K. Ramakrishna Rao

Applied Yoga Psychology

Studies of Neurophysiology of Meditation[1]

Abstract: Yoga-Sūtras *of Patañjali is a foundational psychological text that organizes, codifies, and systematically presents in* sūtra *form the psychology as practised in India around second century BCE. Its theme is to help humans free themselves from their congenital bondage due to conditioned existence and consequent suffering. The goal is to restore the person to her inherent unconditioned blissful being. The quintessence of Yoga is meditation. Meditation consists of* dhāraṇā *(concentration, focused attention) and* dhyāna*, a contemplative state of passive attention precipitated by a prolonged practice of concentration.* Dhyāna *practice leads to* samādhi*, a stand-still altered state in which the mind is controlled and restrained from habitual cognitive processing. This paper provides a theoretical background of Patañjali Yoga and a select review of empirical research on the neurophysiological correlates of meditation, highlighting on the one hand some of its methodological shortcomings and conceptual problems and suggesting on the other hand the areas of promise for further research on meditation.*[2]

Keywords: Yoga, meditation, Indian psychology, neurophysiology

Correspondence:
Email: krrao007@gmail.com

[1] This paper is based on the invited address given at the XVIII Annual Conference of the National Academy of Psychology held at the Indian Institute of Technology, Guwahati, India, during 14–17 December 2008.

[2] For a more comprehensive review of meditation studies, see Rao (2011). The author thanks Dr D.P. Chattopadhyaya, Center for Studies of Civilizations, and Mr Sanjay Sethi, Matrix Publishers, for permission to use in this article some parts from Rao (2011).

Introduction

Contemporary psychology is essentially bio-centric. Its widely shared assumptions are (a) that the person is a brain-driven machine, and (b) that one's achievements and actions, beliefs and behaviour, cognition and conduct can be studied scientifically and understood in their entirety following the machine model within the reductionist framework. Indeed, during the past several decades, neuropsychology has made rapid strides giving credibility to the claim that human thought, passion, and action are ultimately reducible to what goes on in one's brain. I believe, however, notwithstanding the enormous gains in our understanding of human nature made by the neuro-centric reductionism, there are glaring gaps in our knowledge of the way humans think, feel and act, and that these gaps in principle appear to be uncomfortably unbridgeable and consequently call for bold initiatives for developing more inclusive models. Yoga appears to provide one such model.

In an important sense, Yoga provides the foundational concepts and methods for most of the psychological discourse in the Indian tradition. Indeed, Yoga contains the architectonic for a comprehensive psychological edifice that would have pan-human relevance. If Sāmkhya-Yoga is a twin philosophical system, Advaita-Yoga may be seen as constituting a twin psychological system in the Indian tradition. I believe, Yoga at the psychological level is as consistent with Advaita Vedanta as it is with Sāmkhya at the metaphysical level. Yoga and Advaita together constitute a coherent system of Indian psychology. There are of course other classical systems of Hindu thought, like Nyāya with its important insights into the nature of perception (Matilal, 2002), and also Jain and Buddhist contributions to understanding mind and consciousness, which fit quite well in interesting ways with what I call Yoga-Advaita psychology. This is not the occasion to dwell on this, except to emphasize that applied *yoga psychology* is indeed applied *Indian psychology*.

Patañjali's *Yoga-Sūtras* of the second century BCE is a systematic attempt to develop a theory of mind, within the dualist architecture of reality, grounded in the reported exceptional experiences of people and prevalent practices at the time. The objective was to describe and discuss the ways to enhance human potential and bring about the transformation of the person to overcome suffering and achieve a state of personal freedom and bliss. Yoga as practised at the time was given a coherent theoretical framework succinctly by Patañjali in four short chapters. The prevailing practices of the time with their perceived

efficacy from the first-person accounts of people engaged in them are taken as the factual base for building the theoretical edifice. In order to study yoga as a normal science in the conventional sense, one needs, however, to go beyond the esoteric claims and (a) test the claims themselves, (b) examine the logical connection between the claims and theories, and (c) deductively draw from theories the hypotheses to be tested rigorously with real-life data. For deriving testable hypotheses in this area, the scientist needs more than the usual intellectual ingenuity and skills in experimental design and analytical sophistication. She needs thorough familiarity with Yoga[3] theory and practices, the necessary conceptual clarity, and understanding of the nuances of the practices and their connectivity to theories (Rao, 2011).

The Indian tradition emphasizes the pragmatic application of the knowledge of the variety of conscious and unconscious factors that condition our being and behaviour, for the goal is one of controlling them with the expectation of transforming persons and rendering them free from imperfections, ignorance, and consequent suffering. Yoga is conceived to be the most useful tool for this purpose of attaining a state of unconditioned consciousness, which entails freedom of the person and perfection in her thought and action (Rao and Paranjpe, 2008). In what follows, I start with a discussion of Yoga as a theory and then examine the practice of yoga. I proceed then to briefly present some ideas on applied psychology of yoga and the concept of meditation. The main part of the paper deals with a review of research relating to the neurophysiological effects of meditation. Based on the review of the literature, we examine if the meditative state is a unique physiological state. Summarizing the research findings, we conclude with a discussion of state-of-the-art meditation research and its implications for psychology.

Yoga Theory

Reality, according to the Sāmkhya-Yoga system, is governed by two fundamental principles, consciousness (*puruṣa*) and matter (*prakṛti*). As fundamental principles, they have metaphysical and epistemological implications. The dualism of Yoga consists in its assertion of *prakṛti* and *puruṣa* as two irreducible but complementary principles of reality. They enable us to understand the relative roles of permanence and change in our being. These two principles are not merely the metaphysical constituents of reality, they have equally useful

[3] When Yoga is referred to a system of philosophy it is spelled with capital 'Y' and when it refers to practices it is spelled in lower case 'y'.

epistemological implications. At the ontological level they are depicted as entities. We see them from the epistemological perspective as two distinct processes. Both *puruṣa* and *prakṛti* are fundamental, one representing the permanent and unchanging and the other denoting the equally permanent but changing aspects of reality and knowledge. Knowledge may be processed through the route of *prakṛti* or it may be obtained directly from *puruṣa*. Both avenues are available to humans even though we largely depend on the former. However, Yoga considers only that which is derived from the *puruṣa* as true knowledge (Rao, 2002).

Prakṛti (matter) has three basic constituent elements; *sattva* (information), *rajas* (energy), and *tamas* (mass/inertia). *Sattva* is akin to consciousness in that it is translucent and allows consciousness to pass through and reflect itself in it. In reflecting itself in an object, it reveals the object. The images of reality are thus inlaid in the *sattva* component of *prakṛti* inasmuch as consciousness (*puruṣa*) is ubiquitous. Each and every object that has evolved out of *prakṛti*, however gross it may be, has an element of *sattva* in it. It is its essence, its information content. The human mind has evolved suitably equipped to process the information content inlaid in the *sattva* component of the objects that are in its reach. The brain, the nervous system, and the sensory-motor apparatus enable the mind to process the information content in objects and interact with them. This becomes possible because there is a reflexive relation between consciousness and the object which is revealed by its reflections.

We must recognize, however, that every object in its association with *puruṣa* forms a mind of its own however primitive it might be. The minds thus formed may reflect but may not be able to reflect on the reflection itself. If the layer of *tamas* is too opaque to allow the *puruṣa* reflections to reflect back, the mind loses its functional character. Only when there is a conjunction between consciousness (*puruṣa*) and a material form capable of reflecting back on the reflection of consciousness, a conscious mind with subjective experiences is formed. Such a mind acts like a functional trap. In it (a) non-conscious material forms in its proximity become conscious experiences, i.e. the *sattva* component of objects is processed, (b) the inert and characterless consciousness assumes form and manifests activity in the mind, and (c) the mind mistakenly takes those forms and actions as its own consciousness. When consciousness (*puruṣa*) is thus trapped, in the yoga view, we have the ego sense and subjective experience, which tend to bind it more and more firmly to sensory processes. This is the existential context in which we find ourselves. The *puruṣa* ‘consciousness’

finds itself cruising in the unceasing and not infrequently turbulent flow of cognitive states in the mental stream. At this stage, the person has two options. The mental stream (*cittanadi*), as Vyāsa calls it (*YS* 1.12), may through discriminative knowledge (*viveka*) flow in the direction of achieving a state of consciousness *as-such* (*kaivalya*) progressively detaching itself from the influence of *prakṛti*. Alternatively, it may flow non-discriminatively (*aviveka*) in the direction of increasing bondage, and get further entangled with *prakṛti* and the whirlpool of material existence. One is the direction of good, leading to liberation, and the other is that of evil, causing suffering.

There is a reflexive relationship between consciousness (*puruṣa*) and the *buddhi* of the mind. The *buddhi* processes information from the *sattva* content of objects. This information by its very nature is subject to a variety of distortions, primarily because *buddhi*, though it is predominantly *sattvic*, also contains *rajas* and *tamas*. *Puruṣa* in its association with *buddhi* reflexively takes the contents of the latter as its own; and the embodied mind has the knowledge of the objects and events. When every trace of *rajas* and *tamas* is removed and *buddhi* is all *sattva* with no fluctuations in the mind, *puruṣa* is revealed in the mind in its purity and consciousness manifests itself in its true form. This is the highest form of knowledge. Devoid of all distractions it is sublime and infallible. That is the state of *kaivalya*, the ultimate goal of yoga practice (Rao, 2002).

From the epistemological perspective, knowledge processed by the mind through its sensory channels from the *sattva* of material bodies is phenomenal, which gives us transactional awareness. There is no finality and absoluteness about it. It is at best an informing image and in the worst case it is outright misleading falsehood. This is so because it is mixed up with *rajas* and *tamas* and the distorting influences of the human condition. When the mind is relieved of all the vestments of *rajas* and *tamas* by practice of concentration and passionlessness, and is grounded completely in *sattva* itself, it can now have the true reflection of the *puruṣa* and know the difference between changing and ephemeral phenomenal awareness and self-illuminating transcendental awareness. Relational thinking gives way to insight and intuition, as the knowledge comes from the *puruṣa* itself without any distortions. Such knowledge, Yoga thinkers believe, as many classical Indian philosophers also do, is permanent and absolutely true because there is no possibility of distortions and misunderstandings such as those that afflict phenomenal awareness. Thus, it would seem, unless we transcend the constraints imposed by the 'mind trap', we can not have knowledge in its pristine form. The pursuit of liberation in this

view is the quest for perfect knowledge, which is none other than accessing consciousness *as-such*. Self-realization is none other than knowing oneself the way she really is without the blemishes and biases brought about by *rajas* and *tamas*, their past effects accumulated as karma. In other words, self-realization is realization of *puruṣa* (consciousness *as-such*) in one's being.

