THE PHYSIOLOGY OF HIGHER STATES OF CONSCIOUSNESS

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The author reviews current research on the Transcendental Meditation Programme delineating physiological correlates of the development of higher states of consciousness.—EDITOR

Over the last thirty-five years Maharishi Mahesh Yogi has developed a science and technology of consciousness that provide an entirely new approach and insight into the nature of consciousness. According to Maharishi, what we consider normal waking consciousness represents a very restricted value of the full range of human consciousness that corresponds to the more excited levels of mental activity. Systematically quieting the internal functioning of the physiology and at the same time enlivening mental awareness allows the experience of a much fuller and more universal state of consciousness that is at the same time completely wakeful, yet settled and unified. This unified state of consciousness is referred to as the state of transcendental or pure consciousness, in which there are no thoughts, no sensory experiences, and no distinction between subject and object—only pure awareness, the experience of consciousness itself. The state of pure consciousness is distinctly different from the waking, dreaming or sleep states of consciousness, and is the basis for a set of "higher" or more optimal states of consciousness.

According to Maharishi’s Vedic Science, pure consciousness is the ultimate basis of all subjective and objective states. In this state we have the ability to directly experience and influence the Laws of Nature. The Laws of Nature are perceived as the dynamical principles that govern the flow of consciousness. These principles are realized not in the ordinary sense, in terms of understanding specific mathematical relationships, but instead as impulses of Natural Law on the level of consciousness itself. These experiences of pure consciousness have been recorded in the Vedic texts, which serve to document the systematic repeatability of these experiences and to assist other scientists in verifying their own subjective experiences.

The unfamiliarity and the subjective nature of the methodology of Vedic Science has caused scientists to search for more familiar objective methodologies in order to verify the identity of pure consciousness as the Unified Field of all the Laws of Nature. To this end an extensive research program has been carried out over the last twenty years which encompasses a number of disciplines, one of the most important being physiology.

A basic tenet of both contemporary and Vedic physiology is that for every state of consciousness there is a corresponding state of physiology. It is predicted, therefore, that the state of pure consciousness, as well as higher states of consciousness, will be characterized by specific styles of neurophysiological functioning which can be measured by objective criteria.

The principal focus of this chapter will be to review progress made in identifying those criteria which characterize higher states of consciousness.

PART 1: OBJECTIVE PHYSIOLOGICAL CORRELATES OF PURE CONSCIOUSNESS

For scientists, the introduction of the Transcendental Meditation (TM) technique by Maharishi offered a great opportunity to objectively measure the physiological, biochemical, and psychological correlates of the fourth state of consciousness. The technique, in which the mind settles down, or "transcends," to quieter levels of awareness, is easy to learn, taught in a standardized format, and requires no change in beliefs or lifestyle. Also, from the time Maharishi first introduced the TM technique into the West in the early 1960s, he encouraged research in all areas.

To a large extent, Maharishi had predicted the basic types of changes that were to be found in the early studies
and in more elaborate studies to follow. For example, in his book The Science of Being and Art of Living, published in 1963, he stated that when the mind transcends during Transcendental Meditation, the metabolism reaches its lowest point; so does the process of breathing, and the nervous system gains a state of “restful alertness” which, on the physical level, corresponds to the state of “bliss consciousness,” the transcendental field of existence (pp. 192–198, 204).

Maharishi describes this state of restful alertness as a fourth major state of consciousness distinct from waking, dreaming, and sleeping. The first major publication of evidence verifying Maharishi’s predictions was in 1970 in the journal Science, in the article, “Physiological Effects of the Transcendental Meditation Technique” (Wallace, 1970b). The conclusion of this and other early studies was that Transcendental Meditation produces a state of restful alertness, indicative of a fourth major state of consciousness that is physiologically and biochemically unique. The findings showed first that the body achieved a deep state of rest and relaxation as indicated by such parameters as a decrease in respiration rate and oxygen consumption, a marked increase in skin resistance, and a decrease in arterial lactate and plasma cortisol levels; and second that the mind achieved a relaxed yet inwardly alert state as indicated by an increase in alpha and theta wave activity in the frontal parts of the brain and an overall increase in EEG coherence (Wallace et al., 1971; Wallace et al., 1972; Orme-Johnson & Farrow, 1976). Since these initial findings, many hundreds of studies have been completed in all fields which, when taken together, support and enrich the concept of a transcendental or fourth state of consciousness (Chalmers, Clements, Schenkluhn, & Weinless, in press).

In this section we will briefly address certain methodological issues which have helped clarify the existence of a fourth state of consciousness, and will then highlight recent findings in several key areas: respiration, muscle metabolism, hormones and neurotransmitters, EEG coherence, and meta-analysis.

**Methodological Issues**

Perhaps the most important methodological issue is to identify the independent variable—the state of pure consciousness. How do we actually know that what we are measuring during TM is the state of pure consciousness? Most of the early studies took a very general approach and compared the average magnitude of a particular variable such as respiration rate during different experimental and control periods. The average value of respiration rate during the meditation period, for example, was compared to the value either during an equivalent resting or relaxation control period. Unfortunately, with this type of design it is impossible to characterize specific periods in which the subject is experiencing pure consciousness. During the practice of the TM technique there appears to be a mixture of states; the technique itself is a dynamic one having both an “inward phase” and an “outward phase.”

In the inward phase subjects report their mental activity settling down to quieter levels until they eventually transcend all mental activity and experience the state of pure consciousness. In the outward phase they report emerging from the state of pure consciousness and the gradual reappearance of more excited states of mental activity, until they begin the inward phase once again. The degree of clarity subjects report in the experience of pure consciousness varies greatly, as does the frequency and duration of each of these inward and outward phases. Subjects who are overly tired before practicing the TM technique report having short periods of drowsiness or even sleep during meditation. Through the entire 20 or 30 minutes of the TM technique there is often a mixture of active waking state, drowsiness, sleep or relaxation, quiet waking state, and transcending to a state of pure consciousness.

According to Maharishi, deep rest allows the system to “normalize” itself—that is, to remove any functional or structural abnormalities. When one rests during a cold or illness the body’s internal system spontaneously attempts to remove any foreign invaders and to heal itself. In a similar manner, according to Maharishi, when the body settles down to a state of restful alertness and one experiences pure consciousness, the internal systems of the body automatically begin to remove any deep-seated stresses or abnormalities (Maharishi Mahesh Yogi, 1972, lesson 13). One of the consequences of this normalization process during TM is that the mind shifts out of pure consciousness and either becomes more active, returning to a more excited state, or less active to the point of drowsiness or even sleep. The mixture of states that occurs during the practice of the TM technique thus is a direct consequence of the dynamics of the procedure and the initial condition of the individual’s nervous system.

The earlier research, which we refer to as phase I studies, did not carefully discriminate between this mixture of states during meditation. This has led to some confusion over the difference between the physiological correlates of pure consciousness and those of relaxation and drowsiness. Later studies, which we refer to as phase II studies, have used subjective reports coupled with certain objective criteria, such as periods of respiratory suspension, to help selectively study periods of pure consciousness. As we shall see, these more recent and better-designed studies have demonstrated more marked and unique physiological changes.
Another methodological problem that the later research has helped clarify is the use of appropriate dependent variables—that is, objective criteria which can discriminate between the state of pure consciousness and other states. Researchers have tended to use physiological parameters that are too few and too limited. A classic example of the problem of using limited measurements can be seen in the first attempts to distinguish between dreaming and waking through the use of electroencephalogram (EEG) patterns. The EEG pattern during dreaming looks extremely similar to that during waking, and yet behaviorally the two states are entirely different. Based on these EEG patterns dreaming was initially referred to as "paradoxical" sleep. It was not until the observation by Aserinsky and Kleitman (1965) of so-called rapid eye movements (REM) and the subsequent recording of electrooculograms (EOG) and electromyograms (EMG) during dreaming that clearly defined criteria were established which enabled physiological discrimination between dreaming, sleep, and wakefulness. Researchers have further characterized dreaming by variations in other physiological parameters (Dement & Masserman, 1964; Jouvet, 1967; Oswald, 1962; Snyder, Hobson, Morrison, & Goldfrank, 1964).

The same point applies to research on the TM program. If only one or a few parameters are used it may not be possible to discriminate between two states, such as relaxation or pure consciousness, that might occur alternately during the TM technique. As the following sections show, by using a multidisciplinary approach to the study of consciousness, subsequent research has demonstrated that there exist discriminating parameters which are able to better characterize the state of pure consciousness. Unless these measures are utilized, the unique characteristics of this state may remain obscured.

**Respiration**

The results of studies on respiration suggest the importance of looking at continuous measurements so that the "deeper" periods of meditation can be identified; and further, the importance of studying more advanced subjects who report clear experiences of pure consciousness. To some extent, this was done in one of the first studies on the TM technique. Allison (1970), in a report on one advanced subject, found that respiration rate decreased from 12 breaths/min before meditation, to 4 breaths/min during, and again returned to 12 breaths/min after meditation, with no evidence of compensatory breathing.

A more extensive study by Farrow and Hebert (1982) has helped clarify these previous results (see Figure 1). In four independent experiments Farrow and Hebert attempted to determine frequencies of breath suspension episodes during the TM technique and whether these episodes were correlated with the experience of pure consciousness.

