

## Original Article

# Studies of Advanced Stages of Meditation in the Tibetan Buddhist and Vedic Traditions. I: A Comparison of General Changes

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This article is the first of two comparing findings of studies of advanced practitioners of Tibetan Buddhist meditation in remote regions of the Himalayas, with established results on long-term practitioners of the Transcendental Meditation programs. Many parallel levels of improvement were found, in sensory acuity, perceptual style and cognitive function, indicating stabilization of aspects of attentional awareness. Together with observed increases in EEG coherence and aspects of brain function, such changes are consistent with growth towards a state of total brain functioning, i.e. development of full mental potential. They are usually accompanied by improved health parameters. How they may be seen to be consistent with growth of enlightenment will be the subject of a second article.

**Keywords:** Buddhism – cognition – EEG – enlightenment – meditation – transcendental meditation

## Introduction

### Long-Term Meditation and Health

Studies of advanced meditators, and any advanced meditation states they may achieve, indicate effects to be expected from long-term practice of the techniques concerned. In South Asian countries like India and Tibet, long-term meditation is still widely held to be the way to achieve the highest goal of human life, ‘enlightenment’, a term now described in terms of the stabilization of higher states of functioning of the human psychophysiology (1). In societies and cultures with this understanding, there are naturally numbers of individuals available for the study of progressive development towards such states, and their reputed practical advantages, for example to health.

In the western world, studies of long-term meditators engaged in busy professional lives have observed significant health expenditure reductions (2,3). Reduced insurance costs of 50% averaged over all disease categories were observed in a retrospective study (2), following which a prospective study found costs incurred through General Practitioners to go down by 7% per year relative to controls for the first several years of

practice (3). This suggests that the full 50% reduction may take some 7 or so years to develop. Of particular significance was that long-term heart disease costs reduced by 87% (2). As health costs have now become a major problem to government in many countries consuming ever increasing fractions of the Gross Domestic Product, with heart disease being the major cause of death, understanding long-term meditation practice more deeply, and the reality of its practical benefits, is of obvious importance.

Most systems of traditional medicine regard meditation, or related mind–body techniques, as valuable forms of health maintenance and therapy. Both Ayurveda and Traditional Chinese Medicine deal similarly with subtle aspects of the physiology known as nadis (Ayurveda) or acumeridians (TCM) (4). Meditation assists in keeping these clear, and in pain relief (5). The Chumash Indians in North America have long utilized related techniques in their medical practices (6,7).

### Studying Meditation and Stages of Enlightenment

Many techniques used in contemporary mind–body medicine have as their ultimate goal states of improved psychophysiological functioning similar, or directly related, to enlightenment such as meditation techniques and forms of psychotherapy based on transpersonal psychology, neurolinguistic programming and their various outgrowths. Traditionally, in both East

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and West, such states are held to radically improve health, but are described and defined in terms of subjective aspects of conscious awareness such as changes in attention and cognitive style. Empirical science cannot directly study changes in consciousness and subjective awareness, but must first determine objective measures associated with them. Scientists aiming to study and characterize such changes must use psychological and physiological tests, correlating them with subjectively experienced changes in awareness reported by the subjects investigated.

To gain access to appropriate subjects with authentic experience is rare. They are seldom found within the world of commerce and science. More often they lead reclusive lives in the vastness of the world's most desolate places, or are under the direction of an enlightened master, such as the Dalai Lama, whose permission has to be obtained to make measurements on those for whom he is responsible. Results are not simply of interest to those interested in changes brought about by long-term meditation, or persistent adherence to a spiritual path, but, because they hold promise of solutions to some of the developed world's most intractable problems, to all concerned with the medical and social policies of modern government.

### Specific Mental Techniques used for 'Meditation'

This article reviews a selection of studies on advanced Tibetan Buddhist meditators and practitioners of the Transcendental Meditation™ program (TM) (Transcendental Meditation and TM are service marks registered in the US Patent and Trademark Office, licensed to Maharishi Vedic Education Development Corporation, and used under sublicense), as taught by His Holiness Maharishi Mahesh Yogi, two systems with numbers of studies on highly experienced subjects.