Mental phenomena that give us phenomenal awareness are intentional in that they are about objects. When the person has transactional awareness (phenomenal consciousness), she experiences subject-object duality (*visayin* and *visaya*) in her normal states of cognition and action. In transcendental states, however, consciousness manifests in its pure form where there is no object to which consciousness is directed and no awareness of subject-object duality. Interestingly, knowledge can be obtained in both the intentional and non-intentional modes; but only that which is gained in the latter is considered the highest because it is considered pure and unbiased. For example, in yogic literature a distinction is made between *savitarka* and *nirvitarka samādhi*. In both there is a direct, intuitive awareness. In the former we gain knowledge of objects in their conceptual form. The latter gives us knowledge free from any conceptual form. 'The thing in this state does not appear to be an object of my consciousness, but my consciousness becoming divested of all "I" or "mine" becomes one with the object itself; so that there is no notion here as "I know this", but the mind becomes one with the thing, so that the notion of subject drops off and the result is the one steady transformation of the mind into the object of its contemplation' (Dasgupta, 1924, p. 151). In *asamprajñāta samādhi*, consciousness is completely on its own and a total transcendence from all mental constraints is achieved. There can also be a reverse flow. Glimpses of consciousness obtained in not so perfect a state of *samādhi* may be conceptualized and translated back into phenomenal forms. Intuitions may be rationally reconstructed and one may transform a glimpse of direct awareness into an empirical event.

Phenomenal awareness may be thus induced by transient transcendental states. This is clearly unlike normal phenomenal awareness which arises from processing *prakṛti*. There is yet another source of phenomenal awareness. In the case of anomalous awareness such as in ESP, the information is obtained directly by *buddhi's* (mind) link up with the *sattva* of an object without the mediation of the senses. This possibility is open to *buddhi* because it is a manifestation of the universal *mahat*, like other *buddhis*. There is thus an interconnectedness of minds whether they are functional as in humans or dormant as in gross objects. Anomalous awareness is then a form of phenomenal

awareness and may be seen as qualitatively different from transcendental awareness. The yoga system of Patañjali describes a variety of anomalous phenomena and how they may be obtained (Rao, 2011).

Yoga Practice

Yoga is not merely a theory of mind, but also a practical discipline that claims to provide empirical support for its ideas to enhance human potentials and help transform the person. Patañjali tells us in *Yoga-Sūtras* how the mind can be restrained to achieve a quiescent state, how the natural modifications and fluctuations (*vṛttis*) of the mind can be restricted, and how a variety of *siddhis* (anomalous extraordinary phenomena) may be obtained by the practice of yoga. According to Patañjali, fluctuations of the mind (*citta-vṛtti*) may be controlled by practice (*abhyāsa*) of concentration and detachment (*vairāgya*) in thought and action. Paranormal abilities are acquired by practising *samyama* (meditation), the triple process of concentration, contemplation, and containment of the mind. *Kaivalya*, the goal of self-realization, is achieved by the total eradication (*nirodha*) of the mental states. *Yoga-Sūtras* narrate different hurdles in the human condition that afflict and hinder the practice of yoga and prescribe the means of overcoming them (Rao, 2011).[4]

Patañjali prescribes an eight step practice for reaching the highest state of consciousness, the state in which one realizes the *puruṣa*, consciousness *as-such*, unencumbered with any phenomenal awareness. The first five are preparatory and the last three are the essential stages of yoga. The preparatory stages are *yama* (things to avoid), *niyama* (things to do for ethical living), *āsana* (bodily exercises for physical fitness), *prāṇāyāma* (breathing exercises), and *pratyāhāra* (internal attention to move away from external sensory inputs). The essence of yoga is *samyama*, which we may characterize as meditation in its comprehensive, holistic sense. *Samyama* involves the triple effort of *dhāraṇā* (concentration), *dhyāna* (contemplation), and *samādhi* (containment). *Samādhi* is often translated as absorption. Actually it is an altered state in which the mind is contained and restrained from normal habitual processing. The first three *sūtras* in the third chapter of *Yoga-Sūtras* describe them in the following way. Concentration involves focusing attention on an object, which progressively leads to the restraining of the natural wanderings of the mind. In the state of *dhyāna* (contemplation) there is an uninterrupted flow of the mind

[4] See Part III which contains the author's *sūtra* by *sūtra* translation and psychological rendering of Patañjali's *Yoga-Sūtras*.

toward the object of meditation so that the practitioner can focus the attention totally on a single object for a prolonged period of time. Such prolonged one-pointed attention to a single object leads to a state of passive attention, the further practice of which leads to a cognitively stand-still state of *samādhi*, a state of containment and control of the mind. In a state of *samādhi* there is the awareness of the object alone, without an awareness of the cognizing self. There is thus a merging of the subject and object in one's experience. When the yogin thus loses self-awareness and enters a state of completely contained absorption in the object of meditation, she achieves a state of higher consciousness that enables her to grasp the essence of the objects in focus. The yogin is thus believed to know the things in their true state without the biasing influence of the senses or the presuppositions and biases of the mind. Some of these experiences may appear anomalous to those who do not have similar experiences themselves. The final point of a yogin's progress is complete liberation from all phenomenal constraints of the mind so that she may realize the state of *asamprajñāta*, as mentioned before. In psychological terms, the practice of yoga enables the yogin to move from focal attention to passive attention and finally to 'inattention', a state of the mind where the normal activities of the mind are under control.

There are thus three distinct levels of yogic development. At the first level, yoga is the bonding of body and mind, such yoking of the mind with the world of objects provides for controlled reciprocal influence of body and mind. This is best achieved by steady concentration and focused attention. At the second level, yoga is the cultivated binding of mind and consciousness, which is accomplished by prolonged passive attention. At the third level, yoga consists in the yoking of the consciousness of the person with consciousness *as-such* in a state of inattention, which finally results in the experience of *kaivalya*. The ultimate goal of yoga practice is to reach the third level leading to *kaivalya*. The emphasis in *Yoga-Sūtras* is on *samādhi* and psychological aspects of mind and its control. The bodily aspects of yoga practice find only a passing mention as preliminary steps and as prelude to the last three stages of *dhāraṇā*, *dhyāna*, and *samādhi*. Here again, Patañjali limits himself to their effects on paranormal phenomena and of course *kaivalya*, without discussing other ramifications on body and mind, on physical health and psychological well-being.

Applied Psychology of Yoga

From the preceding account of Yoga theory and practices, it is quite apparent that yoga psychology has several possibilities for important applications for physical well-being, mental health, and for enhancing cognitive and other human abilities. The first two levels refer more appropriately to mundane phenomena and secular aspects.

For over half a century, a significant amount of empirical research on yoga has appeared. Much of it involves the study of the effects of meditation on the physiology and psychological states of practitioners. From the vast amount of published data now available, it is apparent that the practice of meditation does produce significant changes in the body and the mind that could have beneficial effects. However, meditation research has not produced the promised advances consistent with the pace and extent of research and the interest and expectations they aroused. There is clearly some lack of conceptual clarity and methodological rigour, especially in the earlier studies. Also, the enthusiastic claims of some of the researchers appear to be somewhat over-generalized based on limited samples. Yoga involves, as mentioned, progression through eight stages — *yama*, *niyama*, *āsana*, *prāṇāyama*, *pratyāhāra*, *dhāraṇā*, *dhyāna*, *samādhi*. Again, there is not just one yoga but a variety of techniques that are not uniform, which go in the name of meditation. Many contemporary researchers have used the general rubric of yoga or meditation for all and sundry studies without carefully making the needed distinctions between the variety of techniques and the different stages in the progress of meditation. For example, that people can meditate without practising *āsanas* and *prāṇāyāma* provides for a discontinuity in the progress on the traditional yoga path. Without knowing what effects such discontinuities would have on the achieved state of meditation/yoga, we could hardly compare the results of the studies (Rao and Paranjpe, 2008). We need to keep this primary difference in mind when reviewing empirical research on meditation.

What is Meditation?

Despite the numerous techniques that are in vogue, the key ingredient of meditation is the control of mind by attentional manipulation that ranges from concentrated focus to defused passivity and cultivated inattention, a complete quiescence of the mind. Contemporary studies of meditation have not really addressed the question of what precisely constitutes meditation, as we will find in the following discussion. Meditation is often equated with meditation practice. This is what I

call the functionalist fallacy of mistaking an act for the agency, identifying the means with the end. This is the other side of the category mistake made popular by Ryle (1949/1962) in his refutation of Cartesian dualism. Practices may vary, but the end product should be similar, if not the same, so that we may designate it as meditation.

The failure to distinguish between meditation and the practice of meditation is the root of the confusion as to whether meditation is a state or a technique. Meditation as popularized is a practising technique; but as a subject of research it is equated with a state. The necessity to distinguish between the state and the technique led some writers to coin such phrases as 'meditative experience' (Goleman, 1978), 'meditative mood' (Carrington, 1977), or 'relaxation response' (Benson, 1975). To compound this confusion, meditation technique is not clearly limited to one practice or to one set of practices. Sometimes any practice that is believed to produce a particular state is regarded as meditation (Smith, 1986). At other times, engaging in a certain practice is automatically equated with being in a meditative state (Wallace, 1970). There is thus a general failure to clearly define meditation either as a technique or a state. If meditation is a state, we need precise criteria for identifying it; if it is a technique, the different steps involved in practising it should be clearly described. If there are multiple techniques of meditation, we need to understand what the intrinsic commonality between them is and how they bring about the designated state of meditation.

In the Buddhistic practices, as described by Buddhaghosha in *Visuddhimagga, jhāna* (Sanskrit *dhyāna*) is a state. In fact, eight *jhāna* states are distinguished. By the time one reaches the fourth stage of *jhāna*, there is the cessation of all those limiting conditions that bind the mind and limit its functions. The last four stages are efforts to seek out or realize answers to ultimate philosophical questions and experience reality the way it is. In the Rāja yoga as described in Patañjali's *Yoga-Sūtra*, *dhāraṇā* (concentration) and *dhyāna* (contemplation involving prolonged and unwavering concentration) leads to *samādhi*, a state of the mind comparable to Buddhistic *jhāna*. The counterparts to *dhāraṇā* and *dhyāna* of Yoga are *upacāra* and *appanā* in Buddhistic psychology. *Upacāra* is concentration that is unsteady, while *appanā* is steady concentration leading to a state of containment of and control over the activities of the mind. Thus, *dhāraṇā* and *dhyāna* (in Yoga), and *upacāra* and *appanā* (in Buddhism), are techniques, whereas *samādhi* and *jhāna* are states. However, all three are subsumed under the general rubric of meditation because the end product of the practices is an identifiable state.