In the first experiment, 95 subjects who had been practicing the TM technique from one month to 13 years were studied before, during, and after meditation. Eleven of the subjects exhibited a total of 151 breath suspension episodes, almost all occurring during the TM technique. In the second and third experiments, more advanced TM subjects were studied as well as nonmeditating controls, and the criteria were altered so that they accounted for individual variations in average respiration time. As a result, the frequency of breath suspension episodes was greater. For example, in the second experiment, 21 of the 28 TM subjects exhibited a total of 116 episodes, while 9 of the 23 controls exhibited only a total of 14 breath suspensions. The frequency of episodes and mean, maximum, and total episode lengths were all substantially greater in the TM group than in the control group.

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**FIG. 1.** In four different experiments a number of subjects were tested for spontaneous suspensions of breath during the Transcendental Meditation technique. The TM practitioners exhibited significantly more suspensions than controls. Subjects practicing the TM technique pressed a button after each experience of Transcendental Consciousness—the subjective experience of an extremely settled and expanded state of awareness. Each button press closely corresponded to the end of a period of markedly reduced breath flow.
In the third experiment there was an attempt to correlate the occurrence of breath suspensions with the subjective experience of pure consciousness. In this experiment all subjects had participated in advanced courses designed to deepen and extend the clarity of experience in meditation; all reported frequent and sustained experiences of being measured. In a number of the sessions, for example, multiple electrodes were attached for other measurements. To determine whether the breath suspensions were intentional, the compensatory hyperventilation seen after intentional breath suspension periods was analyzed and compared to breathing activity following respiratory suspensions during the TM technique. A subject asked to intentionally hold his breath for time periods similar to the TM respiratory suspensions showed a significant and marked increase in minute ventilation (2.71 liters per minute), as compared to a nonsignificant increase (0.57 liters per minute) after the periods of respiratory suspension during the TM technique.

Another concern was to distinguish the periods of respiratory suspension seen during sleep apnea from those during the TM technique. This was determined by the fact that EOG measurements during the TM technique did not show the typical, slow-rolling eye movements preceding or associated with sleep apnea.

Several other recent studies have extended Farrow and Hebert’s results and have more carefully analyzed the neurophysiological control of respiratory patterns during the TM technique. For example, Wolkove, Kreisman, Darragh, Cohen, and Frank (1984), comparing long-term TM subjects with nonmeditating controls at rest, confirmed Farrow and Hebert’s findings of both a significant decline in minute ventilation and the observation of periods of respiratory suspension in TM subjects. Also, several studies have found that when TM subjects were given increasing amounts of carbon dioxide in inspired air there was a reduced respiratory response. This suggested a decreased sensitivity to high carbon dioxide concentration and an alteration in the neurophysiological mechanisms which regulate breathing (Wolkove et al., 1984; Singh, 1984).

The most extensive investigation in this area is that of Kesterson (1986). In this study a cross section of groups of TM and TM-Sidhi participants were tested during their group practice of the TM-Sidhi program. Three categories of subjects were identified according to their pattern of breathing while practicing the TM technique.

The first group showed no changes in the frequency of breathing during meditation, the second a large decrease in the rate of breathing, and the third group prominent, frequent periods of respiratory suspension. The subjects in the third group were studied extensively in order to determine the underlying neurophysiological mechanisms producing the suspensions. Similar to the findings of Wolkove et al. (1984) and Singh (1984), these subjects demonstrated decreased sensitivity to high levels of carbon dioxide in ambient air during meditation. Further, they showed an increased sensitivity to low levels of oxygen. It was also discovered that many of the subjects demonstrating spontaneous suspensions during meditation were, in fact, breathing apneustically—that is, the
suspension began with a full inspiration and continued with a gradual inspiration during the suspension.

Furthermore, Kesterson discovered a drop in the respiratory quotient (RQ—the ratio of carbon dioxide produced/oxygen consumed) for almost all subjects in his experiment during the practice of TM. He hypothesized that this drop was a consequence of mild hypoventilation, which is known to decrease RQ. He demonstrated in a series of separate experiments that, in fact, alveolar ventilation decreased significantly more than oxygen consumption for meditators during TM, but not for nonmeditating controls during relaxation—an argument in favor of hypoventilation. He cites this change as further evidence for brainstem inhibition of respiratory control during TM.

Kesterson suggests his findings are contrary to previous models which hypothesized that the respiratory changes observed during TM originate in decreased metabolic needs. His findings indicate that they are a result of specific alterations in neurophysiological centers within the brain, more specifically those respiratory centers in the medulla involved with the regulation of inspiration and expiration. Kesterson’s research suggests that oxygen consumption may not be as good a discriminator of transcending as respiratory patterns. Oxygen consumption is sensitive to bodily movements; and any state of rest or relaxation will result in a gradual decrease in metabolic rate. The specific patterns of respiratory activity during the TM technique seem, according to Kesterson’s finding, to be better indicators of the subjective experience of transcending, especially when coupled with other physiological measurements such as EEG coherence.

The most important conclusions drawn by Kesterson, however, are those concerning changes in states of consciousness. Sullivan (1980) has noted that respiratory pattern is a good discriminator between sleep, dreaming and wakefulness—that is, between states of consciousness. In fact, he suggests that if respiratory physiologists had discovered REM sleep instead of EEG researchers, it would have been called RERM. Rapid Erratic Respiratory Movements. Deep sleep is characterized by slow, periodic monotonous patterns, REM sleep by irregular variations unrelated to carbon dioxide control, and wakefulness by regular patterns greatly modified during different activities. Brainstem inhibition of respiratory centers, a buildup of carbon dioxide, a drop in RQ and mild hypoventilation are all known to accompany the transition between these states of consciousness.

The respiratory patterns demonstrated by advanced TM meditators and investigated by Kesterson are indicative of a transition from normal waking consciousness to a state of restful alertness. The subjects who showed the greatest changes in breathing pattern while meditating were also the most alert and reported the best experiences. Kesterson argues that the changes in breathing pattern signify a unique transitional state—the unified state of pure consciousness—which underlies the three separate states of consciousness, waking, dreaming, and sleeping.

**Muscle Metabolism**

One of the first biochemical findings noted in subjects during the TM technique was a marked decrease in the level of lactate in arterial blood and a continued low level afterward (Wallace et al., 1971). Lactate or lactic acid is the by-product of a less efficient type of metabolism known as anaerobic metabolism, which occurs when cells are not able to utilize oxygen. Even under normal conditions anaerobic metabolism exists and, as a result, a certain amount of lactate is constantly being produced by various cells in the body. Lactate production is dramatically increased in situations where the oxygen supply is eliminated or decreased in certain cells in the body. For example, in the skeletal muscle cells of a runner who is sprinting the last hundred yards of a mile race, the cells must rely on anaerobic metabolism even though it is less efficient. During these last hundred yards the runner is building up what is known as an oxygen debt, which is indicated by the increased production of lactic acid or lactate.

At the University of California at Irvine, Jevning and Wilson replicated and extended the early findings on decreased levels of arterial lactate during the TM technique in a series of well-controlled experiments, comparing TM meditators to nonmeditating controls (Jevning, Wilson, Smith, & Morton, 1978; Jevning, Wilson, Pirkle, O’Halloran, & Walsh, 1983). Jevning and Wilson also studied forearm muscle blood flow (Jevning, Wilson, O’Halloran, & Walsh, 1983), revealing another intriguing and unexpected finding. In addition to measuring blood flow they measured the partial pressure and absolute levels of oxygen and carbon dioxide of the arterial and venous blood in the forearm of TM subjects during meditation and in nonmeditating controls during rest. From these measurements they were able to calculate the metabolic activity of the forearm muscles. They found the normal difference in oxygen content of the arterial and venous blood was significantly reduced in TM meditators during meditation, as compared to controls during rest. This suggests that less oxygen was being used by the cells, indicating a state of lower metabolism and deeper rest in the muscles of the TM subjects.

More interestingly, they found that the normal difference in carbon dioxide content of arterial and venous blood was markedly reduced in TM subjects during meditation, with a less marked reduction in the controls during rest. These findings indicated a decrease or complete
cessation of carbon dioxide production by the forearm muscles after 20–30 minutes of TM. Calculations of the respiratory quotient during meditation showed a value of almost zero, as compared to the normal value of about .60. Thus, a dramatic alteration in local metabolism occurs as a result of the TM technique. This change is particularly interesting in the light of the earlier research, which showed no changes in the systemic levels of oxygen and carbon dioxide as reflected by the partial pressure of arterial oxygen and carbon dioxide levels (Wallace et al., 1971).

Wilson, Jevning, and Guich (1987) speculate that the changes may be due to an alteration in fat metabolism. To account for the fact that carbon dioxide is not produced, it is necessary to postulate that the two- or three-carbon fragments produced do not enter the tricarboxylic acid cycle. Two metabolic pathways which may not involve carbon dioxide production are beta-oxidation of fatty acids, and glycolysis. Wilson et al. suggest that fatty acid oxidation is the more likely of these pathways for a number of reasons: one is that the previously observed decrease in blood lactate during the TM technique suggests that the end-products of glycolysis are not being formed.

In order to account for the low arterial-venous carbon dioxide content it is also necessary to explain why the products of fatty acid metabolism do not enter the tricarboxylic acid cycle. Wilson et al. speculate that under the resting conditions of the experiment the energy production may exceed utilization, producing conditions which inhibit the further normal metabolism of these products. These unmetabolized products must undergo further oxidation at some other site or organ in the body. The reported marked increase in brain blood flow suggests that perhaps oxidation of these products is occurring there. Further research is being conducted in this area in order to reveal the mechanics and significance of these findings.