The two traditions use different but not unrelated techniques, the 'Six Dharmas (or 'Yogas') of Naropa and Niguma' (8), being the best known of Tibetan Buddhism. Of these, the 'Yoga of the Clear Light' seems closest to Transcendental Meditation, since it is said to bring the awareness to a state of no mental content, filled, rather, by the light of the intelligence underlying creation. The particular techniques investigated aim to strengthen specific mental abilities such as maintaining focus of attention, or experiencing 'compassion towards suffering', and are described below. In contrast, Transcendental Meditation is an effortless mental technique using purely phonetic qualities of a meaningless sound, or 'mantra', to 'turn the mind inwards towards its source', and requires no mental effort, concentration or particular mental ability. It can be traced to Maharishi Patanjali's Yoga Sutras (9), as can the TM-Sidhi Program based on it. More detailed comparison is better done from the perspective of the goal of each system—enlightenment—and will be made in Part II.

### Scientific Studies of Advanced Meditation

This article compares psychophysiological changes attributable to long-term practice of Tibetan Buddhist and Transcendental Meditation techniques, with particular reference to

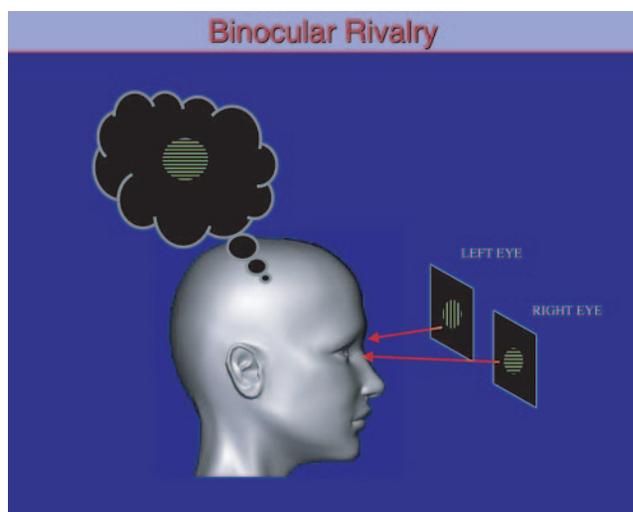
their potential use in medicine. One objective of comparing studies on the long-term practice is to stimulate research on both. The larger number of citations on Transcendental Meditation merely reflects the longer period of time it has been researched, its literature now comprehending some 600 or more studies carried out at over 120 universities and research institutions since 1963. That on Tibetan Buddhism is more recent, and is being pursued by leading scientists in their respective fields, encouraged by a forum between scientists and Tibetan Buddhist leaders, where several studies were planned (10). It was suggested that the insights and skills of experienced Tibetan Buddhist monks could well benefit neuroscientific studies of the mind. For example, since neural mechanisms underlying consciousness and attention can be studied by perceptual rivalries (11,12), binocular rivalry would be appropriate—without changing external stimulation, perceptual rivalries induce fluctuations in conscious awareness, probing subtle levels of development such as those produced by long-term meditation practice.

### Binocular Rivalry in Tibetan Buddhists

In a resulting study, Carter *et al.* (13) tested 76 advanced Tibetan Buddhist adepts with from 5 to 54 years experience, including three hermits who had dwelt in isolated mountain retreats for over 20 years, to determine possible different effects of two meditation practices on visual processing and cognition. 'Compassion', a feeling, contemplative technique described as, 'a non-referential contemplation of suffering within the world combined with the emanation of loving kindness', and a 'one-point', concentration technique, defined as, 'the maintained focus of attention on a single object, through which the mind is calmed and distracting influences of other internal and external events are reduced', were compared for their influence on binocular rivalry—the competition between two alternative presented images to be held in mind.

Specifically, horizontal and vertical green stationary gratings were presented to the right and left eye, respectively, through head-mounted display goggles (Fig. 1), and the number of spontaneous changes from one form cognized to the other in a given time period was measured. This apparently simple task has the advantages of being easy to measure, culturally non-specific, not requiring equipment difficult to transport to remote regions at high elevation, and being a highly sensitive probe to investigate alterations in brain function.