As mentioned, there are in vogue currently numerous forms of meditation practice. Some of these are being patented! Many of these are 'meditation made easy' sorts of exercises. The instant meditative systems which attempt to teach meditation in a matter of minutes are indeed a far cry from classical meditation systems that require a better part of one's life to master. A few minutes of daily practice of meditation is said to restore health to body and give powers to mind, and even help bring about global transformations for the good of humankind. Whether the traditional and contemporary practices of meditation involve essentially the same process is a question that cannot be answered until systematic studies comparing them are carried out.

There are, however, radical differences on the surface between classical and the popular contemporary meditative systems in their objectives and goals: (1) In the classical traditions meditation is a rigorous discipline practiced for many years before one considers herself to be proficient. (2) Teaching of meditation in traditional systems requires long term close supervision and personalized attention by the teacher who provides constant guidance. (3) Meditation proper is preceded by several preparatory steps that are considered necessary in most cases for proper meditation. (4) Good health and well-being are not the effects but necessary conditions for practising meditation. (5) In classical usage, meditation is more a state of the mind rather than a technique. Vyāsa equates yoga with *samādhi*. In his commentary on the very first *sūtra* of Patañjali's text, Vyāsa says that 'Yoga is concentration' (*samādhi*) (Woods, 1914/2007, p. 3). I believe the same is the case with Buddhist *jhāna*. Current meditation research with its focus on the practice of meditation for simple health benefits may be mistaking the husk for the kernel of the meditation seed.

The purpose of meditation, we are told by Patañjali and the successive Rāja yoga practitioners, is to control the wanderings of the mind (*citta-vṛttis*) and empty the mind of its thought content (Rukmani, 2001). The second *sūtra* of the first chapter of *Yoga-Sūtras* reads: 'Yoga is the restriction of the fluctuations of the mind-stuff' (Woods, 1914/2007, p. 8). It follows that yogic meditation should be helpful in controlling ruminative mentation and negative thoughts/feelings, which often characterize maladjustment and troubled psyche. In fact, 'silencing' of one's thoughts is an important sign of progress in meditation. Therefore, yogic meditation should have useful therapeutic implications. Successful practice of meditation implies that these hindrances are overcome at least to some degree. Therefore, emotional well-being, reduced anxiety, and ego-involvement may be expected to correlate with progress in successful meditation.

Practice of yoga is associated with the manifestation of extraordinary abilities (*siddhis*), including extrasensory acquisition of information and non-conventional interaction with the environment. Meditation is believed to lead to enlightenment and peak, self-transforming experiences. Thus, yoga and meditation could have numerous benefits to humankind at various levels, ranging from ultimate *kaivalya*, as Patañjali thought, to ordinary excellence in one's thoughts, feelings, and actions, as popularly believed. There is here a vast territory open for excavation. Indeed, this was not lost sight of. There are literally more than a thousand research publications during the past fifty years, and there is continued academic interest in the study of meditation and its effects on health and wellness.

Meditation Research

Empirical research on meditation is vast. Some of it is well done, but much of it is lacking in conceptual clarity and methodological rigour. Interest in the scientific study of yoga and meditation is indeed worldwide and not confined to the Indian subcontinent (Pratap, 1971). It is one area where classical Indian ideas inspired an immense amount of research. In fact, much of this research, though based on Indian concepts and practices, is carried out in other countries. A bibliography on meditation and related states included in *Meditation: Classical and Contemporary Perspectives* (Shapiro and Walsh, 1984) contains a little over seven hundred items. Of these, less than seven percent are by those with Indian names. Many of the Indians listed are working in western countries. A smaller bibliography of 452 items compiled by Peo of the Scandinavian Yoga and Meditation School (1978) has about 14% of the items by authors of Indian origin. The *Yoga Research Bibliography* (Monro, Ghosh and Kalish, 1989), with over 1,350 items, lists some 20% Indian authors. If we consider only those studies that are published in refereed journals and cited in articles published in scholarly and scientific journals, the number of Indian authors would be even smaller. For example, the more recent review in *Meditation Practices for Health: State of the Research* (Ospina *et al.*, 2007) lists 813 studies published between 1956 and 2005 involving research on the therapeutic use of meditation. Sixty-one percent of these were carried out in North America. Under 'references and included studies' it lists 1031 items. Of these about 13% are authored by Indians. Thus, clearly there appears to be no increasing interest in studying meditation by Indians. This is so despite the fact that there is a general awareness among Indians that techniques based on yoga and

meditation could be beneficial for reducing stress. In an interview survey of 100 male executives, Dubey and Kumar (1986) found that yoga, TM, autosuggestion, and relaxation therapies are among the techniques believed to be effective in reducing stress.

There are a number of excellent reviews of meditation research (Davidson, 1976; Schuman, 1980; West, 1987; Holmes, 1984; Shapiro and Walsh, 1984; Bogart, 1991; Jevning, Wallace and Beidebach, 1992; Andresen, 2000; Grossman *et al.*, 2004; Cahn and Polich, 2006; Lutz, Dunne and Davidson, 2007; Kristeller, 2007; Kristeller and Rikhye, 2008). Meditation refers to a discipline or technique for mind control and physical well-being as well as for reaching a special state of mind. Much scientific research on meditation has assumed that it is a state. As Schuman (1980) notes, 'Based on research involving practitioners of Yoga, Zen or Transcendental Meditation (TM), meditation has been considered a unique psychophysiological state, associated with a distinct configuration of autonomic and electrocortical changes' (p. 333). Studies on meditation have explored the physiology and psychology of meditation and attempted to investigate whether the practice of meditation produces a unique state that lowers arousal, and whether it is conducive to better health and well-being. The available evidence comes from some anecdotal observations, a lot of casual research, and a few controlled experiments. A major part of the experimental effort went into learning about (a) the neurophysiological effects and correlates of meditation, (b) psychological effects and correlates of meditation, and (c) effects of meditation on health and wellness.

Notwithstanding more than fifty years of research and the publication of a thousand-and-odd reports, there is no consensus on any clear-cut and unambiguous effects of meditation. A recent report by a team of researchers, commissioned by an agency of the U.S. Department of Health and Human Services, entitled *Meditation Practices for Health: State of the Research* concludes 'Many uncertainties surround the practice of meditation. Scientific research on meditation practices does not appear to have a common theoretical perspective and is characterized by poor methodological quality. Firm conclusions on the effects of meditation practices in healthcare cannot be drawn based on available evidence' (Ospina *et al.*, 2007, p. v). This does not, however, mean that there are no effects claimed or that the entire research is sloppy. Indeed there are a lot of claims and some credible research. The problem is somewhere else.

In my view, the major problem with meditation research is that most of it is carried out by those who have little understanding of the

theoretical and cultural nuances of meditation. As mentioned, much of the research was done in the U.S. and Europe, either by those who had the methodological expertise but not the necessary insight into the practice of meditation, or by those who had some familiarity with meditation but little sophistication in experimental design. The term meditation is used to refer to all and sundry practices — from Qi Gong, Tai Chi and Yoga to relaxation response, and mantra and mindfulness meditation (Ospina *et al.*, 2007). The majority of the studies are with instant meditations such as Transcendental Meditation (TM) with a sprinkling of Tibetan monks with advanced Buddhist meditation experience. The mix of the so-called meditation practices seems to be a hotchpotch of disparate practices rather than a meaningfully related family of practices. Meditation research in the West is much like the early psychological research in India with borrowed concepts and tools lacking in relevant conceptual clarity and methodological sophistication. The research on the neurophysiological effects of meditation, which involves some of the more sophisticated and better controlled work, provides a good illustration of the wide mix of quality and practices with attendant lessons. Therefore, let us consider in some detail published research in this area.

Neurophysiological Effects and Correlates of Meditation Practices

A French cardiologist, T. Brosse (1946) travelled to India in the mid-thirties of last century and took electrophysiological measurements of yogins. She reported that a yogi stopped his heart for a while. A similar observation was made by Bhole and Karambelkar (1971). There are other anecdotal reports of pit burial, where yogins are said to stay alive when they are buried underground for several days. Casual studies by Vakil (1950) and Hoeing (1968) seemed to confirm this. Studies by Bhole, Karambelkar and Vinekar (1967a,b) in which the subjects were observed when they were in an airtight pit showed reduced consumption of oxygen compared to basal requirements. In a somewhat better controlled study by Anand *et al.* (1961) with Ramananda Yogi sealed in an airtight box, low pulse rate and lower consumption of oxygen were observed. Anand and Chhina (1961) reported that in a case when a yogin was believed to stop his heart there was still electrical activity of the heart even though it was too reduced to be heard even with a stethoscope.

Wallace (1970) concluded his study of twenty-seven TM meditators with the assertion that ‘transcendental meditation produces a

fourth major state of consciousness which is physiologically and biochemically unique' (p. 107). Wallace reported significant decrease in oxygen consumption, carbon dioxide elimination, cardiac output, heart rate, and respiration rate during meditation as compared to pre- and post-meditative periods in the same subjects. Significant increases in skin resistance, changes in certain EEG frequencies, and marked decrease in arterial lactate were also noted during meditation.

The findings of Wallace were considered to be the first major scientific confirmation of some of the claims made for TM in support of the contention of Mahesh Yogi that there exists a transcendental state, identifiable by measurable physiological parameters, a state easily accessible to those practicing a simple technique of meditation. Wallace's findings have become a great stimulus for a good deal of further research.

EEG (Electroencephalogram) Studies of Meditation: A large number of studies have attempted to study the EEG correlates of meditative states even before the publication of the study by Wallace. There are more than one hundred studies that have investigated the effects of meditation on the tonic changes in the EEG patterns of meditators. This began more than fifty years ago. The general finding is alpha abundance during periods of meditation and coherence among central and frontal lobes. There are, however, some exceptions as we will note shortly. Bagchi and Wenger (1957; 1958) did not find any changes in the alpha activity of fourteen Indian yogins between meditation and rest periods. However, they did find decreased respiratory rate and increased skin resistance that indicated a state of deep relaxation of the autonomic nervous system without drowsiness or sleep (Wenger and Bagchi, 1961).

Anand, Chhina and Singh (1961) reported that their meditating Indian yogins who produced persistent alpha activity did not show any alpha blocking to external stimuli. The dominant alpha activity observed during meditation was not disturbed by loud noises or flashes of light or even when the yogin's hands were immersed in ice-cold water. Working with Zen meditators in Japan, Kasamatsu and Hirai (1966) also observed an increase of alpha activity during meditation. But their subjects, unlike those tested by Anand *et al.*, showed EEG patterns that resembled the alpha-blocking response of the waking state when external stimuli were applied to them. However, they showed no evidence of habituation to recurring stimuli that we find in normal subjects, who typically get used to the recurring stimuli and fail to physiologically respond to them. The remarkable difference in

the findings of Anand *et al.* and Kasamatsu and Hirai is interpreted as a result of the difference between the two meditative practices of their subjects. Yogic meditation is a concentration type of meditation with focused attention emphasizing inner absorption. It seems to involve active attention. In Zen meditation, however, one allows the free flow of all sensory inputs, to which one passively attends. In other words, concentrative meditative practices may lead to decreased reactivity to external stimuli, whereas 'mindfulness' or insight meditation helps to maintain alertness at an unusual level (Johnson, 1970; Mills and Campbell, 1974). If this interpretation is correct, one could regard the two types of meditation, Zen and Rāja yoga, as giving rise to physiologically distinct patterns.