**Hormones and Neurotransmitters**

Several different research groups have investigated hormonal and neurotransmitter changes during the TM technique. Findings have been reported during the TM technique such as a decrease in plasma cortisol (Jevning, Wilson, & Davidson, 1978—see Figure 2), and an increase in phenylalanine (Jevning, Pirkle, & Wilson, 1977) in TM meditators as compared to resting controls. Researchers have found changes in meditators after periods of practicing TM such as: an increase in plasma prolactin (Jevning, Wilson, & Vanderlaan, 1978), an increase in urinary 5-hydroxyindole-3-acetic acid (Bujatti & Riederer, 1976) and a decrease in urinary free cortisol and serum thyroxine levels (Bevan, Young, Wellby, Nenadovic, & Dickins, 1976; Bevan, 1980).

One of the most interesting hormonal studies is a longitudinal study on plasma hormone levels by Werner et al. (1986) in TM-Sidhi participants. Blood samples were taken in subjects practicing the TM technique just prior to their starting the more advanced TM-Sidhi program, and then during sessions at intervals of 5, 49, 115, and 167 weeks after starting. During each session samples were taken over five consecutive days. The results showed significant longitudinal decreases in some hormone levels, particularly

![Reduced Cortisol](image)

**FIG. 2.** Cortisol is a hormone in the bloodstream which is found in large concentrations during stress, fasting, or dehydration. This study found that people who had been practicing the Transcendental Meditation program for three to five years had significantly lower cortisol levels during the TM technique compared to just before beginning the technique (p < .01), and significantly lower levels during TM compared to controls who were resting with eyes closed (p < .03).
in the pituitary hormones—thyroid stimulating hormone (TSH), growth hormone, and prolactin—with no marked change in cortisol or the thyroid hormones T3 and T4.

Werner et al. speculate that the relatively unchanged levels of the thyroid hormones (despite continually decreasing TSH levels) imply either a marked increase in the sensitivity of the regulation of the thyroid gland, or the production of more biologically active hormones.

Another important finding was the simultaneous longitudinal decrease in the three pituitary hormones measured—TSH, growth hormone, and prolactin—which suggests that the TM-Sidhi program affects the regulation of anterior pituitary function. Mechanisms known to be important in the control of anterior pituitary function include such factors as: neurotransmitter levels in the hypothalamus, hypothalamic releasing factors, and pineal function. It is not possible from this study to distinguish which of these mechanisms might be influenced by the long-term practice of the TM-Sidhi program. However, the simultaneous decrease in all three hormones suggests a global mechanism. It may be that the TM-Sidhi program increases melatonin secretion by the pineal gland, which then decreases the secretion of the pituitary hormones TSH, prolactin, and growth hormones either directly or indirectly by affecting transmitter levels in the hypothalamus.

The findings of the above study reveal one further longitudinal effect of the TM-Sidhi program on endocrine stability. Several of the hormones exhibited reduced day-to-day variation for subjects who had been practicing the TM-Sidhi program for two years. This finding, which suggests reduced ultradian fluctuation, is particularly interesting because it indicates a unique and more stable style of neuroendocrine functioning.

One of the most exciting and promising biochemical studies on the development of higher states of consciousness is the recent investigation into an unknown substance by Walton et al. (1987). This investigation originated from the earlier studies of Walton, Lerom, Salerno, and Wallace (1981) in which they were measuring urinary levels of the serotonin metabolite 5-hydroxyindole acetic acid (5-HIAA) in subjects practicing the TM and TM-Sidhi program.

Using a general colorimetric assay their measurements suggested circadian rhythms as well as a specific increase in 5-HIAA immediately after the practice of the TM-Sidhi program. However, when they used a more specific colorimetric assay for 5-HIAA, the same subjects did not show the same changes as previously seen. They therefore concluded that part of the substance being measured in the more general assay was not 5-HIAA, but some unknown substance (Walton, Francis, Lerom, & Tourenne, 1983) which the more specific assay did not detect. They then attempted to isolate and purify this unknown substance (Walton et al., 1987).

Preliminary evidence suggested that this unknown substance had a high affinity for imipramine binding sites and that it blocked serotonin uptake in platelets. More recently, the substance, referred to as "substance M," was also partially isolated from bodily fluid samples. Studies are currently underway using high pressure liquid chromatography, thin layer chromatography, and mass spectrophotometry to purify and isolate substance M. If, indeed, substance M is a biochemical substance produced as a result of the TM and TM-Sidhi program, and if it is responsible for mediating many of the wide variety of physiological changes seen both during and after the TM-Sidhi program, then this would be a highly significant scientific discovery.

In this regard it is interesting to note Maharishi’s explanation that the Vedic Literature refers to a particular substance which is associated with the state of pure consciousness and the establishment of enlightenment (Maharishi Mahesh Yogi, lecture, November 1980). The discovery of such a substance, uniquely correlated to the experience of unbounded consciousness, would be exactly in line with the current progress of neurochemical research, which has attempted to describe all mental states in terms of the biochemistry of the brain (Bradford, 1986, pp. 412-490). This discovery would have important implications for our understanding of the relationship between the brain and consciousness.

**EEG Coherence**

EEG is one of the measures used most frequently to study meditation. Early studies focused on EEG power and reported regional changes in both the alpha and theta frequencies (Wallace, 1970a; Wallace et al., 1971; Banquet, 1973; Banquet & Sullihan, 1974; Hebert & Lehmann, 1977). The most important and useful development in the EEG research on the TM program has come through the application of EEG coherence measurements. EEG coherence is derived from a computer analysis of the EEG signals from two spatially separated areas of the brain. Coherence provides a measure of the correlation between two EEG records for each frequency and attains a high value at a given frequency if the phase relationship between two channels is nearly constant over a specified time interval.
One of the first applications of this measurement was by Walter and Adey at the Brain Research Institute at U.C.L.A. (Walter, Rhodes, Brown, & Adey, 1966). In a series of articles Walter and coworkers utilized coherence to distinguish between various functional states. For example, they noted a decrease in alpha and theta coherence during sleep. They further speculated on the location of key centers of the brain possibly responsible for the generation and synchronization of EEG signals. One of the most interesting findings of their studies was a marked increase in theta EEG coherence in Astronaut Frank Borman’s Gemini Flight, during a 40-minute period in the second half of the first orbit, when he was in very relaxed yet awake state (Walter et al., 1966; Walter, Kado, Rhodes, & Adey, 1967).

Coherence measures have also been used in a number of other studies (Gevins & Schaffer, 1980). For example, John’s Neurometric testing program, which includes a variety of computerized EEG and evoked potential measures, has been utilized to successfully distinguish certain child learning disabilities (John et al., 1970; John, 1977).

In order to examine EEG coherence during the TM technique, Levine (1976) developed a computerized technique known as the coherence spectral array (cospar). This technique was designed to show relationships of only high and long-term coherence and thereby increased the likelihood that a given coherence peak represented true long-range order in the EEG (see Figures 3a, 3b, and 3c).

Since TM-specific changes had been reported mainly in the frontal and central regions of the brain, cospars were computed for these areas. The most common effect was an increase in the height and/or incidence of coherence peaks in the alpha band with the beginning of the TM technique but without a marked decrease at the end of that period. The second most frequent effect during meditation was the spreading of coherence peaks to other, generally lower, frequencies. The third was an abrupt onset of strong coherence with the start of the TM technique and an abrupt decrease at the end.

Intrahemispheric TM-specific effects appeared more frequently and dominantly in the frontal channels. One of the most interesting cospars observed was that of a long-term meditator of 15 years (see Figure 3b), in which continuously strong coherence was seen concurrently in delta, theta, alpha, and beta bands both during and outside of meditation. Levine points out that alpha coherence is not unique to the TM technique, although the patterns of change observed, particularly in the spread of coherence to other frequencies, appear to be characteristic of the TM state. This was not observed in control subjects during either extended periods of eyes-closed relaxation or in “mock” meditations involving repetitive backwards counting in a non-taxing fashion. In the “mock” meditation, any strong alpha coherence which may have been present upon initially closing the eyes tended to be reduced.

Levine found that drowsiness and sleep were characterized by a loss of any consistent, strong inter-hemispheric coherence which may have been present in the
Increased EEG Coherence II
Long-Term TM Practice

High Coherence in All Frequencies
Transcendental Meditation
Fifteen Years Meditator

**FIG. 3b.** In the cospar (coherence spectral array) of a long-term meditator of 15 years, continuously strong coherence was seen concurrently in delta, theta, alpha, and beta bands both during and outside the practice of the Transcendental Meditation technique.

Long-term TM practice had a high coherence in all frequencies, with coherence in the alpha band, and a gradual decline in total coherence. In REM sleep there was significant coherence in the delta band along with an increase in total coherence. Also, sleep spindles were sufficiently coherent to be picked up by the cospar. These findings of changes in coherence during certain stages of sleep are consistent with the earlier sleep studies on nonmeditators (Dumermuth, Walz, Scollo-Lavizzari, & Kleiner, 1972). They further help to clearly distinguish the physiological changes seen during the TM technique from those seen in sleep or drowsiness (Levine, Hebert, Haynes, & Strobel, 1976).