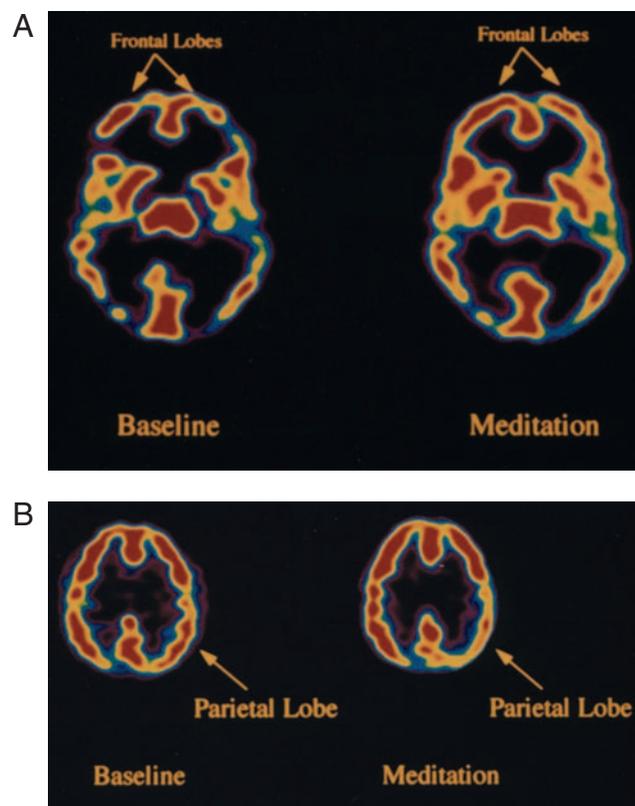
Carter *et al.*'s (13) data (either button-press records or verbal reports) showed the effect of the two kinds of mental activity ('meditation') on visual switching to be entirely different: 'Compassion' had no observed effect on switching rate, but it decreased markedly in 50% of the subjects after performing the 'one-point' technique. Further when the rivalry display was viewed during practice of the technique, some highly significant changes in cognitive processing came to light.



**Figure 1.** The two competing images used in binocular rivalry tests of Buddhist monks. Vertical lines are seen by one eye and horizontal lines by the other.

- (i) Three subjects reported perfect visual stability for the entire period of practice: Since these included two of the three most experienced adepts, the results indicate that progressive image stabilization is associated with more advanced states on the path of development. Whether the 50% who showed some degree of image stabilization may be regarded as more ‘advanced’ than those who showed none, will require further study to confirm. It is, however, consistent with observations on Transcendental Meditation that long-term practice increases psychophysiological stability.
- (ii) At such times, the reported stable percepts differed from either of the two presented gratings, differences in both form and color being evidenced: Carter *et al.* noted this observation to be totally different from previous results obtained from over 1000 meditation-naïve individuals (13). It confirms that long-term practice of this Tibetan Buddhist technique has powerful effects on visual cognition.

One reason why this may be the case can be deduced from another interesting study of a similar (or possibly identical) ‘one-point technique’. Newberg and co-workers (14,15) used single photon emission computed tomography (SPECT), a brain imaging technique, to investigate patterns of blood flow in similarly experienced Tibetan Buddhist meditators. Blood flow patterns indicate brain regions activated during technique practice—the greater the blood flow, the more active the region. They found systematic changes in blood flow indicating that distinctive patterns of neural activity had developed. The frontal cortex became active (Fig. 2A), while activity in the parietal cortex was decreased (Fig. 2B). This is consistent with the idea that if specific practices regularly give rise to specific patterns of brain activity, then as these incorporate into daily life, new mental abilities will develop—the goal of practice.



**Figure 2.** (A) Comparison of brain blood flow for Buddhist monks while performing mental task and in ordinary activity. Note the increase in blood flow to the frontal cortex indicating increased activity in that area of the brain. (B) Comparison of brain blood flow for Buddhist monks while performing mental task and in ordinary activity. Note the decrease in blood flow to the parietal cortex indicating decreased activity in that area of the brain.

### Different Techniques Produce Different Results

Consistent with other studies of meditation and related techniques, Carter’s results indicate increased mental control, based on more sensitive cognitive processing and a greater sense of inner freedom. Such differences in observation for two different techniques are consistent with other studies of similar meditation practices (16), and with a fundamental principle: *different mental techniques and meditation practices produce different physiological effects.*

This principle was first observed in investigations of advanced mental techniques at the Maharishi European Research University (MERU) psychophysiological laboratory in Weggis, Switzerland, in the 1970’s—specifically, different meditation and siddhi techniques (17–22) named in Patanjali’s Yoga Sutras (9). Other studies of Tibetan monks also suggest it.

The principle was first stated by David Orme-Johnson, the MERU laboratory director, and K.G. Walton, after comparing 10 meta-analyses comprising many hundred studies of different meditation techniques (23). Their findings amplified a meta-analysis for a single variable, where anxiety reduction was found to be consistently different for different mind–body

techniques—even different mantra meditations—showing that similar techniques from the same tradition can produce very different magnitudes of effect (24).

One meta-analysis, in particular, is important for results consistent with the idea that regular, long-term meditation may bring enlightenment—that on self-actualization (25), an important measure of good mental health and the nearest concept to enlightenment in Western psychology. For this reason, measures of self-actualization for Tibetan Buddhist monks would be of particular interest.