However, this interpretation is problematic on several grounds. In an early review of the physiology of meditation, Davidson (1976) pointed out that the alpha-blocking responses of the Zen meditators in the study by Kasamatsu and Hirai (1966) are essentially uninterpretable. The Zen masters meditated with their eyes open, and the control subjects were tested with their eyes closed. Consequently, the EEG measurements of the latter cannot be regarded as true controls. In addition, there were too few subjects in these studies — three subjects in the Zen study, and four in the study by Anand *et al.* (1961). Until replications with refined methodologies are made, it would seem premature to conclude that a case has been made for differential reactivity to external stimuli by Zen and yogic meditators. A study by Banquet (1973), which is sometimes cited as a confirmation of the finding of Anand *et al.* (1961) regarding the failure to elicit alpha blocking in meditators, was carried out with TM practitioners. However, TM is more like Zen than the concentrative meditation of Rāja yogins tested by Anand. In an attempt to replicate the findings of Anand *et al.* (1961) and Kasamatsu and Hirai (1966), Becker and Shapiro (1981) tested thirty experienced Zen, yoga, and TM meditators, along with twenty college-student controls. They found that EEG alpha-blocking and skin conductivity response both showed clear habituation in all groups without any significant differences between them. Schuman (1980) concludes:

> Even assuming the basic effects to be replicable, it does not follow that changes in the alpha-blocking response are necessarily due to the meditative ASC achieved through mindfulness and concentration practices. Differences in cognitive set during meditation might account for differences in alpha blocking apart from the induction of an ASC. (Schuman, 1980, p. 360)

There is, however, a general tendency in the EEG studies of meditation for subjects to produce greater alpha activity, whatever the form of meditation (Anand *et al.*, 1961; Akishige, 1968; Kasamatsu and Hirai, 1966; Banquet, 1973; Glueck and Stroebel, 1975; Deepak *et al.*, 1994; Dunn *et al.*, 1999; Aftanas and Golocheikine, 2001). Also, a number of reports show increased theta activity, especially among the advanced practitioners (Kasamatsu and Hirai, 1966; Banquet, 1973; Ghista *et al.*, 1976; Pagano and Warrenburg, 1983; Lou *et al.*, 1999; Aftanas and Golocheikine, 2001; 2002). Another interesting finding is the intrahemispheric coherence of EEG during meditation (Banquet, 1973; Rogers, 1976; Orme-Johnson, 1977; Dillbeck and Bronson, 1981; Badawi *et al.*, 1984; Travis and Pearson, 1999; Aftanas and Golocheikine, 2001; and Hebert and Tan, 2004). Gaylord, Orme-Johnson and Travis (1989) reported global increases in alpha and theta coherence among central and frontal lobes following a period of TM compared to an eyes-closed condition. No such coherence was seen in subjects practising progressive relaxation. Orme-Johnson (1977) characterized such a coherence as 'the EEG signature of the transcendental state'.

As Lutz, Dunne and Davidson (2007) point out, 'the early studies only reported coarse visual descriptions of EEG. Changes in fast-frequency oscillations during meditation have been rarely reported'. The exception is by Das and Gastaut (1955). In this important early study, Das and Gastaut recorded the EEG of yogic practitioners who were believed to be in a deep state of meditation. The recordings show EEG activity in gamma frequency indicating extreme cortical arousal. This was, however, accompanied by great inhibition of skeletal musculature. This apparent paradox and the fact that these recordings were taken with somewhat crude devices did not help the study to receive the attention it deserved. This observation is not an isolated one. A study by Wenger and Bagchi (1961) also showed signs of autonomic arousal with increased heart rate and skin conductance among meditating yogins. French neuropsychologist Banquet (1973) reported results somewhat comparable to those reported by Das and Gastaut in a more sophisticated study. Corby *et al.* (1978) investigated meditators who practised a Tantric form of meditation in a study that involved a control group. The adept meditators showed increased autonomic arousal during meditation whereas the control subjects, unexperienced meditators, who focused on their breath and on a mantra, showed autonomic relaxation.

Kjaer *et al.* (2002) studied eight advanced practitioners of yoga *nidrā* and found a significant increase in the power of theta activity

during meditation. Lazar and associates (2005), who investigated the effects of insight meditation on the brain, reported increased 'thickening in the right prefrontal cortex' with more practice of meditation, suggesting greater volitional control. There were also some structural changes in the areas of the brain associated with sensory and emotional processing. Further, Lazar *et al.* also reported that regular practice of meditation may help to slow age-related thinning of the frontal cortex.

In a more recent study, Lutz *et al.* (2004) recorded the EEGs of long-term practitioners of Tibetan Buddhist meditation. Their experience of meditation practice ranged from 15 to 40 years with 10,000 to 50,000 hours of practice. The EEG recordings show 'sustained electroencephalographic high-amplitude gamma-band oscillations and phase-synchrony' during meditation. Lutz *et al.* point out that the behavioural and functional consequences of the sustained gamma activity seen among these meditators is not known. However, Kelly *et al.* (2007) suggest that the apparent paradox observed by Das and Gastaut among yogins in a deep state of meditation points to an interaction of ergotropic system with the parasympathetic system. Referring to the study of Lutz *et al.* (2004), Kelly *et al.* (2007) suggest that the recordings indicate a 'meaningful theoretical connection between coherent large scale gamma oscillations… and perceptual "binding" as conceived by contemporary global-work space theorists' (p. 571).

The work of James Austin (1999; 2006) — a clinical neurologist, neuropharmocologist, and a meditator with over 30 years of experience — provides glimpses of higher states of consciousness achieved by meditation practitioners where 'cognitive phenomena emerging in meditation dramatically surpass ordinary cognitive operations in speed, precision, complexity, and integrative power' (*cf.* Kelly *et al.*, 2007). Austin suggests that the hyper-awareness found during peaks of meditation is mediated by intralaminar nuclei of the thalamus with the potential to increase the fast-frequency in other cortical areas, a suggestion dubbed as 'clearly speculative' by Lutz *et al.* (2007).

Reviews of EEG studies of meditation generally point to increased alpha and theta activity, especially among those practising TM (Lutz *et al.*, 2007). It is well known that increase of alpha activity is associated with the experience of a relaxed state of mind. However, what is not clear is how the increased alpha activity is caused by meditation beyond reducing the arousal level (Cahn and Polich, 2006). Moreover, as we have seen, there are indeed cases where subjects in a deep meditative state have shown increased levels of arousal. Is it the case that different meditation practices give rise to different EEG patterns?

A few studies investigated possible physiological correlates of the experience of a pure consciousness state that is free from all thoughts and mentation. Taking the clue from *Yoga-Sūtras* and other writings on meditation, which suggest a possible link between breath control and higher states of awareness, a number of experimental studies were conducted to test whether breath suspension episodes among meditators are associated with subjective reports of pure conscious experience. For example, Farrow and Hebert (1982) report several studies in this area. The results of these studies show that (a) meditating subjects report ten times the number of periods of respiratory suspension than the control non-meditating subjects, and that (b) the subjective reports of pure consciousness experience by meditating subjects highly correlate with the occurrence of breath suspension episodes. After reviewing the relevant literature Austin (1998) concluded: 'These studies of TM subjects link clear, thought-free consciousness with two quite different sets of physiological evidence. The most impressive of these events suspends respiratory drive and causes a relative hypoventilation. The second cluster of associated findings are more subtle and variable. They include peripheral autonomic changes and tendencies toward increased EEG coherence' (p. 97).

There are also a few studies of evoked potentials (EPs) and event-related brain potentials (ERPs) and meditation. Cahn and Polich (2006) list in their review 20 studies. The results are somewhat varied and inconsistent with a possible hint of increased attentional resources during meditation (Ikemi, 1988; Travis *et al.*, 2000; 2002). There are no reliable indicators of consistent effects that throw any significant light on the possible role of meditation on cognitive information processing. Cahn and Polich (2006) conclude that the major difficulties with these studies 'are a lack of methodological sophistication, no replication of critical conditions, and inconsistency of task and study populations' (p. 196).

Neuroimaging Studies of Meditation: Most of the neurophysiological studies of meditation used EEG, hoping to find some kind of an EEG 'signature' of the meditative state. Only in recent years have we seen the application of neuroimaging techniques for studying meditation. Among these are Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI).

Using neuroimaging techniques (PET), Lou *et al.* (1999) recorded blood flows during yoga *nidrā* practice in which the subjects first listened to a relaxation tape followed by instructions of guided meditation. There are different phases in guided meditation. In the

experimental condition, the subjects were asked to follow the instructions given in guided meditation while in the control condition they remained neutral. The results showed that in each of the phases of guided meditation there is activation in the related regions of the brain in the experimental condition compared to the control condition. Lou and associates also reported increases of blood flow in bilateral hippocampus, parietal, and occipital sensory and associated areas in all phases of meditation relative to the baseline control condition. This pattern of brain activity is associated with imagery. At the same time, decreased activity was found among the meditating subjects in the orbitofrontal, dorsolateral prefrontal, anterior cingulated cortices, temporal and inferior parietal lobes, caudate, thalamus, pons, and cerebellum regions. These are the areas associated with executive function. Thus, we find in this study meditation to have a differential function. On the one hand, there is increase of activation in areas associated with imagery, and a decrease of executive and control function on the other.

Newberg *et al.* (2001) used SPECT (Single Proton Emission Computed Tomography), a less sophisticated technique than PET, to study eight experienced practitioners of Buddhist meditation. During meditation, the subjects were instructed to keep their attention focused on a visual object with increasing intensity. Unlike the subjects in the study by Lou *et al.* (1999), the meditating subjects in this study showed increased activity in orbitofrontal, dorsolateral prefrontal areas of the cortex and thalamus. This difference in the results of the two studies is seen as due to different kinds of meditation practice employed in the two studies.

Lazar *et al.* (2000) investigated a form of *kundalini* yoga with fMRI. Five subjects who had practised *kundalini* yoga for at least four years participated in the study. In the experimental condition they practised mantra repetition and breath awareness during meditation. In the control period they mentally constructed animal names. The fMRI scans revealed increased activation during experimental periods relative to control periods in the limbic regions, midbrain, and pregenual anterior cingulated cortex, which are associated with autonomic control, and frontal and parietal cortices linked to attention. Lazar and associates also observed significant increased activity from early to late meditation states. In another study, Lazar *et al.* (2003) compared the fMRI scannings of mantra-based *kundalini* meditation and mindfulness-based *vipāssana* meditation. The results showed different patterns of brain activity for the two different meditative practices.