Farrow and Hebert (1982), as part of their extensive analysis of periods of respiratory suspension during the TM program, studied detailed changes in skin resistance, heart rate, and EEG power and coherence in one advanced subject. Again, periods of respiratory suspension were highly correlated with the subjective experience of pure consciousness. While the periods of respiratory suspension were abrupt, discrete, and relatively uniform, changes in other parameters associated with the experience of pure consciousness were graded and more variable. Basal skin resistance, for example, increased before and during these periods and often dropped abruptly at the end of the periods. The mean heart rate also decreased during the episodes and then increased afterwards.

EEG coherence in the alpha and beta bands was high before and during the first half of the respiratory suspension period, decreased gradually during the second half, and then decreased abruptly at the end of the period. Coherence in the delta band was much more variable, but also dropped at the end of the respiratory suspension period. The mean change in coherence between before, during, and after the respiratory suspension period was statistically significant in all the EEG bands.

In a subsequent study (Badawi, Wallace, Orme-Johnson, & Rouzere, 1984), the preliminary results of Farrow and Hebert were replicated using a much larger group and including several additional meditating and nonmeditating control groups. EEG alpha coherence, especially in the frontal areas of the brain, was found to increase during periods of respiratory suspension. The first control group, consisting of nonmeditators, showed no periods of respiratory suspension during relaxation with eyes closed. In the second control group, TM subjects were asked to voluntarily hold their breath while EEG coherence was measured. There was no significant change in EEG coherence during these periods. One of the conclusions of this study was that EEG coherence was more indicative of periods of pure consciousness than were EEG power measures and that further studies should utilize markers such as periods of respiratory suspension in order to more precisely study the physiological characteristics of the pure consciousness state.

From these EEG studies as well as the other physiological studies on breath suspension during the TM technique, it appears there are distinct physiological correlates associated with the experience of pure consciousness that uniquely distinguish it from other states. Since during TM the subject may experience usual states of consciousness such as wakefulness and drowsiness, there are also physiological signs of these states as well.

The most definitive studies by far are those which have attempted to carefully distinguish the state of pure consciousness from other states. These studies have noted specific periods of low metabolic rate, respiratory suspension, and high intra- and interhemispheric EEG coherence in alpha and theta frequencies, especially in the frontal and central areas of the brain, which are highly correlated with the subjective experience of pure consciousness. By using more careful subject selection, coupled with subjective reports, simultaneous electrophysiological measurements, and/or more in-depth physiological measurements, a more precise analysis of the state of pure consciousness has been obtained. Some of the most important studies which have utilized these criteria are those done on participants in the TM-Sidhi program by Orme-Johnson, Clements, Haynes, and Badaoui (1977) and Orme-Johnson and Haynes (1981).

The TM-Sidhi program was developed by Maharishi from the *Yoga Sutras* of Patanjali. The TM-Sidhi tech-
Techniques are designed to develop full mind-body coordination. The basis of success in using these techniques is the state of pure consciousness and the highly coherent state of physiology associated with it. The TM-Sidhi program involves entertaining certain mental formulas, or sutras, at the level of pure consciousness. Through this procedure it is possible to strengthen mind-body coordination to the maximum degree, so that the body responds to every intention of the mind (Orme-Johnson & Farrow, 1976, pp. 701-702).

Orme-Johnson's group studied twelve subjects who reported clear experiences of Transcendental Consciousness during the TM technique, clear experiences of Transcendental Consciousness during a night's sleep, and clear experiences using specific sutras during the practice of the TM-Sidhi program. He found that these subjects exhibited higher EEG coherence in the alpha and theta frequencies in the frontal and central areas of the brain, compared to ten male subjects whose experiences were less clear.

The areas of the brain that showed the highest amount of EEG coherence varied considerably among the individuals in both groups. There was, however, a significant correlation between degree of alpha coherence (in whichever area of the brain showed highest coherence) and the clarity of the experience of Transcendental Consciousness during the TM technique. The subjectively reported experience of Transcendental Consciousness during sleep (referred to as witnessing during sleep) was also significantly correlated with alpha coherence over all EEG electrodes, and less strongly with theta coherence and beta coherence.

Further, all subjects showed a positive correlation between the following variables: the various subscales of the Torrance Test of Creative Thinking (fluency, originality, flexibility, and novel use), total EEG coherence, experience of Transcendental Consciousness during sleep, and number of clear experiences of the TM-Sidhi abilities, or "sidhis." It was also found that clarity of experience of Transcendental Consciousness during the TM technique was strongly correlated, as would be expected, with experience of Transcendental Consciousness during sleep and number of clear experiences of the sidhis.

In one study, Orme-Johnson et al. (1977) made a more detailed analysis and classification of the subjective stages of development in the TM-Sidhi experience. EEG measurements made on 10 subjects while they practiced the advanced TM-Sidhi techniques showed a general increase in coherence correlated with experiences of the sidhis. One striking example showed a marked increase of EEG coherence in the right hemisphere of the brain during the TM-Sidhi technique of Yogic Flying, particularly in the beta frequency range (see Figure 3c). In another subject, EEG coherence and heart rate were recorded simultaneously during the Yogic Flying technique. Coherence and heart rate during the TM technique have usually been found to be negatively related. In this case, particularly during the period corresponding to the first stage of Yogic Flying (a "hop" by the subject) as observed on a TV monitor, the EEG coherence increased markedly along with an increase in heart rate. Orme-Johnson suggests that as a result of the TM-Sidhi program the subject had a greater ability to maintain the experience of pure consciousness (as shown by increased EEG coherence) even during physical activity.

One further subject whose records were analyzed in detail showed cycles of coherence in four separate areas of the brain during the TM and TM-Sidhi program. The subject was asked to press a button after a clear experience of a particular sutra. In general, the subject described his experience as a sequence: an abstract experience of pure consciousness, then a blissful sensation as the subjective experience of the specific sutra developed, followed by the thought to push the button. Orme-Johnson found that periods of high coherence occurred in the alpha and/or theta frequencies in all areas of the brain starting from approximately 5 to 25 seconds before pressing the button in 12 out of the 13 button presses. Periods of high coherence were also found to precede "hopping" in this subject. Periods of coherence were also found to correspond to slower respiration and greater stability of skin resistance, as has been noted by other researchers (Farrow & Hebert, 1982; Badawi et al., 1984).

**EEG Coherence III: Yogic Flying**

[Diagram: EEG Coherence During Yogic Flying]

**FIG. 3c.** In this example, the cospar shows a marked increase of EEG coherence in the right hemisphere of the brain during the TM-Sidhi technique of Yogic Flying, particularly in the beta frequency range.
Meta-Analysis

In the most thorough review article on all the physiological studies on the TM technique, Dillbeck and Orme-Johnson (1987) used meta-analysis to compare the state produced during the TM technique with ordinary rest or relaxation. Their analysis clearly distinguished the state produced during TM from rest and indicated several methodological problems in previous review articles.

The first problem has been a tendency to aggregate data from different meditation techniques that are procedurally quite different and have different effects. Second, previous reviews have not always fully utilized the information present in the studies of meditation that were cited.

In analyzing the information present in these studies, two possible approaches can be taken, narrative and quantitative, each giving quite different conclusions. In the narrative approach, some studies are excluded on design considerations and the remaining results verbally integrated. This can lead, unfortunately, to a great degree of variability due to a number of factors such as different criteria of what is a “good” study, differences in interpretation of results, and use of crude criterion measures such as presence or absence of statistical significance while ignoring such considerations as statistical power.

The importance of statistical power and sample sizes is a critical issue given the sample sizes of many of the studies on meditation. As Dillbeck and Orme-Johnson point out, for a moderate effect size to be detected, there should be a minimum of 15 subjects per group for between-subject comparisons and 10 subjects per group for within-subject comparisons.

In their review, Dillbeck and Orme-Johnson adopted a quantitative approach in which the statistical measure known as effect size was calculated. In order to do so they first completed a series of computer searches, locating all studies listed in the following databases through 1985 with the keywords meditation or relaxation response: Psychological Abstracts, Science Citation Index, Social Science Citation Index, Index Medicus, and Sociological Abstracts. The reference section of each paper listed was also searched for additional citations. All studies that assessed physiological effects of the TM technique were selected. In addition, other papers also listed in previous reviews were included for their measures of change during the eyes-closed rest control condition. Dillbeck and Orme-Johnson then calculated effect sizes for each of the studies. Because they wished to make use of all the information possible from all studies, effect sizes were calculated separately for the TM technique and rest as the number of standard deviations of change from the pre-meditation or pre-rest mean (using the standard deviation of the pre-period).

Using the statistical technique of meta-analysis (which integrates the findings of all research in an area) on physiological research on the TM technique, they demonstrated that the effect size for the TM technique is significantly larger than for ordinary eyes-closed rest for findings of increased basal skin resistance, decreased respiration rate, and decreased plasma lactate. No significant difference between eyes-closed rest and TM was found for heart rate or spontaneous skin resistance responses, although TM participants were found to have significantly lower levels of these two variables, as well as lower respiration rate and plasma lactate levels, during the pre-meditation or pre-rest baseline periods (see Figure 4).

Dillbeck and Orme-Johnson made two major recommendations for future research. The first was methodological. Studies comparing the TM technique and rest should have an adequate sample size, should be designed with explicit calculation of statistical power, and should also take closer account of the relevant confounding variables (e.g., dynamics and sub-stages of the TM technique, individual differences, recent and long-term life experiences of stress, differences over time in the quality of experience, and length of time practicing the technique).

