measures	1	0.22	0.22	0.00	0.9092
Groups X Measures	2	1.87	0.94	1.49	0.2978
Error	6	3.76	0.63		
Total	17	78.02			

Vasomotor Amplitude During Eyes Closed 2 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	11.38	5.69	0.16	0.8497
Error Between	6	208.33	34.72		
Measures	2	1.09	0.55	0.46	0.6460
Groups X Measures	4	0.87	0.22	0.18	0.9411
Error	12	14.25	1.19		
Total	26	235.93			

Appendix VIII (Cont'd)

Vasomotor Amplitude During Eyes Closed 3 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	1.84	0.92	0.04	0.9498
Error Between	6	136.62	22.77		
Measures	1	0.72	0.72	0.00	0.9505
Groups X Measures	2	2.90	1.45	0.89	0.4626
Error	6	9.84	1.64		
Total	17	151.20			

Vasomotor Amplitude During Eyes Open 2 As Compared to Control Period

Source	df	SS	MS	F	Prob.
Groups	2	2.72	1.36	0.06	0.9349
Error Between	6	141.66	23.61		
Measures	1	2.72	2.72	6.58	0.0419
Groups X Measures	2	2.69	1.35	3.26	0.1099
Error	6	2.48	0.41		
Total	17	152.28			