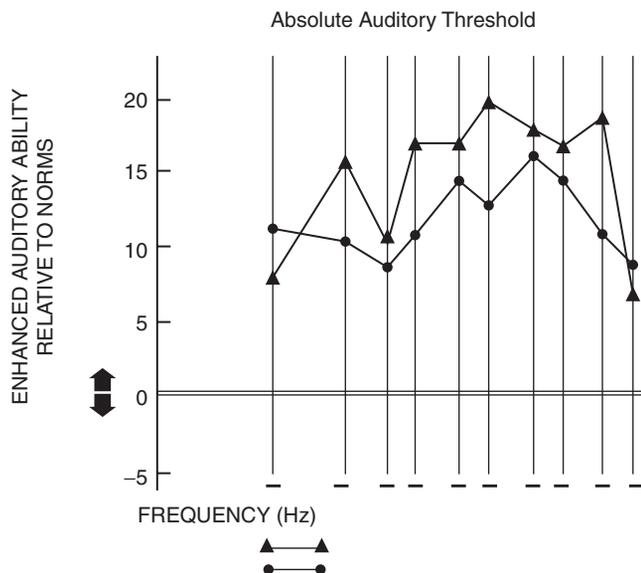
## Effects on Hypertension

In all the meta-analyses analyzed by Orme-Johnson and Walton (23), Transcendental Meditation had the largest effect-size. The closest to approach TM in such studies was a ‘mindfulness’ technique (26) (a term used to describe specific Buddhist practices) in a meta-analysis of randomized control trials of hypertension reduction (27). Control of hypertension is probably the most important, specifically medical, medical application of these techniques yet identified. Here, traditional practices seem more effective than modern attempts to mimic them. To find the cause of hypertension decrease, Barnes (28) studied a group with a mean of 22 years of regular TM practice, a time of practice similar to that of the Tibetan Buddhists. He identified the probable cause as decrease in the constriction of peripheral blood vessels, leading to a systematic decrease in total peripheral resistance to blood flow.

## Changes in Sensory Acuity and Discrimination

Some of the 1975–77 discoveries at the MERU laboratory bear a strong relationship to those of Carter and co-workers (13), e.g. unique increases in sensory acuity. Auditory thresholds were found to be 11.7 db improved in advanced TM practitioners, and a further 3.0 db after practice of an ancient Vedic technique to enhance the sense of hearing (29) (Fig. 3). Such were the changes observed that the investigating scientists were forced to have their audiometers recalibrated to a lower decibel range, something the manufacturer had never previously been requested to do (Clements G. Private Communication). This suggests that the Transcendental Meditation and TM–Sidhi techniques are able to tune up the brain’s sensitivity, increasing gain and/or decreasing internal noise to a degree never previously seen.

It would be of interest to use a similarly improved device to study auditory thresholds in Carter’s elusive, reclusive subjects. They would undoubtedly be exceptionally sensitive. There was an audiometric booth at the Mentmore Research Laboratories, where I was director in 1979–80. A visiting team of scientists investigating hearing thresholds for a wide variety of populations told us that by far their best subjects had been a group of Buddhists, who were expected to remain so. To all our astonishment, our group of experienced TM and TM–Sidhi practitioners was slightly better, both for the group average



**Figure 3.** Improved absolute auditory threshold resulting from the TM-Sidhi programme. Subjects who had been practising the TM-Sidhi techniques for 8 months on a residential course in the Transcendental Meditation programme showed hearing thresholds 11.7 dB more sensitive than average for healthy young adults. After 15 min of practising the TM-Sidhi techniques for enhancing hearing ability, the hearing thresholds were improved by a further 3.0 dB. Present theories of audition would suggest that such unusually good hearing reflects a high level of integration of neurophysiological functioning and may be closely related to the high coherence found during Transcendental Meditation and the TM-Sidhi techniques. See text for references.

and for the greatest recorded sensitivity. It taught me something I have never forgotten. On certain measures, changes seen in meditation practitioners are so great as to be of significance in their own right, and demand investigation of possible mechanisms behind them.

In this regard, a long-term residential group of advanced TM practitioners with up to 28 years experience, was investigated in the late 1980’s, by the late Professor N.N. Lyubimov, the brain surgeon and Praesidium Member of the Russian Academy of Sciences, who was Director of the Brain Research Institute of the University of Moscow. In a series of multiple electrode, evoked-potential studies of the kind he used for patients following brain surgery, Lyubimov (30) made two major discoveries: first, increased areas of cortex were being made available for sensory processing; and, second, new brain processing circuits were developing, similar to those seen in surgical cases, where loss of one sense modality stimulates others to develop beyond their normal capacities. Lyubimov’s findings suggest possible mechanisms behind the observed improvements in sensory acuity and discrimination. Further careful investigation along these lines would be worthwhile, tracking precise changes in selected individuals.