Two fMRI studies of Zen meditation (Baerentsen, 2001; Ritskes *et al.*, 2003) showed opposite patterns of brain activity in the anterior cingulate region. Brefczynski-Lewis *et al.* (2004) compared the fMRI scannings of experienced practitioners of concentration meditation with those who were given instructions in concentration meditation just a week prior to fMRI scanning. Both groups showed common activation in the attention related areas of the brain. However, the activation was more for the experienced practitioners, especially in the frontal-parietal network. In another study employing Tibetan *Loving-Kindness-Compassion* meditation, Lutz *et al.* (2004) found, during meditation, 'a common activation in the striatum, anterior cingulate cortex and left-prefrontal cortex and a deactivation in the right interior parietal'. This pattern appears to be significantly related to expertise in meditation, the adepts showing more robust activation patterns.

Newberg and Iversen (2003) put together the results of several neuroimaging studies in the form of a model of the neurotransmitter and neurochemical changes taking place during meditation. They believe that these changes are consistent and involve certain cerebral structures. Associated with these changes are some autonomic and neurochemical changes. In brief, the model suggests that meditation first activates the prefrontal and cingulate cortex. This enables the meditator to focus and concentrate. Newberg and Iversen go on to suggest that differentiation resulting from the control of nerve impulses to check the distracting stimuli may have the effect of altering the notion of the self. Meditation also enhances activity in the limbic system and results in enhanced parasympathetic activity, which is associated with decreased heart and respiratory rates and enhanced sense of relaxation.

Is the Meditative State a Unique Physiological State?

As mentioned earlier, the presence of slow-wave EEG activity, reduced oxygen consumption and carbon dioxide elimination, reduced heart rate, and increase of skin resistance during TM meditation were claimed by Wallace as indicating a unique physiological state of profound relaxation, a wakeful hypometabolic state. Dhanaraj and Singh (1977) and Corey (1977) obtained results similar to those reported by Wallace *et al.* (1970; 1971; 1972) suggestive of the hypometabolic state believed to be unique to meditation. Fenwick *et al.* (1984), who also observed in their studies a drop in oxygen consumption and carbon dioxide production, suggest that the drop could be

attributed to muscle relaxation. They conclude: 'No evidence has been found to support the hypothesis that TM produces a unique state of consciousness or metabolic functioning. Both the metabolic changes and the EEG phenomena observed during TM can be explained within the framework of accepted physiological mechanisms' (Fenwick *et al.*, 1984, p. 462).

Again, many of the same autonomic-metabolic changes are found also during sleep and drowsiness. In fact, in a study by Pagano *et al.* (1976) the EEG records of five male subjects who had been practising meditation for over two and a half years were obtained when they were practising TM and when they were taking a nap while sitting. Analyses of the data showed that; '(1) during TM, meditators spent 39.2% in stage W (wakefulness), 19.2% of time in Stage 1 EEG sleep activity, 23.0% of time in Stage 2, and 16.8% in Stages 3 and 4; (2) there were no significant differences between meditation and nap sessions in the amount of time spent in sleep Stages 2, 3, or 4' (Pagano and Warrenburg, 1983, p. 156).

This study raises questions about the physiological uniqueness of the meditative state. Further, the experiments of Wallace were criticized on the ground that they did not have non-meditating control subjects. Some of the results Wallace found in his original study, such as a large 16% decrement in VO_2 (volume of oxygen consumption) during meditation, appear to be exaggerated because the baseline values of his subjects in the resting period were 9% above the expected value. Davidson (1976) pointed out:

> That (a) TM represents a state of profound physiological rest, greater than that attainable with sleep of much longer duration; and (b) the specific changes in consciousness and the unique (and, in my opinion, unquestionable) benefits of meditation are somehow linked to the physiologic changes discussed above still seem to lack a solid basis in experimental fact. (p. 354)

Davidson's assessment has been supported by later reviews as well. On the basis of the results of their own experiments and a review made by others, Pagano and Warrenburg (1983) concluded:

> We regret to report that our search for a unique or dramatic effect directly attributable to meditation thus far has not been successful… Our experience has been that when good scientific methodology has been used, the claims made have been extravagant and premature. (p. 203)

The work of Jevning and associates involving the study of blood hormones suggests that there may be other parameters that may

distinguish physiologically the meditation state from sleep state. Their results seem to indicate that 'long-term regular practice [of TM] is associated with development of a psychophysiological response of decreased pituitary-adrenal activity during meditation' (Jevning and O'Halloran, 1984, p. 467).

A few studies do show that there are indeed observable differences between a meditative state and drowsiness. In one study by Ikemi (1988), it is reported that the changes in EEG frequencies during the practice of self-regulation based on meditation could be distinguished from those in a drowsy state. The results also showed reduction of amplitude in contingent negative variations during meditation practice.

There are other good reasons to consider meditative states different from drowsiness and sleep. A number of studies have shown increases in theta and alpha coherence during meditation compared to baseline resting wakefulness. This clearly suggests that meditation is different from drowsiness and Stage I sleep (Travis *et al.*, 2002; Aftanas and Golocheikine, 2003; Faber *et al.*, 2004). Further, typically during sleep there is a decrease in cerebral blood flow, but an increase in cerebral blood flow is observed during periods of meditation (Jevning *et al.*, 1996). Also, as mentioned earlier, some studies of deep meditation show increased arousal and gamma activity which is not a characteristic of sleep.

However, the fact that a meditative state is different from sleep and ordinary wakeful states does not warrant the conclusion that it is a unique state. We have already referred to the studies which show different electrophysiological correlates, especially the more recent ones. For example, the EEG patterns of meditating Buddhist monks studied by Lutz *et al.* (2004) are different from those obtained with Sahaja yoga meditators studied by Aftanas and Golocheikine (2001; 2002; 2003). A comparative study of mindfulness meditation and concentrative meditation by Dunn *et al.* (1999) showed greater frontal theta activity among mindfulness meditators than concentration meditation. Therefore, there is good reason to believe that different meditative techniques may have different electrophysiological effects associated with them. It is for this reason that recent reviews of literature in this area tend to group these studies under the relevant meditative techniques such as TM or *vipāssana* meditation.

General Discussion of Meditation Research

In an early review of experimental literature on meditation and somatic arousal reduction, Holmes (1984) concluded that across

experiments or measures there is no evidence that meditating subjects show lower levels of arousal than resting subjects, and 'the most consistent finding was that there were no reliable differences between meditating and resting subjects' (p. 5). Holmes pointed out that the studies fall into three groups: (1) case studies, (2) experiments in which the subjects served as their own controls, and (3) experiments with independent control groups. Case studies, inasmuch as they lack controls, cannot serve as empirical tests of an hypothesis. Experiments in which the same subject served as his or her own control at best provide equivocal evidence. Much of the evidence in support of the hypothesis that meditation lowers somatic arousal comes from experiments with the subjects serving as their own controls. Such evidence, however, is not sufficient to prove that meditation lowers arousal more effectively than simple resting, because the subjects' expectations may be critical. Meditators generally believe in the efficacy of meditation over resting, and this may be sufficient to cause the observed differences. Holmes pointed out that none of the experiments in which proper controls were provided gave evidence that meditation reduces somatic arousal significantly better than resting. He concluded that 'not one experiment provided consistent evidence that meditating subjects were less aroused than resting subjects… Indeed, there does not even appear to be one bad experiment offering consistent evidence that meditation reduces arousal more than sleep' (*ibid.*, p. 6).

Dillbeck and Orme-Johnson (1987) argued persuasively, however, that the reviews such as those by Holmes do not take into account significant effect size differences between meditation and typical resting conditions. Their meta-analysis showed that the effect size for TM was almost twice the size found with a simple eyes-closed rest condition across several indicators of reduced somatic arousal. Dillbeck and Orme-Johnson also cite a number of studies such as the one by Warshal (1980) suggesting that TM involves improved reflex response and therefore greater alertness.

From my own review of meditation research about twenty years ago, I concluded that 'much of contemporary literature on meditation is characterized by methodologically deficient experiments, conceptually confused discussions, and largely unsubstantiated claims' (Rao, 1989, p. 51). More recent research showed greater methodological sophistication and vastly improved technology made possible by the advent of neuroimaging studies of the brain. Nevertheless, the general state of overall research results appears none too different from the above assessment. For example, the report *Meditation Practices for*

Health: State of the Research (Ospina *et al.*, 2007) concludes: 'Firm conclusions on the effects of meditation practices in healthcare cannot be drawn based on the available evidence. Future research on meditation practices must be more rigorous in the design and execution of studies and in the analysis and reporting of results' (p. v). Even those reviewers favourably disposed toward meditation research speak only of the promise and need for future research (Lutz *et al.*, 2007) and not of any firmly established findings.

There are indeed severe methodological and conceptual problems in several of the meditation studies. These include (a) the widespread practice of same-subject designs in which each subject acts as his own control; (b) the failure to control for individual differences in personality, attitudes, expectations, training, and the duration and quality of meditation practice of the subjects tested; and (c) conceptual confusion leading to (i) a failure to distinguish between meditation as a state and as a technique, (ii) lack of adequate criteria to identify a meditative state and scales to measure its quality and depth, and (iii) the simplistic notion that sitting cross-legged and chanting a mantra is qualitatively the same as the classical discipline of meditation as described in the *Yoga-Sūtras*. Further, (d) the meditative techniques employed in research are too numerous and varied to allow general conclusions; (e) the experimental designs are often not appropriate to answer the issues being investigated; and (f) in many studies, especially those using TM, the subjects are self-selected, making the results less generalizable. It is observed that (g) when controlled trials were employed they did not control for systematic differences between self-selected subjects and those who are routinely recruited and those subjects who continue to practice and the dropouts who abandoned it; and (h) experimenter expectations and bias are often not controlled (Canter, 2003). Also, (i) use of multiple co-interventions confounds relevant variables and makes it almost impossible to trace the source of the observed effect; and (j) there is an inherent difficulty in employing double-blind procedures in this area.

The above problems notwithstanding, the widespread interest in meditation has had some useful consequences. First, despite the numerous well-taken criticisms, it is difficult to deny that the practice of meditation has certain psychosomatic benefits. The criticism that a meditative state is similar in some respects to a state of drowsiness or sleep does not make meditation any less important. We may recall that in the *Vedānta* view, for example, sleep state is closer to a transcendental state than the waking state. Higher states of consciousness appear to depend on controlling sensory inputs. Meditation does seem

to be a useful tool for reducing sensory noise. Second, meditation research is a good example of how a concept once considered esoteric can be empirically studied in a controlled setting. Third, meditation studies open up windows of opportunity to look at eastern psychological traditions that may have significant implications for research in areas that are currently neglected because there are no useful theoretical models to explore them. And, fourth, meditation research may play a significant role in developing research methods that overcome the first- and third-person divide.