The second recommendation was that researchers studying the effects of the TM technique should be familiar with the traditional theoretical framework of the technique. In particular, the three most important concepts for those studying this technique at present are: (a) there is a state of Transcendental Consciousness that is predicted to have unique physiological correlates, including global physiological integration characteristic of a restfully alert state rather than just reduced somatic arousal; (b) the TM technique is best viewed as a dynamical process with alternating sub-stages of Transcendental Consciousness and physiological normalization; and (c) the regular practice of the TM technique is predicted to develop better health and adaptive efficiency.

In summary, the refinement of methodologies, as well as the increase in the number of studies, has helped provide a more detailed description of the physiological correlates of this fourth state of consciousness, as well as a deeper understanding of basic neurophysiological mechanisms involved. Another meta-analysis that is important to mention is that by Eppley and coworkers (Eppley et al, 1989). They looked at over 99 different studies and found that compared to other meditation and relaxation techniques the TM technique was twice as effective in reducing anxiety. Duration of study, dropout rate, and number of follow-up hours of instruction were statistically con-
Meta-Analysis: Physiological Changes During the TM Technique

![Graph showing physiological changes during the TM technique]

**FIG. 4.** A meta-analysis of published research on physiological changes during the Transcendental Meditation technique—31 studies in all—found that during meditation, TM practitioners had significantly higher basal skin resistance and significantly lower respiration rates and plasma lactate levels than subjects during eyes-closed rest. Meta-analysis is the preferred scientific procedure for drawing definitive conclusions from large bodies of research.

PART 2: PHYSIOLOGICAL MEASURES OF HIGHER STATES OF CONSCIOUSNESS

If the nervous system is capable of supporting a state of pure consciousness, Maharishi’s Vedic Science predicts that it is also capable of supporting higher states of consciousness in which pure consciousness coexists with waking, dreaming and sleeping. Numerous studies have demonstrated that experience affects the structure and function of the nervous system. The presence or absence of certain types of stimuli during critical stages of animal development has a dramatic effect on the basic anatomical connections of nerve cells in the brain and thus on all types of perceptual and behavioral processes (Helmut, Hirsch, & Spinelli, 1971). In the light of these experimental findings, it is appropriate to ask: what is the effect of the presence or absence of the experience of pure consciousness on the functioning of the nervous system?

To answer this question we must consider the empirical evidence concerning the effects of the Transcendental Meditation program not only during meditation, but during activity, and further, the possible underlying neurophysiological mechanism for the development of higher states of consciousness. According to Maharishi’s Vedic Science, the development of these higher states occurs spontaneously as a result of the repeated experience of pure consciousness and the integration of this state into activity (Maharishi Mahesh Yogi, 1972, lesson 23).

Maharishi, in his revival and systematic presentation of ancient Vedic wisdom in the Science of Creative Intelligence and Vedic Science, has described the process of development of optimal neurophysiological functioning in terms of seven major states of consciousness. According to Maharishi, with the regular experience of the fourth state of consciousness, pure consciousness, the nervous system adapts to a new style of functioning. There is a gradual refinement of neurophysiological functions resulting in a new, more expanded state known as Cosmic Consciousness. In this state, as we have previously described, pure consciousness exists along with waking, dreaming, and sleep (Maharishi Mahesh Yogi, 1972, p. 23-5). In the waking state, for example, there is an experience of an inner wakefulness, with great creativity and clarity of consciousness, even while one is engaged in dynamic activity. Even when the individual is completely asleep he experiences a kind of inner alertness that is referred to in the Vedic tradition as witnessing (Maharishi Mahesh Yogi, 1969, p. 291).

Maharishi then describes how further refinement of neurophysiological functioning results in two even more optimal states, known as Refined Cosmic Consciousness and Unity Consciousness (Maharishi Mahesh Yogi, 1972,
Adaptability to Stress

Orme-Johnson (1973) conducted one of the most important early studies on the effects of the TM technique outside of meditation, which clearly demonstrates improvements in physiological stability and adaptability. This study showed that TM meditators had fewer spontaneous skin resistance responses (100 ohms or greater) outside of meditation than did nonmeditating controls. Orme-Johnson interpreted this finding to indicate a more stable and optimal style of autonomic functioning in the TM subjects as a result of their practice of the TM technique. Previous studies had shown that individuals with low levels of spontaneous skin resistance responses and heart rate show less motor impulsivity; that is, they are less likely to make impulsive and inappropriate movements during a simple motor test like reaction time.

Orme-Johnson’s study also included measurements of how quickly the skin resistance response adapts or habituates to stressful stimuli in TM subjects as compared to controls. Habituation is defined as the systematic decrease in response amplitude to the repeated presentation of the same stimulus. Previous research indicates that an individual who habituates rapidly on skin resistance response is outgoing and has a stable nervous system. Orme-Johnson measured evoked skin resistance responses in meditators and nonmeditators who were presented with noxious tones at regular intervals. The TM meditators habituated significantly faster than the nonmeditators. Also, meditators produced fewer multiple fluctuations in skin resistance during the recovery cycle, thus suggesting a more stable reaction to stress.

Several other studies have repeated Orme-Johnson’s findings of both increased autonomic stability, as measured by a lower number of spontaneous skin resistance responses, in TM participants as compared to controls (Wilcox, 1973; Berker, 1976; Smith, 1976), and faster habituation of autonomic responses such as evoked skin resistance response and heart rate (Goleman & Schwartz, 1976; Daniels, in press).

Perceptual and Motor Performance

A number of studies have shown significant improvements in various aspects of perceptual and motor performance with the practice of the TM technique, such as faster reaction time (Shaw & Kolb, 1976; Appelle & Oswald, 1974), improved responses on visual choice reaction time (Holt, Caruso, & Riley, 1978), a significant reduction of perceptual illusion (Martinetti, 1976) and, in a very well-controlled and extensive study, longitudinal improvements in visual perception and verbal problem solving (Dillbeck, 1982). In several different studies on TM subjects short- and long-term improvements have been reported on hearing ability and discrimination (Pirot, 1973; Schwartz, in press).

Clements and Milstein (1977) determined absolute hearing thresholds by using pure sine wave tones from 250 Hz to 8000 Hz in eight female subjects who had been participating in the TM-Sidhi program for approximately eight months. The subjects in the study had been performing a number of TM-Sidhi procedures designed to enhance sensory abilities, including one that has the specific intention of enhancing hearing beyond the usual range of sensitivity. The auditory thresholds were determined before and directly after a 20-minute period consisting of five minutes of the TM technique followed by 15 minutes of performing the sutra to enhance hearing ability.

The results showed unusually low hearing thresholds for almost all subjects (11.7 decibels more sensitive than norms). The hearing threshold decreased significantly (a further 3.0 db) after 15 minutes of performing the TM-Sidhi sutra designed to produce enhanced hearing ability. The authors examined subjective reports of practitioners and noted that, after the performance of that sutra, subjects commonly reported their hearing was extremely clear. As one subject reported, “Hearing is becoming more and more acute—much fuller and very sweet and blissful. All senses are more refined, not necessarily just sharper, but fuller, with intuition and knowledge of greater depth.”

The authors suggest that the improvements in hearing ability might be due to a reduction of noise within central auditory pathways. Previous findings (Levine et al., 1976; Orme-Johnson et al., 1977) of higher EEG coherence during the TM and TM-Sidhi program suggest higher stability of EEG activity and therefore lower internal noise levels within the cortex.

McEvoy, Frumpkin, and Harkins (1980) studied brainstem auditory evoked potentials in TM-Sidhi program participants. Using a design similar to that of Clements and Milstein, they found a significant change in brainstem auditory evoked potentials after the practice of the sutra designed to enhance hearing, as compared to before the
practice. Their findings indicate a reduced signal-to-noise ratio in the central processing of auditory information.

In an extensive study by Daniels (in press), performance in dichotic listening was measured in fifty subjects. The subjects were divided into five groups: (a) subjects practicing the TM technique; (b) subjects practicing the TM technique but told beforehand that TM subjects perform poorly at this particular task (demotivation); (c) subjects practicing a simulated meditation with the use of a nonsense syllable; (d) subjects practicing progressive relaxation; and (e) subjects who relaxed in their own individual way. Subjects were required to pick out target words embedded randomly in a piece of text. Into each ear separate texts were read at a rate of 180 words per minute. Subjects were tested before and after practicing their specific technique, and scores were determined by the percentage difference in the number of correct hits (positive) on the target word and the number of responses made to the wrong words (false positives). Both groups practicing the TM technique showed significantly better performance on this task than the other three groups. Further, the analysis of false positives indicated that the TM groups performed at a more efficient level before the period of the TM technique than all the other groups before they practiced their own techniques. That the second TM group performed significantly better than the other non-TM groups showed that the improvement in the ability to process information occurred independently of motivational factors.

Several studies have shown longitudinal improvements in field independence (Pelletier, 1974; Orme-Johnson & Granieri, 1977). (See Figure 5.) Field independence is a perceptual measure which reflects the development of a stable internal frame of reference. Improved field independence is a concrete indication of the ability to function without losing one's internal frame of reference. This is similar to the descriptions of higher states of consciousness in which the state of unbounded pure consciousness is maintained as a stable internal reference even in the midst of dynamic activity. Because of this similarity some researchers feel that the improvement in field independence is a significant measurable correlate of Maharishi's description of the development of higher states of consciousness.