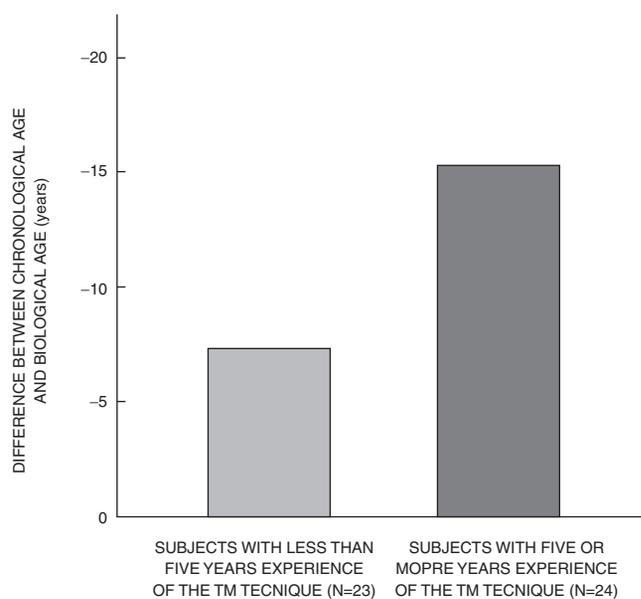
With regard to health, Lyubimov said how impressed he was by the orderliness and coherence evident in his EEG recordings of TM meditators, things his experience had led him to conclude were indicators of healthy brain function. He stated publicly that the EEG’s were the healthiest of any group

he had seen in the course of his life experience as a brain surgeon, recommending the technique to the entire Russian population (31). Contemporary neuroscience increasingly regards health of brain function as a key to general health, especially in light of new discoveries of how the brain compensates for weak function of vital organs (32). Brain wave synchronization, seen at least partly in EEG correlations, indicates good communication between brain components, enabling health to be maintained. It is possible that this represents one way that long-term meditation improves health. Slowly increasing brain coherence would permit the brain's natural compensatory processes to function better. Investigations of Tibetan Buddhist monks evaluating EEG's and evoked potentials, like Lyubimov, would be worthwhile.

## Meditation and Aging

Other investigations have confirmed that auditory threshold sensitivities increase with length of time meditating. Wallace (33) found, that instead of increasing with age as is normally the case, auditory threshold decibel levels tend to decrease with years of regular meditation, a reversal of the aging process. Systolic blood pressure, auditory threshold and near point of vision are the three measures used in the Adult Growth Exam (A.G.E.), to estimate biological age (34). Regular practice of the Transcendental Meditation program appears to reverse biological aging on these and other measures (29,33,35) (Fig. 4).

With regard to aging, older individuals practicing TM also showed higher levels of a key marker of aging,



**Figure 4.** Reduction in biological age. In this study, three measures (auditory threshold, near point of vision, systolic blood pressure), which are known to reflect accurately the biological age of an individual, were applied to a group of subjects who were practising the Transcendental Meditation technique. Reductions in biological age (compared to chronological age) were found, more so for those subjects who had been practising Transcendental Meditation for over 5 years. See text for references.

dehydroepiandrosterone (DHEA), than age-matched controls (36). DHEA is a precursor of the hormones estrogen, progesterone and testosterone, and is necessary to moderate the balance of hormones in the body. Insufficient DHEA contributes to fatigue, bone loss, loss of muscle mass, depression, aching joints, decreased sex drive and impaired immune function. Studies finding increased life-expectancy (37,38) translate these findings of reversal of aging into tangible results. Measurement of Tibetan Buddhists on all such parameters would be significant.

## EEG Coherence

A reason why meditation practice can be regarded as the cause of such changes comes from studies, which find correlations between increased test performance and the deepest level of meditation experience, 'pure consciousness'. Experience of pure consciousness is correlated with increased EEG coherence (18–20) and stabilizes outside meditation (39). EEG coherence increases brain processing capacity, and should therefore improve test performance. Such correlations probably exist for increased sensory acuity as well, for EEG coherence certainly decreases with cortical noise, and, in certain models of brain information processing, can increase amplification of incoming sensory signals.