While the overall negative picture of the Ospina *et al.* (2007) report is not unjustified because of the many apparent methodological pitfalls in published research, we may not ignore the fact that a number of comprehensive meta-analyses do indeed present a somewhat encouraging picture of the state of research in some areas. For example, a comprehensive review and meta-analyses of published and unpublished health related research by Grossman *et al.* (2003) point to a respectable effect size 0.5 with homogenous distribution, suggesting a fairly generalizable positive effect of meditation to cope with problems of a clinical and non-clinical nature. We may also note that Eppley, Abrams and Shear (1989) carried out a meta-analysis of meditation and anxiety and found different outcomes for different kinds of meditation. The analysis included 70 studies of meditation and trait anxiety. Of these, 35 involved TM. Eppley and associates reported significantly larger effect size in TM studies than studies using other types of meditation. Canter (2003), however, counters by saying that the analysis included uncontrolled trials, and therefore the assertion of the authors that the observed effect was not sensitive to research design, type of control, or any other confounding variables is not substantiated by the data. Again, Arias *et al.* (2006), after reviewing what are considered high quality publications, found support for 'the hypothesis that meditative treatments have a multifaceted effect on psychological as well as biologic function' (p. 828). Thus there are various and differing assessments of the results of meditation studies by reviewers.

According to a comprehensive review of meditation states and traits from a neuropsychological perspective by Cahn and Polich (2006), the findings in this area 'are becoming more cohesive and directed, even though a comprehensive empirical and theoretical foundation is still emerging. CNS function is clearly affected by meditation, but the specific neural changes and differences among practices are far from clear. The likelihood for clinical utility of meditation

practice in conjunction with psychological and neuropharmacological therapies is a strong impetus for future studies' (pp. 202–3).

A great deal of meditation research is carried out by researchers involved in or part of a TM organization. Some reviewers (Canter, 2003) find this a serious limitation of TM research and the generalizability of its results. While I do agree that meditation research, like other research in psychology, should find a way of controlling subject-experimenter expectancy effects, I do not believe that there should be any attempt to discourage the participation of scientists who practise a certain form of meditation from investigating the beneficial effects of the meditation they practise. In fact, such experimenters may have a significant advantage in carrying out meditation research. One of the main problems of meditation research is the tendency to consider every little effort to focus one's attention as meditation. Many forms of currently practised meditation may indeed be no different from relaxation exercises. It is only those *actually* practising meditation and that understand its nuances at each stage who can meaningfully relate observed behavioural or physiological effects to a true state of meditation. However, strict procedural precautions and design controls should be in place to eliminate any biasing effects in such studies.

Consider the study by the Czechoslovakian scientists which explored the effects of *kapālabhāti*, a yogic *kriyā* (Novak *et al.*, 1990). *Kapālabhāti* is a yogic exercise of inhalation and exhalation by voluntary rhythmic contraction and relaxation of abdominal muscles. The description of *kapālabhāti* as given in the *Haṭhayoga Pradīpikā* is as follows: 'As the bellows of an ironsmith constantly dilate and contract, similarly let him slowly draw in the air by both the nostrils and expand the stomach; then throw it out quickly (the wind making sound like bellows)' (Singh, Vasu and Bhatt, 2004). It is traditionally regarded as a *kriyā*, a cleansing technique. It stands to reason to consider it as something that emphasizes exhalation as distinct from *bhastrika*, which lays more emphasis on inhalation. In the study mentioned above the scientists attempted to simulate the affect of *kapālabhāti* by a simple periodical air insufflation into a select nostril by rhythmically puffing air current into the left or right nostril. Finding that such air insufflation had a concomitant effect of increased theta activity in the EEG mapping in the two subjects they tested, they concluded that the effect is due to *kapālabhāti*.

The above observation, with its admittedly limited generalizability because there were only two subjects, may be of some interest on its own. But, to suggest that puffing air into one nostril is equivalent to the practice of *kapālabhāti* is, however, quite naïve. Considering the

prevailing view that *kapālabhāti* is a cleansing process and therefore its emphasis is on exhalation, puffing air may have a contrary effect. Moreover, the central part of *kapālabhāti* is flexing abdominal muscles, inward pressure of the abdomen in the navel area with sudden exhalation. This part is conspicuously missing in the modelling of *kapālabhāti* by the Czechoslovakian scientists.

There is an increasing realization on the part of researchers that there is more to meditation than the instant meditation practices as represented by such adaptations as TM and Relaxation Response. For example, the work of Lutz *et al.* (2004) with long-term Buddhist practitioners suggests that the reports of highly experienced meditators are more reliable.

The main problem with research, as mentioned, is equating practices of meditation with meditation. The results obtained so far are best applicable to practices. The observed effects are the effects of certain practising exercises and not necessarily effects of meditation as such.

Neurophysiological studies of meditation are interesting in many ways. We may expect them to suggest some reliable objective correlates of the subjective experience of meditation. This would help meditation research in significant ways by providing measures to understand the depth of meditation independently of the less reliable subjective reports. However, it is unlikely that neurophysiological studies would ever completely unlock the secrets of meditation. My understanding of meditation leads me to think that a profound meditative experience in principle cannot be reduced to certain cortical activation, neurochemical or hormonal changes. The meditator in some ways appears to gain control over the autonomic activity. The simultaneous stimulation of sympathetic and parasympathetic systems, being relaxed and aroused at the same time by advanced meditators, strongly suggests this. The voluntary control of cerebral activity and autonomic and hormonal changes, if firmly established, could signal incontrovertible evidence for a non-cortical interpretation of volition and eventually the existence of mind and consciousness independent of the brain.

From the above review of neurophysiological investigations of meditation it is clear that so far no clear neurophysiological pattern that could be considered a sort of signature of meditation is found. However, reviewers point out that the 'CNS function is clearly affected by meditation, but the specific neural changes and differences among practices are far from clear' (Cahn and Polich, 2006). Therefore, it is now a common practice to review the studies under the

banner of a given meditative technique such as TM rather than club together all studies. For example, Lutz *et al.* (2007) report that 'alpha global increases and alpha coherence over frontal electrodes are associated with TM practice' as seen in the study by Morse *et al.* (1997). Further, the meditation practices involving focused attention on an object appear to be associated with increases in alpha and theta amplitude. At the same time, there is also evidence of increased EEG activity in the beta and gamma range. In objectless meditation practices such as those studied by Lutz *et al.*, as we mentioned above, the main finding is that the ratio of fast-frequency EEG activity (25–42 Hz) to slow-frequency EEG (4–13 Hz) is initially higher at the beginning compared to baseline, and that the difference increases sharply during meditation.

These differences in the EEG activity of meditators practising different techniques are essentially uninterpretable, notwithstanding the well-meaning *ad hoc* explanations offered. Decreased oscillations indicate decreased processing of information for the sensory or motor areas of the brain. The increased frequencies suggest increased processing. The most that can be said is that certain practices are associated with an increase or decrease in the activities in certain areas of the brain. Similar patterns may be seen in ordinary states of relaxation and intense cognitive activity. If we were to make any generalizations about the effects of meditation, they should be more than technique-specific. If all these practices are indeed techniques leading to a meditative state, what is important is that we do not confuse the neurophysical states associated with them as the physiological states of the meditative state as such.

Unfortunately, the failure to clearly distinguish between meditative techniques and meditative states has caused a significant amount of confusion. It would seem that the variety of techniques employed in different meditative practices may have different neurophysiological configurations. However, they may all converge on a common end point, which may be seen as the meditative state. The meditative state itself may not fit into a unique neurophysiological description, either because there is not a single meditative state but different meditative states with different neurological correlates, or because these states are beyond any kind of neurophysiological description. A meditative state may be simply a functional state that bestows on the meditator certain abilities that seem to exceed his normal capabilities. This possibility should be kept in mind when interpreting neurological correlates of meditative practices. What is important is that meditation research must not confound the meditative techniques with meditative

states, and should clearly identify them as such in their studies. They may then find whether different yogic practices have identifiable but different neurophysiological correlates, even if they do not portray one unique neurophysiological configuration. Any insights into the neurophysiological correlates of meditative practices, even if they were technique-specific, would be useful checkposts to aid the meditator. Similarly, researchers may seek to find if there are any reliable neurophysiological indices of meditative states. If the research does show, as I suspect, that the meditative state is not associated with a neurophysiological signature, it makes it no less real because it may be beyond neurophysiological description.

It is of course the case that a large number of studies have shown alpha abundance during the period of meditation. This observation is interesting in that meditative practice appears to lead to a relaxed state of mind. However, as we have noted, meditation is not always accompanied by enhanced alpha activity, and that in some cases of advanced meditators there is evidence of slow-wave EEG activity along with physiological evidence of arousal at the same time. The latter 'paradoxical' observation may be interpreted to mean (a) that alpha abundance or any other neurological configuration correlated with meditation may not be intrinsically related to meditation, and (b) that meditation somehow enables one to gain volitional control over autonomic processes and neural mechanisms. The implications of this interpretation of the observed neurophysiological correlates and effects include that the goal of future studies may not be one of discovering such correlates of meditation. Rather, neuroimaging and other physiological studies of meditation may seek to learn how the meditator is able to gain control over the function of the brain and nervous system. In this connection, the importance of understanding the processes underlying the various forms of attention cannot be overemphasized.

There is some suggestive evidence of possible link between meditation and attention. Apart from the fact that almost all meditative techniques involve manipulation of attention in some form, there is emerging evidence from neuroimaging studies that the prefrontal and frontal areas of the brain are relatively more activated during meditation. Since these areas are associated with attention, it seems likely that meditation practices do indeed involve 'increased attentional demand'. This area appears to have some potential for further exploration.

I venture to conjecture that meditation is a process of moving from full attention through passive attention to 'inattention'. Full attention

is focal and driven by volition. Passive attention is diffused and not directed. Inattention involves, in addition to the absence of attention to sensory images and other kinds of cognitive content, movement of attention in a reverse direction, away from content to consciousness *as-such*. Normal attention guides us to the content of awareness, whereas meditative inattention enables the person to move in the direction of accessing consciousness *as-such*. My understanding of the main trends of classical Indian psychological thought in general, and Yoga in particular, inclines me to think that there is merit in this kind of conceptualization of attention. In any case, there is a need to move beyond the current postulations that do not show much promise to unravel the mysteries associated with meditation in eastern thought.