In the area of motor physiology several studies have shown changes of reflex activity (Warshal, 1980; Haynes, Hebert, Reber, & Orme-Johnson, 1976; Wallace, Mills, Orme-Johnson, & Dillbeck, 1983). Some of these studies have focused on the motor reflex responses as measured by the paired Hoffman or H-reflex. The H-reflex was first described by Hoffman in 1918 and has since been extensively studied under a variety of experimental and pathological conditions (Hugon, 1973). The H-reflex is a way of inducing a spinal reflex response. In the paired H-reflex, pairs of stimuli are given, separated by varying time intervals. By comparing the magnitude of each of the H-waves (the electrical potential of a muscle contracting) and by varying the time intervals, an H-reflex recovery curve is obtained—a measure of the recovery of the H-reflex after it has been conditioned by a previous stimulus.

Haynes et al. (1976) reported that subjects with clear

![Increased Field Independence](image)

**FIG. 5.** Three tests were given that directly measure field independence, the ability to focus attention on specific objects without being distracted by the environment of the objects. Subjects were randomly assigned to either TM or control groups. After practicing the Transcendental Meditation technique for three months, the TM group displayed significantly increased field independence compared to controls.
experience of pure consciousness showed faster recovery of the paired H-reflex; and in addition, faster recovery of the paired H-reflex response correlated significantly with higher EEG coherence and creativity measures. More recently, Dillbeck, Orme-Johnson, and Wallace (1981) reported a significant correlation between flexible performance on a concept learning task and faster recovery of the paired H-reflex response and frontal EEG coherence in TM-Sidhi program participants (see Figure 6).

In a longitudinal study the effects of the TM-Sidhi program on paired H-reflex recovery at nine delay intervals were investigated (Wallace et al., 1983). The experimental group was instructed in the TM-Sidhi program while the controls practiced TM only. The subjects were tested before and after the same three-month period. Significant longitudinal differences were found in H-reflex recovery between the male TM subjects and the male TM-Sidhi subjects, between the time intervals 100 msec and 250 msec, the period most intensively studied.

Several researchers have studied the relationship of H-reflex recovery to different states of awareness. For example, Pivik and Mercier (1979) showed that during non-rapid eye movement (NREM) sleep (stages 2 and 4) the H-reflex recovery during the period between 100–300 msec was significantly reduced. Van Boxtel (1976) made simultaneous measurements of EEG alpha activity and H-reflex recovery curve. He showed that a constant alpha index (percent of time alpha was present) was accompanied by stable H-reflex amplitudes and that a decreasing alpha index (indicative of drowsiness) was accompanied by decreasing H-reflex amplitudes.

These studies suggest the involvement of the reticular activating system in the brain, which is concerned with both maintaining the tone of consciousness and with regulating reflex activity. The correlation of the H-reflex recovery response in TM-Sidhi participants with higher levels of EEG coherence indicates the type of neurophysiological mechanism suggested by both Pivik and Mercier, and by Van Boxtel. The reticular formation (in particular, the reticular activating system) has been suggested by a number of researchers to play an important role in the development of the state of inner awareness in higher states of consciousness (Gelhorn, 1967).

Studies on TM subjects have also shown a significant correlation between faster recovery of the paired H-reflex response and higher academic performance, thus suggesting a general effect of enhanced inner wakefulness as a result of the TM-Sidhi program (Wallace, Mills, Orme-Johnson, Dillbeck, & Jacobe, 1982). While the mechanisms for altering the H-reflex recovery curve remain complex, in this as well as in other reflex studies the H-reflex provides an interesting model for the study of the development of higher states of consciousness.

**Cognitive, Affective, and Physiological Correlates of EEG Coherence**

![Diagram](image)

FIG. 6. The results of several experiments indicate that higher levels of EEG coherence, in particular alpha coherence in frontal brain areas, measured during the practice of the Transcendental Meditation technique, are significantly correlated with a number of different cognitive, physiological, and affective variables: increased fluency of verbal creativity, increased efficiency of learning new concepts, more principled moral reasoning, higher verbal IQ, decreased neuroticism, clearer experiences of Transcendental Consciousness, and faster recovery of the H-reflex, a measure of neurological efficiency.
**EEG Correlates of Higher States of Consciousness**

Many researchers distinguish EEG state effects—that is, short-term physiological changes specific to a particular state (such as those occurring during the practice of the TM technique)—from EEG trait effects—changes which seem to be characteristic of long-term development in the physiology. A number of EEG studies suggest that the regular practice of the TM technique results in particular long-term trait effects, which may best be characterized as increased wakefulness and higher mental functioning. For example, in response to intermittent photic stimulation, meditators showed a significantly smaller decrement in alpha activity and alpha blocking response than did the controls (Williams & West, 1975). Also, TM participants outside of meditation showed larger amplitudes and shorter latencies of the visual evoked cortical response as compared with controls (Banquet & Lesevre, 1980).

Several researchers have studied the sleep EEG pattern of advanced TM meditators to test how the growth of higher states of consciousness might be reflected in these measurements. In one preliminary study of two advanced meditators, Banquet and Sailhan (1976) reported finding unusual brain activity during sleep. All cycles and phases of normal sleep were present, yet at the same time, Banquet says, the “higher levels of consciousness were unimpaired.” The EEG patterns were the same as in normal sleep, with the addition of a rhythmical beta pattern at a constant frequency (20 Hz) present through the different stages. During sleep, subjects “were able to perceive and perform a motor act and were conscious of their dreams.” These findings suggest classical descriptions of witnessing in higher states of consciousness.

In a more extensive study Banquet, Haynes, Hebert, and Reber (1977) measured EEG over ten nights of sleep in five subjects who practiced the TM technique and five control subjects, using standard derivation O1-O2, C3-C4, F3-F4, surface EMG and two EOG electrodes. Analysis involved traditional sleep scoring as well as use of coherence spectral array. Average sleep duration for TM subjects was 64% of that of controls and number of sleep cycles was 1.4 versus 2.8 for controls. Sleep stages shortened both in absolute length and percent of total; for example, stage IV time of TM subjects was 16% of that of controls; stage I was the only stage significantly increased for TM subjects.

Several studies have also shown longitudinal increases in EEG coherence (Dillbeck & Bronson, 1981; Orme Johnson, Wallace, Dillbeck, Alexander, & Ball, in press). In one of these, longitudinal measurements of EEG coherence were made on college students practicing the more advanced TM-Sidhi program as compared to those practicing the TM program alone (Orme-Johnson et al., in press; Nidich, Ryncarz, Abrams, Orme-Johnson, & Wallace, 1983). Out of a subject pool of 143 freshmen and sophomores who were available for testing over the period of a year, and who had no previous experience in the TM-Sidhi program, 24 matched pairs were randomly selected. Subjects were matched for age, gender, and length of time meditating. Both experimental and control groups were measured on a variety of physiological and psychological variables before and after a three-month summer recess. During this period the experimental group learned the TM-Sidhi program while the control group took their usual summer vacation.

A multivariate analysis showed a significantly greater increase in alpha and theta EEG coherence outside of meditation during resting in the TM-Sidhi subjects than in the control subjects. An analysis of the alpha index (derived from calculating the percentage of alpha wave activity) showed no significant difference from pre- to posttesting, suggesting that EEG coherence provides a unique type of information not available by classical EEG scoring methods. The most striking changes in EEG coherence were seen in the frontal and central portions of the brain, as compared to the occipital or posterior portions of the brain. This finding is of particular interest since Orme-Johnson and Levine have shown that frontal alpha coherence seems to be a better indicator of wakefulness than occipital coherence (Orme-Johnson et al., in press; Levine et al., 1976). Even during brief periods of drowsiness, frontal alpha coherence markedly decreases. Thus the findings suggest that the state of increased inner alertness or wakefulness that is seen during the TM and TM-Sidhi program may result in a long-term trait effect of greater inner alertness outside of meditation.

In summary, these and other studies have shown significant correlations between alpha frontal coherence, experiences of Transcendental Consciousness, and a variety of performance measures, including IQ (Raven Progressive Matrices), creativity (Torrance Test of Creative Thinking), grade point average, scores on the Scholastic Aptitude Test, moral reasoning (Kohlberg’s Moral Development Scale), concept learning, faster recovery of the H-reflex, and decreased neuroticism (Orme-Johnson & Haynes, 1981; Dillbeck, Orme-Johnson, & Wallace, 1981; Haynes et al., 1976; Orme-Johnson, 1982). (See Figure 6.) The positive correlation of frontal alpha EEG coherence with intellectual and moral development further reinforces this interpretation of a more alert and optimal style of brain functioning.

The process of growing to the highest state of consciousness—traditionally known as “enlightenment”—is referred to as a process of becoming more and more fully
awake inside, awake to the inner dynamics of consciousness. According to Maharishi, to be "fully awake" means to be established in the state of pure awareness, the Unified Field of Natural Law. Established in that state the individual performs optimally: he acts in accordance with all the Laws of Nature (Maharishi International University, 1974, pp. 195-199).

The very wide range of physiological and psychological effects seen in TM subjects outside of meditation strongly suggests that the continued practice of the TM technique results in a developmental process in which there are improvements in all aspects of the individual's physical, mental, and emotional capacities. By enabling the nervous system to support the state of pure consciousness, the Maharishi Technology of the Unified Field cultures a more optimal style of neurophysiological functioning in which human awareness is brought in tune with the Unified Field of Natural Law.