Of significance to the Carter study (13) is the finding that high EEG coherence is a predictor of superior cognitive processing, in agreement with studies on TM (40,41). It presents a link between (i) the observed effects of meditation practice on brain function, (ii) increased brain processing capacity, (iii) improvements in cognitive function, and (iv) a characteristic of brain function in higher states of consciousness. Possible reasons why this should be the case will be discussed in the second article.

One study of Tibetan Buddhist meditation has also found increases in EEG coherence (42) in the occurrence of synchronous EEG signals in the gamma range of frequencies (25–42 Hz) during the contemplative technique 'Compassion'. Eight highly experienced Tibetan Buddhists were compared with 10 'interested' controls with no previous experience of such techniques. In experienced subjects, the onset of coherent gamma activity coincided with the onset of technique practice, with the difference increasing sharply during meditation for most electrodes, and remaining higher post-meditation than premeditation. Also, for medial frontoparietal electrodes their ratio of gamma-band to slower (4–13 Hz) EEG activity was higher during the resting period before technique practice, a finding related to Newberg *et al.*'s (14) observations of similar areas of the brain under similar conditions. The authors suggest the data indicate the mental practice to 'involve temporal integrative mechanisms inducing neural changes over short- and long-term time periods' (42), i.e. for the Buddhist monks, similar to TM meditators, EEG changes occurring during techniques practised tend to become part of their habitual style of EEG activity. During performance of a 'contemplative' technique, it is natural to study EEG gamma

waves, corresponding to the quality of feeling generated. In contrast, for the Transcendental Meditation technique, which creates a sense of 'fullness', happiness and transcendence, alpha seems to be the first EEG band affected, though all are influenced.

### Cognitive Processing

Another example, which indicates changes in perceptual style, is Field Independence (43,44), which increases considerably (22). This study was remarkable because the advanced subjects, all teachers of TM, completed the Group Embedded Figures test so quickly that it had to be given in half the normal time, with 10 of the subjects (17%) still answering 100% of the problems correctly, operating at 200% or more of the maximum speed the test was originally designed to measure. The mean rates for the two groups, one tested before and after a 3 month, extended meditation course, and the second only after, were respectively 105 and 115% of the maximum test speed, eliminating any question of retest improvement for the first group. The increase found over the 3 month experimental period was significant.

Higher scores on field independence indicate that, in assessing what they perceive, test subjects rely more on their own internal frame of reference (43). Field independence is known to measure a person's ability to structure their perceptual field as well as the social environment, and to be connected to general intelligence. High scores indicate a perceptual style based on a more stable internal frame of awareness, suggesting a strengthening and stabilizing of the sense of 'self'—consistent with the claim that the deepest level of meditation experience, 'self-awareness', is becoming stable during outer activity. These changes will be considered in more detail in Part II.

### Unique Changes and their Implications

The unique results observed in regular, long-term traditional meditators for perceptual rivalry, hearing thresholds and field independence point to an important concept. For these variables, uniqueness of result alone shows the effects must be attributed to meditation practice, rather than to any other factor. This concept generalizes to any variable subject to scientific measurement: if values of a variable observed in practitioners of a mental technique are unique to that population, and, as in the above cases, so extreme that self-selection can be ruled out, the difference from population norms must be attributed to the practice.

This principle applies not only to measurements made objectively by scientific instruments, but also to the reports of subjective experiences characteristic of progress to enlightenment, the topic of Part II. Here, the unique changes found in tests of self-actualization (25), measured by subjective responses to questions on psychological tests, assume greater importance.

More subtle examples of similarly unique changes are found in measures for which population norms are established,

neuroticism (45) and intelligence (46–48). Here, the low speed of value change means the variable stays within normally observed limits. Nevertheless, the changes observed are unique. Previously, from measurements on a wide variety of populations, neuroticism was thought to be stable throughout life, so observed decreases (45) were contrary to prevailing expectations. For intelligence, measures such as I.Q. remain steady after age 16, and then begin to decrease slowly (as was seen in the control groups), so the slow but steady increases in college students (46–48) represent an equally unexpected effect. All such unexpected results of studying long-term meditators are consistent with statements that the mental techniques produce states of awareness, or consciousness, completely different from any kind of ordinary experience such as eyes closed rest or extra sleep (napping).

The improvements in the I.Q.-related measure of choice reaction time, found in the study by Cranson *et al.* (48), are noteworthy. Decreased variability in choice reaction time is considered to reflect decreased noise in the functioning of the central nervous system—a possible explanation for both the improvements in auditory thresholds (29) and the findings of cognitive stability in Carter's study (13).