We recognize of course that there are meditative systems other than that of Patañjali that do not explicitly speak of attention, such as in the Tibetan *Loving-Kindness-Compassion* meditation (Lutz *et al.*, 2004). However, I contend that attention is the key component of meditation even in these systems. Meditation involves focused attention, as in one-pointed concentration exercises in Patañjali yoga, and passive attention, as in some Buddhist forms of meditation. The end point of these exercises in either case is a state of 'inattention', which is a paradoxical state of controlling the mental functions 'inattentively', i.e. by restraining the usual cognitive activity. The Patañjali system places greater attention on focal attention as a starting point, whereas some others like mindfulness meditation emphasize passive meditation (Kabat-Zinn, 1994). In Patañjali, focused attention (*dhāraṇā*) is only the first step. The second step, *dhyāna*, is less focused and more passive and diffused. Finally, *samādhi* is a cognitively stand-still state of inattention, as we suggest. Compassion or altruist action in *karma yoga*, or self-surrender and celestial love in *bhakti yoga*, serve the same purpose of reaching a state of *samādhi* when the normal fluctuations of the mind are controlled. Such control is the *sine qua non* of meditation. It can be reached by beginning with focused attention or diffused attention, or by engaging in cognate activities that control the ego-involvement considered to be the key for corrupting the human condition. The end point, however, is *inattention*, which is the transformation of attention into an altogether different mode. It is not cortically sustained attention, but one achieved by a different mode of mental functioning.

Now, what is the lesson for us psychologists from the meditation research we reviewed? I am reminded of my own experience of doing parapsychological research in the United States. As someone inspired by classical Indian thought, I was ecstatic to learn about the promise

of psychical research and its scientific incarnation in J.B. Rhine's work at Duke University. I felt at once that here is a way to carry out credible scientific research to unravel the mysteries of the human mind and realize the human potentials as implied in yogic *siddhis* (extraordinary abilities). This commitment took me to the USA to work with Rhine at Duke University. I began learning the art of experimental investigation of psi from none other than the father of experimental parapsychology, and ended up succeeding him as the head of the Institute for Parapsychology he founded. In the process, my mindset was completely transformed. The theoretical challenges that brought me into parapsychology were lost in the new methodological challenges I was confronted with. It took me almost forty years to realize how I lost myself in a methodological quagmire, moving away from the theoretical challenges that drew me to the field in the first place. The realization came only when I found myself on a dead-end road. Parapsychology, as pursued in the west, with its theory-free orientation and obsession with empirical facts and methodological rigour, simply does not have the conceptual tools and theoretical models to progress beyond pointing to certain anomalies in one's cognitive performance.

Meditation research is in danger of facing a similar situation. There is a need to critically review the current conceptualization in meditation research and examine whether it is consistent with the core meditative culture. Further, in addition to conceptual clarity, meditation research needs appropriate theoretical models and more suitable methods of investigation. There is reason to think that it is happening to some degree. There are some western researchers of meditation who have undergone extensive training in meditation and spent significant amounts of time in studying and understanding Hindu and Buddhist models of the mind. This augurs well for the future of meditation research in the West. However, the true breakthroughs are likely to come not merely from more sophisticated instrumentation to study the brain, but by greater conceptual rigour in developing theoretical models consistent with the core thinking in eastern meditation literature and tradition, which would generate hypotheses for systematic testing. For example, the notion of making the mind empty or experiencing states of pure consciousness without any cognitive content needs to be operationalized. The concept of 'inattention' may be very appropriate here. Similarly, the classical Indian literature provides abundant material to investigate first-person phenomena and how we may bridge the gap between first-person and third-person perspectives. Meditation researchers would do well to systematically study and analyse the classical Indian psychological literature and incorporate it in

their research designs. What I am saying is that meditation research requires not mere tinkering here and there with the vague hope that everything will eventually fall in place, but a wholesale rethinking, a paradigm shift. Yoga psychology provides one such paradigm that we would do well to pay attention to and develop empirical models and theories to test. There is a tremendous opportunity here for eastern scholars and western scientists to march hand in hand to climb the Himalayan peaks of the human mind.

References

Aftanas, L.I. & Golocheikine, S.A. (2001) Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: High-resolution EEG investigation of meditation, *Neuroscience Letters*, **310** (1), pp. 57–60.

Aftanas, L.I. & Golocheikine, S.A. (2002) Non-linear dynamic complexity of the human EEG during meditation, *Neuroscience Letters*, **330** (2), pp. 143–146.

Aftanas, L.I. & Golocheikine, S.A. (2003) Changes in cortical activity in altered states of consciousness: The study of meditation by high-resolution EEG, *Human Physiology*, **29** (2), pp. 143–151.

Akishige, Y. (ed.) (1968) Psychological studies on Zen: Kyushu Psychological Studies, *Bulletin of the Faculty of Literature of Kyushu University*, **5**, Fukuoka, Japan.

Anand, B.K. & Chhina, G.S. (1961) Investigations on yogis claiming to stop their heart beats, *Indian Journal of Medical Research*, **49**, pp. 90–94.

Anand, B.K., Chhina, G.S. & Singh, B. (1961) Some aspects of electroencephalographic studies in yoga, *Electroencephalography and Clinical Neurophysiology*, **13**, pp. 452–456.

Andresen, J. (2000) Meditation meets behavioural medicine, *Journal of Consciousness Studies*, **7** (11–12), pp. 17–73.

Arias, A., Steinberg, K. & Banga, A. (2006) Systematic review of the efficacy of meditation techniques as treatments for medical illness, *Journal of Alternative and Complementary Medicine*, **12** (8), pp. 817–832.

Austin, J.H. (1998) *Zen and the Brain: Toward an Understanding of Meditation and Consciousness*, Cambridge, MA: MIT Press.

Austin, J.H. (1999) *Zen and the Brain*, Cambridge, MA: MIT Press.

Austin, J.H. (2006) *Zen-Brain Reflections: Reviewing Recent Developments in Meditation and Consciousness*, Cambridge, MA: MIT Press.

Badawi, K., Wallace, R. & Orme-Johnson, D. (1984) Electrophysiologic characteristics of respiratory suspension periods occurring during the practice of the Transcendental Meditation program, *Psychosomatic Medicine*, **46**, pp. 267–276.

Baerentsen, K.B. (2001) Onset of meditation explored with fMRI, *Neuroimage*, **13**, p. S297.

Bagchi, B.K. & Wenger, M.A. (1957) Electrophysiological correlates of some yogic exercises, *Electroencephalography and Clinical Neurophysiology*, (Supplement No. 7), pp. 132–149.

Bagchi, B.K. & Wenger, M.A. (1958) Simultaneous EEG and other recordings during some yogic practices, *Electroencephalography and Clinical Neurophysiology*, **10**, p. 193.

Banquet, J.P. (1973) Spectral analysis of the EEG in meditation, *Electroencephalography and Clinical Neurophysiology*, **35**, pp. 143–151.
Becker, D. & Shapiro, D. (1981) Physiological responses to clicks during Zen, Yoga, and TM, *Psychophysiology*, **18**, pp. 694–699.
Benson, H. (1975) *The Relaxation Response*, New York: William Morrow.
Bhole, M.V. & Karambelkar, P.V. (1971) Heart control and yoga practices, *Darshana International*, **11** (2), pp. 63–69. Also, *Yoga Mimamsa*, **13** (4), pp. 53–65.
Bhole, M.V., Karambelkar, P.V. & Vinekar, S.L. (1967a) Underground burial or *bhugarbha samadhi* — part I, *Yoga Mimamsa*, **10** (1), pp. 1–8.
Bhole, M.V., Karambelkar, P.V. & Vinekar, S.L. (1967b) Underground burial or *bhugarbha samadhi* — part II, *Yoga Mimamsa*, **10** (2), pp. 2–16.
Bogart, G. (1991) Meditation in psychotherapy: A review of the literature, *American Journal of Psychotherapy*, **45**, pp. 383–412.
Brefczynski-Lewis, J.A., Lutz, A. & Davidson, R.J. (2004) *A Neural Correlate of Attentional Expertise in Long-Time Buddhist Practitioners*, (No. 715.8.) San Diego, CA: Society for Neuroscience.
Brosse, T. (1946) A psychophysiological study, *Main Currents in Modern Thought*, **4**, pp. 77–84.
Cahn, B.R. & Polich, J. (2006) Meditation states and traits: EEG, ERP, and neuroimaging studies, *Psychological Bulletin*, **132** (2), pp. 180–211.
Canter, P. (2003) The therapeutic effects of meditation, *Student BMJ*, **11**, pp. 176–177.
Carrington, P. (1977) *Freedom in Meditation*, Garden City, NY: Doubleday.
Corby, J.C., Roth, W.T., Zarcone, V.P., Jr. & Kopell, B.S. (1978) Psychophysiological correlates of tantric yoga meditation, *Archives of General Psychiatry*, **35**, pp. 571–577.
Corey, P.W. (1977) Airway conductance and oxygen consumption changes associated with practice of the Transcendental Meditation technique, in Orme-Johnson D.W. & Farrow, J.T. (eds.) *Scientific Research on the Transcendental Meditation Program: Collected Papers*, Vol. 1, pp. 94–107, Seelisberg, Switzerland: Maharishi European Research University — MVU Press.
Das, N.N. & Gastaut, H. (1955) Variations de pactivite elctrique du cerveau, du coeur et des muscles squelettique au cours de la meditation et de l'ecstase yogique, *Electroencephalography and Clinical Neurophysiology*, (Supplement No. 6), pp. 211–219.
Dasgupta, S.N. (1924) *Yoga as Philosophy and Religion*, London: K. Paul, Trench, Trubner and Co.
Davidson, J. (1976) Physiology of meditation and mystic states of consciousness, *Perspectives in Biology and Medicine*, **19**, pp. 345–380.
Deepak, K.K., Manchanda, S.K. & Maheswari, M.C. (1994) Meditation improves clinicoelectroencephalographic measures in drug-resistant epileptics, *Biofeedback and Self-Regulation*, **19**, pp. 25–40.
Dhanaraj, V.H. & Singh, M. (1977) Reduction in metabolic rate during the practice of the Transcendental Meditation technique, in Orme-Johnson, D.W. & Farrow, J.T. (eds.) *Scientific Research on the Transcendental Meditation Program: Collected Papers*, Vol. 1, pp. 137–139, Seelisberg, Switzerland: Maharishi European Research University — MVU Press.
Dillbeck, M.C. & Orme-Johnson, D.W. (1987) Physiological differences between Transcendental Meditation and rest, *American Psychologist*, **42**, pp. 879–881.
Dillbeck, M.C. & Bronson, E.C. (1981) Short-term longitudinal effects of the Transcendental Meditation technique on EEG power and coherence, *International Journal of Neuroscience*, **14** (3–4), pp. 147–151.