**Health**

The research on the TM and TM-Sidhi program has not only helped verify the experimental validity of higher states of consciousness; it has more importantly revealed their practical significance in improving health and longevity.

What is ideal health? What is the ultimate level of balance and integration? According to Vedic physiology ideal health means wholeness on all levels of life. When individual life is established in the Unified Field of all the Laws of Nature all actions are spontaneously in accord with Natural Law (Maharishi Mahesh Yogi, 1986, pp. 25-26). In terms of physiological activity this means perfect integration and balance, from the finest level of molecular functioning to the grossest levels of physiological organization.

In examining the evolution of life, physiologists recognize that greater internal balance is achieved through the development of more refined homeostatic mechanisms. This enables higher organisms to be more adaptable and therefore freer from the deleterious effects of living in a changing environment.

Is it possible to develop optimal functioning of human homeostatic processes? According to Maharishi, the precise mechanics of how to achieve perfect physiological balance, and thus perfect health, are included in one specific area of the Vedic literature known as *Ayur-Veda*.

**Ayur-Veda: The Science of Life**

_Ayu_ means life or life span; _Veda_ means pure or complete knowledge. Thus, Ayur-Veda, the branch of Vedic Science that deals with prevention of disease and promotion of health and longevity, translates as the complete knowledge or science of life, life lived in its full value to the maximum life span.

Ayur-Veda is the parent of natural medical systems, having an enormous influence on other traditional systems around the world. Even in China, which has its own great tradition of natural medicine, the sweeping influence of Buddhism had brought with it the knowledge of Ayur-Veda. In its original form Ayur-Veda included knowledge about literally every aspect of life and health. However, for hundreds of years, India was occupied by foreign nations and Ayur-Veda's vast knowledge became fragmented and confined to a few experts—and among these, still fewer retained the knowledge in any degree of completeness.

Ayur-Veda was rediscovered by Maharishi in the same manner that he rediscovered Vedic physiology and the other branches of Vedic Science. Maharishi explains that Ayur-Veda deals with the knowledge of how to restore balance in the physiology and in consciousness—to create the necessary physiological conditions which will allow the inner intelligence of the body to heal itself. All of its different approaches are designed to help unfold and express this inner intelligence (Maharishi Mahesh Yogi, 1986, pp. 108-115).

Maharishi's fundamental contribution to Ayur-Veda was the revival of techniques to unfold consciousness and establish complete mind-body coordination; these techniques were originally an integral part of Ayur-Veda but had become separate and de-emphasized. The next step he undertook was to systematically gather the very best of the few remaining traditional experts of Ayur-Veda throughout India. Maharishi worked closely with these great physicians in order to re-evaluate and revive the completeness of Ayur-Veda.

**Maharishi Ayur-Veda**

It is important to distinguish the presentation of Ayur-Veda by Maharishi—known as Maharishi Ayur-Veda—from the fragmented and incomplete knowledge that is most often being practiced in India today under the name of Ayur-Veda. This restoration of Ayur-Veda by Maharishi is new not only to the West, but to India itself.

There are four fundamental areas of life that Maharishi Ayur-Veda is concerned with: (a) mind or consciousness, (b) physiology, (c) behavior, and (d) environment. Within each of these areas there are many therapeutic strategies and procedures. These are briefly summarized in Table 1.

It is not the purpose of this chapter to review extensively all of the different approaches of Maharishi Ayur-
### Table 1. — Four Fundamental Approaches of Maharishi Ayur-Veda

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Mind or Consciousness</td>
<td>Applying knowledge regarding the nature of human consciousness, its relation to the thought process, and its influence on physiological processes, behavior, and environment. This includes techniques such as the Transcendental Meditation and TM-Sidhi program that enhance the individual’s capacity to directly improve his state of mind, thereby reducing stress, increasing mental balance, and improving habits of thinking and behavioral patterns.</td>
</tr>
<tr>
<td>2. Physiology</td>
<td>Applying extensive dietetic measures, sophisticated purified mineral and herbal preparations, and other procedures for the treatment of specific disorders, enhancement of immune system functioning, and promotion of longevity.</td>
</tr>
<tr>
<td>3. Behavior</td>
<td>Providing comprehensive guidelines for personal hygiene, exercise, and health-promoting conduct, as well as daily and seasonal routines to restore integrity to fundamental biological rhythms.</td>
</tr>
<tr>
<td>4. Environment</td>
<td>Eliminating stress and improving the environment for the individual and for society as a whole through collective health measures such as collective practice of the TM-Sidhi program.</td>
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Veda or the scientific research on their applications. These topics are discussed in greater detail in articles in the Spring 1988 issue of *Modern Science and Vedic Science*, by Rigby and Glaser. The focus of this discussion on Maharishi Ayur-Veda will be concerned with the area of consciousness.

The primary Ayur-Veda approach on the level of consciousness is the Transcendental Meditation and TM-Sidhi program. The ancient records of Ayur-Veda specifically refer to gaining perfect health through the practice of meditation and the practice of the sidhis as described in the ancient *Yoga Sutras* of Patanjali. We have been fortunate to be able to objectively study and verify this approach of Ayur-Veda through the application of the TM and TM-Sidhi program to many different areas of health.

One important area of research has been concerned with studying the effects of the TM and TM-Sidhi program on the major risk factors of cardiovascular disease, the number-one killer in most technologically advanced countries. The risk factors which have been studied are: high blood pressure, elevated cholesterol levels, cigarette smoking, obesity, and reactivity to stress.

Several longitudinal studies have shown a reduction in blood pressure in hypertensive patients who have begun Transcendental Meditation (Blackwell et al., 1975; Simon, Oparil, & Kimball, 1976; Agarwal & Kharbanda, in press). A longitudinal study has shown reduction in blood pressure in normal subjects (Cooper & Aygen, 1978), and a cross-sectional study has further shown markedly lower resting blood pressure in elderly subjects practicing TM as compared to the norms for the general population (Wallace, Silver, Mills, Dillbeck, & Wagoner, 1983). (See Figure 7.)

In a well-controlled study in Israel significant improvements were seen in meditating patients with high cholesterol levels as compared to controls (Cooper & Aygen, 1979). (See Figure 8.) Improvements in smoking and obesity in TM subjects have also been reported (Shafii, Lavely, & Jaffe, in press; Bauhofer, in press).

A recent study examined cardiovascular reactivity to stressful stimuli in TM and control subjects who had been matched for age and gender. The results of this study showed that meditating subjects had reduced cardiovascular reactivity as well as lower blood pressure, lower levels of epinephrine and lower beta-adrenergic receptor sensitivity as compared to controls (Mills et al., 1987). These and other studies suggest that the TM technique has an important effect on susceptibility to heart disease by altering the individual’s physiology so that he is more resistant to the deleterious effects of stress and thus better able to cope with the fast pace of life today.

Two further studies have shown beneficial effects of TM on cardiovascular disease in patients with angina pectoris and arrhythmia (Zamarra, Besseghini, & Wittenberg, 1975;
FIG. 7. Systolic blood pressure, the pressure in the blood vessels at the end of a heart beat, is often used as a measure of hypertension. Systolic blood pressure was measured in people practicing the Transcendental Meditation program and compared to known values for the general population. Both men and women in all age groups who practiced the TM program had significantly lower blood pressures. Furthermore, the long-term TM practitioners had lower blood pressures than the short-term practitioners.

FIG. 8. This study tested subjects with high blood cholesterol levels at the beginning of the experiment and 11 months later. The subjects who practiced the Transcendental Meditation technique showed a significant drop in the level of cholesterol in the blood when compared to themselves (p<.005), while the control group showed very little decrease. Diet was controlled in this study.

Lown et al., 1976). Other health-related studies have reported improvements as a result of the TM technique in conditions such as bronchial asthma (Wilson, Hansberger, Chiu, & Novey, 1975), insomnia (Miskiman, 1977; Fuson, in press), a number of major and minor psychiatric disorders (Dick & Ragland, 1976; Rigby, 1977; Suurkula, in press; Eyerman, 1981; Wood, in press; Brooks & Scarrano, 1985), and drug abuse problems (Shafii, Lavelly, & Jaffe, 1974; Katz, 1976; Brautigam, 1976; Schenklhun & Geisler, 1976; Monahan, 1977; Lazar, Farwell, & Farrow, 1976; Orme-Johnson, 1981; Ramirez, 1976; Ferguson, in press; Siegel, 1981).

Finally, the most important health-related study to date examined statistics from a major health insurance carrier over a five-year period (see Figures 9 and 10). This study found that a group of two thousand members participating in the Transcendental Meditation program had consistently lower rates of inpatient hospitalization and outpatient doctor visits than the average of all other groups with the same carrier. The rate of hospital admissions for the TM group was 63.0% lower than the norm for medical reasons and 71.5% lower for surgery, but was similar to the norm for obstetrical. The rate of outpatient doctor visits was 58.8% lower for medical and 56.0%
FIG. 9. A study of health insurance statistics on over 2000 people practicing the Maharishi Technology of the Unified Field over a five-year period found that the participants in the Transcendental Meditation program consistently had less than half the doctor visits and hospitalization than other groups of comparable age, gender, profession, and insurance terms. The difference between the TM and non-TM groups was greatest for individuals over 40. In addition, the TM practitioners had markedly fewer incidents of illness in 17 medical treatment categories.