Similarly, various EEG changes found in TM are unique, e.g. alpha waves spreading forwards from the occipital lobes to the front and dominating the entire brain cortex. An experienced EEG scientist commenting on this phenomenon in 1979 told us he had never seen alpha frequencies outside the occipital cortex (Dr S. Shaw, Private Communication). In long-term practitioners, alpha waves are first observed to spread from occipital cortex to frontal cortex and encompass the whole brain during Transcendental Meditation; they then appear to stabilize outside the practice, and may form the basis for increased coherence observed during sensory signal processing (31).

Similarly, for the experienced Tibetan Buddhists, Newberg and co-workers (14) observed activation of the frontal cortex in terms of increased blood flow to that region. Using less sophisticated measures, Jevning and co-workers (49,50) observed a 44% increase in non-renal, non-hepatic blood flow. They concluded that blood flow to the brain as a whole increases by 65% on average, with 20–30 s bursts of up to 100–200%. Since frontal cortex activity increases during TM, Jevning's observation should include frontal cortex blood flow, though this would be worth confirming.

### Discussion

All the above improvements in the functioning of mind and brain (13–30,39–42,45–50) are consistent with those observed in mental health (2), and may partly explain them. All indications are that long-term practice of both forms of meditation are beneficial to mental health.

The studies of Tibetan Buddhist monks (13–16,42) yielded measurements on recluses, including cave dwelling hermits, a rare achievement. The Transcendental Meditation organization maintains a comparable group of western practitioners in

the Himalayas, an ideal environment for deep experience and profound transformation. Most have over 30 years meditation experience (maximum 48 years experience), a suitable group for comparison purposes. One advanced TM practitioner (now a PhD in the field) has been under regular observation since 1974 or earlier—over 30 years.

Long-term practice of meditation by both Tibetan Buddhists and TM meditators has been observed to produce stable changes in system function. In the former (42), (i) prolonged mental training resulted in long-term shifts in EEG baselines, (ii) such shifts remained higher after technique practice than before practice, indicating (iii) that EEG coherence length in the cortex increased.

However, it would be wrong to ascribe these changes necessarily *just* to practise of the ‘one-point’ technique. The monks concerned would have practised many techniques (8), so the results could well be partly the result of *all-round* development resulting from practising a suitable balance of techniques, in which they would have been instructed. The power of the one-point technique to switch on an ability may be a result of their *overall* development. The difference would be hard to distinguish.

In the case of the Transcendental Meditation and TM–Sidhi Program, similar increases in coherence length have been observed in the alpha range of frequencies (51–53). Some of the Buddhist meditation techniques traditionally used (8) are closer to TM than those studied. This suggests further research to see if alpha and gamma frequencies can be influenced separately, or whether TM-like alpha stabilizing techniques have to be performed first, in order to gain the affective and emotional control required to succeed in a ‘contemplative’, mood-inducing practice.

It would be of interest to know the means of the measures investigated for the source population from which the monks were drawn, as well as correlations between length of practice and changes in measure for those tested—the number presumably being enough to obtain significance for the line of regression. One question that needs to be checked is whether those having pre-existing high levels of the measures chosen are preferentially suited for the reclusive way of life, in which case high values may be at least partly due to some process of self-selection. However, the comparison of the two techniques suggests that the results were not due to lifestyle (living alone at high altitude), keeping silence, the natural beauty of the environment, eating wild or non-industrially grown food, or some similar circumstance.

With regard to Carter’s measure of perceptual rivalry, one question is the extent to which the effects seen during and immediately after practice stabilize, as is the case for the TM technique. A second is whether the stable percept could be altered at will, so that either form could be chosen and kept in the mind until a conscious decision was made to change it? (My own experience after I was instructed in TM in 1969 while at graduate school at Massachusetts Institute of Technology was of a greatly increased level of control in the ability to

switch images, a friend on the experimental psychology faculty having interested me in such phenomena.) Similar studies on TM would be worth doing.

Establishing causal connections between different psychophysiological observations can be tricky, so proof that the meditation is causing the effects is difficult. One way is to construct a model in which different measures are related, and then establish the model’s correctness, as intimated above in discussing the role of correlations. This will be taken up in Part II, and integrated into a coherent theory.

Otherwise, causal connection between measured effect and practice of technique can be established by two means: random control trials or time series analysis. In the former, measurements of group statistics do not demonstrate causality for individual subjects. Time series analysis has advantages: its statistical analysis of multiple data points for each subject can establish that change of trend or value coincides with date of instruction, and that therefore the technique is really the cause of the change. This form of self-control protocol is a formalization of what is intuitively deduced from simple observation. Large numbers of subjects then improve statistics and confirm the effect’s reliability.

It is significant that, in describing the TM technique (55,56), its founder has always stated that it involves neither concentration nor contemplation, indeed that ‘dhyān’, the essence of yoga meditation (9) involves neither of these categories of mental process. In the Yoga tradition from which Transcendental Meditation comes (9), ‘dhyān’, the process of meditation, involves an expansion of awareness, mediating between the focus of ‘dharāna’, when the technique is innocently introduced, and the unbounded awareness of ‘samādhi’, or transcendental consciousness, to which the mind is naturally and automatically drawn. ‘Dhyān’ does not involve concentration, for any effort or concentration interferes with the natural, expansive response of the mind. The TM technique’s founder emphasizes that ‘concentration’ is a recently introduced mistranslation of the words ‘dharāna’ and ‘dhyān’, and results in failure to transcend (55). It represents a misunderstanding of this aspect of ‘meditation’.

## Conclusions

The studies of the Tibetan Buddhist, one-point technique (concentration) (13,14) and the compassion technique (contemplation) (13,42) show psychophysiological effects contrasting with those on TM (18, 52) exemplifying the idea that: *different techniques produce different effects*: Is the opposite assumption not unfortunate?

Though originally hypothesized equivalent, Benson’s ‘Relaxation Response’ produces different patterns of physiological response from TM, both after 1 week, and long-term practice, of each (57), and far smaller effect sizes in meta-analyses (23). Early belief that the integrated psychophysiological response elicited during Transcendental Meditation is a *universal* behavioral mechanism, comparable to the fight or flight response, easily invoked by other,

different techniques, should be treated with caution. The summation of long-term research such as that reported and reviewed here is not consistent with it: Was the original assumption not wishful thinking?

The fact that different techniques produce different effects has to be the criterion by which to judge all claims about systems of meditation and relaxation: if a specific practice has not been thoroughly investigated no claims should be made for it on the basis of those found for other practices, even those from similar backgrounds and cultural systems (even methods and standards of teaching may be more important than has hitherto been realized).

With regard to protocols, *for certain techniques such great effects are sometimes observed, that they could only have been due to regular practice.* In such cases, the effect observed is independent of any control group (though one may be required to estimate precisely its magnitude). Control groups are also obviated by time series analysis protocols, in which changes in trend values before and after intervention can validly establish causality—it is determined by coincidence of change of trend with time of intervention: Would this not ease experimental design and costs?

Of central importance are the observed increases in cortical coherence at various frequencies (16–21,31,40–43,53–55,57). Part II will explore why they should result from practice of these mental techniques, how they may explain improved sensory and cognitive function, improved mental function, and physical and mental health, and finally their relationship to enlightenment.

Long-term practice of traditional South Asian meditation techniques, be they of Buddhist or Vedic origin, result in changes in cognitive style consistent with the development of a more balanced and stable mode of awareness, characterized by increased wakefulness, and simultaneous sensitivity to outer stimuli and inner patterns of cognitive and mental processing. Such changes are consistent with improved mental health. Measures of brain function indicate increased brain activation, particularly in the frontal cortex, and increased available brain processing power. Transcendental Meditation techniques, in particular, yield results now described in terms of development of ‘total brain function’, because of all-round development in so many areas, and because EEG is activated over the entire cortex. It would be valuable to know which of these changes hold for long-term Tibetan Buddhists. Similarly, tests of perceptual rivalry, SPECT measures of cortical blood flow, and possible gamma coherence should be made on long-term TM subjects. Comparison of results should stimulate further research; in particular, it would be useful to investigate techniques utilized in Naropa’s ‘Yoga of the Clear Light’ (8).

From both these sources, evidence is building that long-term practice of a technique stabilizes changes produced during practice: new brain circuits form; cortical learning takes place. Meta-analyses suggest that practices from the oldest traditions are more effective. Parallel results on Tibetan Buddhists and Vedic, TM meditators include improvements in sensory acuity, perceptual style and cognitive function; stabilization

of aspects of awareness is also indicated. These are all consistent with the idea that regular meditation increases brain capacity and available mental potential.

Continuing this trend to its logical conclusion, the culmination of such processes of development will be a state where the individual’s full mental potential becomes available. How this fits the concept of ‘moksha’ or enlightenment, held in such high esteem throughout the South Asian region, and said to be in a state of ‘perfect health’ will be addressed in Part II.

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