FIG. 10. A study of health insurance statistics on over 2000 people practicing the Maharishi Technology of the Unified Field over a five-year period found that participants—when compared to other groups of similar age, gender, profession, and insurance terms—consistently needed much less medical treatment in all 17 disease categories. For childbirth, there was no significant difference between groups. The group practicing the Transcendental Meditation technique had 87.3% less hospitalization for heart disease, 55.4% less for benign and malignant tumors, 87.2% less for nervous system disorders, and 73.0% less for nose, throat and lung problems.

lower for surgery. When compared by age, the health insurance statistics showed that the TM group had lower rates of inpatient hospitalization and outpatient doctor visits in all age groups. The rate of hospital admissions for the TM group in all categories of disease was lower than the norms; for example, admissions rate in the TM group was 87.3% lower for heart disease.

The TM group was also compared with five other groups of similar professional membership—two banking industries, a school system, a computer firm, and a city government unit—and found to have lower rates of inpatient hospital admissions and outpatient doctor visits than any of the other groups. For the TM group, hospital admission rates were 55.6% lower for medical and 76.3% lower for surgical procedures.
lower for surgical than for the controls. The study controlled for other factors that might affect health care use, such as cost-sharing, age, gender, geographic distribution, and profession and found that they could not account for the meditators' lower rates. In addition, the TM meditators showed a much lower rate of increase in health care utilization as a function of age than did comparison groups (Orme-Johnson, 1987).

Reversing the Detrimental Effects of Aging

The study of aging provides a very clear opportunity to test the hypothesis that more optimal states of physiological functioning can be cultured through the Maharishi Technology of the Unified Field, including the various approaches of Maharishi Ayur-Veda.

One of the first statements in Caraka (Sharma & Dash, 1976), the classic text of Ayur-Vedic literature, is:

\[ \text{athato dirghanjivitiyam adhyayam vyakhyasamah} \]

We shall now expound the chapter on “The Quest for Longevity.”

The Vedic texts also state:

\[ \text{Ayurved amritanam} \]

Ayur-Veda is for the seekers of perfect health and immortality.

Maharishi explains that the entire purpose of Ayur-Veda is to cultivate that style of functioning of the body and nervous system which will develop and maintain higher states of consciousness. In the highest state of consciousness, enlightenment, one’s awareness is established in pure consciousness. Operating from this level, life is lived spontaneously in accord with Natural Law, and the value of pure consciousness begins to be maintained in the physiology (Maharishi Mahesh Yogi, 1986, p. 32).

A number of studies have shown the beneficial effects of the TM and TM-Sidhi program on the aging process. Studies on aging by Palfone and his associates (1974) at Duke University have correlated the following seven factors with influencing longevity (listed in order of significance): (a) cardiovascular disease, (b) work satisfaction, (c) cigarette smoking, (d) physical function, (e) happiness rating, (f) self-health rating, and (g) performance IQ. Studies on TM participants have reported improvements in all seven factors. This research may be briefly summarized as follows: (a) Studies show, as we have mentioned above, that a number of cardiovascular disease risk factors such as high blood pressure and high cholesterol levels improve as a result of the regular practice of the TM technique. (b) Job satisfaction also has been reported to improve with the TM technique (Frew, 1974). (c) Cigarette smoking and alcohol consumption decrease in TM participants (Wallace et al., 1972; Shafii et al., in press). (d) A variety of improvements in physical function have also been noted above, such as faster reaction time, improvements in respiratory and circulatory functions, and improved sensory performance. (e) Studies have shown increased happiness ratings, contentment, self-actualization, and self-regard, and decreased anxiety and neuroticism (Orme-Johnson & Farrow, 1976). Increased happiness is further demonstrated by the significant improvement in hospitalized patients suffering from severe depression. These findings are also of interest in light of a study by Vaillant (1979), which clearly establishes that better mental health is associated with longevity. (f) Improvements in self-health rating have been reported (Wallace, 1970a) as well as (g) improvements in intelligence on IQ tests designed to measure fluid intelligence (Tjoa, 1975).

The above studies provide strong circumstantial evidence for the beneficial effects of the TM technique on the aging process. In addition several studies have been conducted which are concerned directly with specific measures of biological aging.

Reduction of Biological Aging

Using a measure of biological aging which includes subtests of auditory threshold, near-point vision, and systolic blood pressure, it was found that long-term TM meditators had significantly younger biological age than short-term meditators, controls, and norms for the general population, and that the strength of this effect is related to the length of practice of the TM technique (Wallace, Dillbeck, Jacobs, & Harrington, 1982). Further statistical analysis indicated that while subjects who excluded meat from their diets had younger biological ages, the effect of the TM program was independent of both diet and exercise pattern (see Figure 11).

Two studies conducted in England have replicated and extended these initial findings. In one cross-sectional study, TM subjects were found to have a biological age seven years younger than their chronological age. A follow-up study 1.5 years later found that the biological age of the same meditators actually decreased by another 1.5 years (Toomey, Pennington, Chalmers, & Clements, in press; Toomey, Chalmers, & Clements, in press).

Another important recent study on biological aging involves the measurement of one of the most reliable biochemical markers of the aging process, serum dehydroepiandrosterone sulfate (DHEAS) by Glaser, Brind, Eisner, and Wallace (1986). DHEAS declines progressively with age. Peak levels occur in one’s mid-twenties; by the eighth
and ninth decades of life, one’s DHEAS level may have declined 80 percent.

DHEAS levels were measured in 254 men and 74 women who were experienced participants in the TM and TM-Sidhi program, and compared according to gender and five-year age groups to 981 men and 481 women control subjects who were not meditating. The mean DHEAS levels in meditators were significantly higher than in the controls in all five of the age groups measured in women, and in eight of eleven age groups in men. Further, the difference was more pronounced in the older subjects: the mean percentage of DHEAS elevation over control values was higher for the older age groups, with mean differences of 23% for men over 45, and 47% for women over 45. This effect was independent of identifiable contributing factors including diet, exercise, obesity, or use of alcohol.

The mean levels measured in the older meditators were generally comparable to levels in control groups 5 to 10 years younger. Low levels of DHEAS in women have been correlated with higher incidence of breast cancer, and administration of DHEAS or DHEA has been shown to improve obesity, diabetes, spontaneous and induced tumors, and autoimmune processes in mice—all diseases associated with senescence. That regular practitioners of the Transcendental Meditation technique have higher DHEAS levels than control populations is another indication of younger biological age in TM participants.

One further recent study considered the effects of TM on cognitive and behavioral flexibility, health, and longevity in elderly individuals (Alexander, Langer, Newman, Chandler, & Davies, 1989—see Figure 12). In assessing the effects of the TM program on aging the study examined whether such effects are produced independently of context, expectation, or simple relaxation components.

Seventy-three residents of homes for the elderly (60 women and 13 men, with a mean age of 80.7 years) were randomly assigned to either a no-treatment condition or to one of three treatments designed to be equivalent in external structure and features fostering expectation: the TM program, “mindfulness” training (an active thinking procedure), and a relaxation program.

All groups were initially similar in expectancy of benefits and on pretest measures, yet after a three-month experimental period the TM group had significantly improved in comparison to one or more treatment conditions on three measures of cognitive flexibility (the Overlearned Verbal Task, the Stroop Color-Word Interference Test, and the Associate Learning Test for difficult word pairs), word fluency, two methods of assessing change in systolic blood pressure, self-report measures of behavioral flexibility and aging, and in nurses’ rating of mental health (after 18 months). Also, the TM subjects reported feeling more interested during their practice, and better and more relaxed immediately after their practice, than did the active thinking and relaxation subjects. Overall, more TM subjects found their practice to be personally valuable than
Improved Health and Longevity in the Elderly

**Lower Blood Pressure**

<table>
<thead>
<tr>
<th>Systolic Blood Pressure (adjusted for pretest level)</th>
<th>Controls</th>
<th>Relaxation</th>
<th>Active Thinking</th>
<th>TM</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 t 140</td>
<td>145 t 150</td>
<td>p &lt; .01</td>
<td>150 t 155</td>
<td>145 t 149</td>
</tr>
</tbody>
</table>

**Increased Cognitive Flexibility**

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<th>Controls</th>
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<th>Active Thinking</th>
<th>TM</th>
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<tbody>
<tr>
<td>110 t 140</td>
<td>145 t 150</td>
<td>p &lt; .001</td>
<td>150 t 155</td>
<td>145 t 149</td>
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**Enhanced Longevity**

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<th>Systolic Blood Pressure (adjusted for pretest level)</th>
<th>Controls</th>
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<td>p &lt; .001</td>
<td>150 t 155</td>
<td>145 t 149</td>
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**FIG. 12.** This study randomly assigned residents of homes for the elderly with an average age of 80.7 years to one of four programs: the Transcendental Meditation program, an active thinking (mindfulness) program, a relaxation program, or a control group with no treatment. Despite similarity among groups on pretest measures, expectation, and time spent in practice with eyes closed, the TM group improved most over a three-month period on blood pressure, cognitive flexibility, and other health and cognitive measures. After three years, all in the TM group were still living, in contrast to lower rates for the other groups and a 62.5% survival rate for the 478 other residents.

The results of these studies on biological aging, supported by the large number of other physiological studies, strongly indicate that the Maharishi Technology of the Unified Field retards and even reverses the aging process. Taken together the several hundred studies on the TM and TM-Sidhi program clearly define more optimal levels of physiological functioning which are associated with the development of higher states of consciousness.

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EEG and coherence


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