Dubey, B.L. & Kumar, H. (1986) Management of stress and mental health of executives, *Indian Journal of Clinical Psychology*, **13** (2), pp. 155–160.
Dunn, B.R., Hartigan, J.A. & Mikulas, W.L. (1999) Concentration and mindfulness meditations: Unique forms of consciousness?, *Applied Psychophysiology and Biofeedback*, **24**, pp. 147–165.
Eppley, K., Abrams, A.I. & Shear, J. (1989) Differential effects of relaxation techniques on trait anxiety: A meta-analysis, *Journal of Clinical Psychology*, **45**, pp. 957–974.
Faber, P.L., Lehmann, D., Gianotti, L.R., Kaelin, M. & Pascual-Marqui, R.D. (2004) Scalp and intracerebral (LORETA) theta and gamma EEG coherence in meditation, paper presented at the meeting of the *International Society for Neuronal Regulation*, Winterthur, Switzerland.
Farrow, J.T. & Hebert, R. (1982) Breath suspension during Transcendental Meditation technique, *Psychosomatic Medicine*, **44**, pp. 133–153.
Fenwick, P.B.C., Donaldson, S., Gillis, L., Bushman, J., Fenton, G.W., Perry, I., Tilsley, C. & Serafinowicz, H. (1984) Metabolic and EEG changes during Transcendental Meditation: An explanation, in Shapiro, D.H. & Walsh, R.N. (eds.) *Meditation: Classic and Contemporary Perspectives*, pp. 447–464, New York: Aldine.
Gaylord, C., Orme-Johnson, D.W. & Travis, F. (1989) The effects of transcendental meditation techniques and progressive relaxation on EEG coherence, stress activity, and mental health in black adults, *International Journal of Neuroscience*, **46**, pp. 77–86.
Ghista, D.N., Mukherji, A., Nandagopal, D., Srinivasan, T.M., Ramamurthi, B. & Das, A. (1976) Psychological characterization of the 'meditative state' during intuitional practice (the Ananda-Marga system of meditation) and its therapeutic value, *Medical and Biological Engineering*, **14** (s), pp. 209–214.
Glueck, B.C. & Stroebel, C.F. (1975) Biofeedback and meditation in the treatment of psychiatric illness, *Comprehensive Psychiatry*, **16**, pp. 303–321.
Goleman, D. (1978) *The Varieties of the Meditative Experience*, New York: Irvington Publishers.
Grossman, P., Niemann, L. & Schmidt, S. (2003) Mindfulness-based stress reduction and health benefits: A meta-analysis, *Proceedings of the 61st Annual Scientific Conference of the American Psychosomatic Society*, 13–16 March 2003, Phoenix, AR [cited 9 October 2005].
Grossman, P., Niemann, L. & Schmidt, S. (2004) Mindfulness-based stress reduction and health benefits: A meta-analysis, *Journal of Psychosomatic Research*, **57** (1), pp. 35–43.
Hebert, R. & Tan, G. (2004) Enhanced EEG alpha phase synchrony in practitioners of the Transcendental Meditation technique, paper presented at the meeting of the *International Society for Neuronal Regulation*, Winterthur, Switzerland.
Hoeing, J. (1968) Medical research on yoga, *Confinia Psychiatrica*, **11**, pp. 68–89.
Holmes, D.S. (1984) Meditation and somatic arousal reduction: A review of the experimental evidence, *American Psychologist*, **39** (1), pp. 1–10.
Ikemi, A. (1988) Psychophysiological effects of self-regulation method: EEG frequency analysis and contingent negative variations, *Psychotherapy and Psychosomatics*, **49** (3–4), pp. 230–239.
Jevning, R.A. & O'Halloran, J.P. (1984) Metabolic effects of transcendental meditation: Toward a new paradigm of neurobiology, in Shapiro, D.H. & Walsh, R.N. (eds.) *Meditation: Classic and Contemporary Perspectives*, pp. 465–472, New York: Aldine.

Jevning, R., Anand, R., Biedebach, M. & Fernando, G. (1996) Effects on regional cerebral blood flow of Transcendental Meditation, *Physiology and Behavior*, **59**, pp. 399–402.

Jevning, R., Wallace, R.K. & Beidebach, M. (1992) The physiology of meditation: A review. A wakeful hypometabolic integrated response, *Neuroscience and Biobehavioral Reviews*, **16**, pp. 415–424.

Johnson, L.C. (1970) A psychophysiology for all states, *Psychophysiology*, **6**, pp. 501–516.

Kabat-Zinn, J. (1994) *Wherever You Go, There You Are: Mindfulness Meditation in Everyday Life*, New York: Hyperion.

Kasamatsu, A. & Hirai, M. (1966) An electroencephalographic study on the Zen meditation (Zazen), *Psychologia*, **12**, pp. 205–225.

Kelly, E.F., Kelly, E.W., Crabtree, A., Gauld, A., Grosso, M. & Greyson, B. (2007) *Irreducible Mind*, New York: Rowman & Littlefield.

Kjaer, T.W., Bertelsen, C., Piccini, P., Brooks, D., Alving, J. & Lou, H.C. (2002) Increased dopamine tone during meditation-induced change of consciousness, *Cognitive Brain Research*, **13**, pp. 255–259.

Kristeller, J. (2007) Mindfulness meditation, in Lehrer, P.M., Woolfolk, R.L. & Sime, W.E. (eds.) *Principles and Practices of Stress Management*, 3rd ed., pp. 393–427, New York: Guilford Press.

Kristeller, J. & Rikhye, K. (2008) Meditative traditions and contemporary psychology, in Rao, K.R., Paranjpe, A.C. & Dalal, A. (eds.) *Handbook of Indian Psychology*, pp. 506–538, New Delhi: Foundation Books (Cambridge University Press).

Lazar, S.W., Bush, G., Gollub, R.L., Fricchione, G.L., Khalsa, G. & Benson, H. (2000) Functional brain mapping of the relaxation response and meditation, *Neuroreport*, **11** (7), pp. 1581–1585.

Lazar, S.W., Rosman, I.S., Vangel, M., Rao, V., Dusek, H. & Benson, H. (2003) Functional brain imaging of mindfulness and mantra-based meditation, paper presented at the meeting of the *Society for Neuroscience*, 8–12 November 2003, New Orleans, LA.

Lazar, S.W., Kerr, C.E., Wasserman, R.H., Gray, J.R., Greve, D.N., Treadway, M.T., McGarvey, M., Quinn, B.T., Dusek, J.A., Benson, H., Rauch, S.L., Moore, C.I. & Fischl, B.D. (2005) Meditation experience is associated with increased cortical thickness, *Neuroreport*, **16**, pp. 1893–1897.

Lou, H.C., Kjaer, R.W., Friberg, L., Wildschiodtz, G., Holm, S. & Nowak, M. (1999) A ^{15}O-H_2O PET study of meditation and the resting state of normal consciousness, *Human Brain Mapping*, **7**, pp. 98–105.

Lutz, A., Greischar, L.L., Rawlings, N.B., Ricard, M. & Davidson, R.J. (2004) Long-term meditators self-induced high-amplitude gamma synchrony during mental practice, *Proceedings of the National Academy of Sciences USA*, **101**, pp. 16369–16373.

Lutz, A., Dunne, J. & Davidson, R.J. (2007) Meditation and the neuroscience of consciousness: An introduction, in Zelazo, P.D., Moscovitch, M. & Thompson, E. (eds.) *The Cambridge Handbook of Consciousness*, pp. 499–554, New York and Cambridge: Cambridge University Press.

Matilal, B.K. (2002) *Perception: An Essay on Classical Indian Theories of Knowledge*, New Delhi: Oxford University Press.

Mills, G.K. & Campbell, K. (1974) A critique of Gellhorn and Kiely's mystical states of consciousness: Neurophysiological and clinical aspects, *Journal of Nervous and Mental Disease*, **159**, pp. 191–195.

Monro, R., Ghosh, A.K. & Kalish, D. (1989) *Yoga Research Bibliography*, Cambridge: Yoga Biomedical Trust.

Morse, D.R., Martin, J.S., Furst, M.L. & Dubin, L.L. (1997) A physiological and subjective evaluation of meditation, hypnosis, and relaxation, *Psychosomatic Medicine*, **39** (5), pp. 304–324.

Newberg, A., Alavi, A., Baime, M., Pourdehnad, M., Santanna, J. & d'Aquili, E. (2001) The measurement of regional cerebral blood flow during the complex cognitive task of meditation: A preliminary SPECT study, *Psychiatry Research*, **106**, pp. 113–122.

Newberg, A.B. & Iversen, J. (2003) The neural basis of the complex mental task of meditation: Neurotransmitter and neurochemical considerations, *Medical Hypotheses*, **61** (2), pp. 282–291.

Novak, P., Lepicovaka, V., Dostalek, C. & Hajek, P. (1990) Influence of rhythmic nasal air insufflation upon EEG mapping: Modelling of *Kapālabhāti*, *Yoga Mimamsa*, **29** (2), pp. 13–26.

Orme-Johnson, D.W. (1977) EEG coherence during transcendental consciousness, *Electroencephalography and Clinical Neurophysiology*, **43** (4), p. 581.

Ospina, M.B., Bond, K., Karkhaneh, M., Tjosvold, L., Vandermeer, B., Liang, Y., Bialy, L., Hooton, N., Buscemi, N., Dryden, D.M. & Klassen, T.P. (2007) *Meditation Practices for Health: State of the Research*, prepared by the University of Alberta Evidence-based Practice Center for the Agency for Healthcare Research and Quality of the U.S. Department of Health and Human Services, Rockville, MD.

Pagano, R.R., Rose, R.M., Stivers, R.M. & Warrenburg, S. (1976) Sleep during Transcendental Meditation, *Science*, **191**, pp. 308–309.

Pagano, R.R. & Warrenburg, S. (1983) Meditation: In search of a unique effect, in Davidson, R.J., Schwartz, G.E. & Shapiro, D. (eds.) *Consciousness and Self-Regulation: Advances in Research and Theory*, Vol. 3, pp. 153–210, New York: Plenum Press.

Peo (1978) *Medical and Psychological Scientific Research on Yoga and Meditation*, Copenhagen: Bindu.

Pratap, V. (1971) Scientific studies on yoga: A review, *Yoga Mimamsa*, **13** (4), pp. 1–18.

Rao, K.R. (1989) Meditation: Secular and sacred: Review and assessment of some recent research, *Journal of the Indian Academy of Applied Psychology*, **15**, pp. 51–74.

Rao, K.R. (2002) *Consciousness Studies, Cross-Cultural Perspectives*, Jefferson, NC: McFarland & Co.

Rao, K.R. (2011) *Cognitive Anomalies, Consciousness and Yoga*, New Delhi: Center for Studies in Civilizations and Matrix Publishers.

Rao, K.R. & Paranjpe, A.C. (2008) Yoga psychology: Theory and application, in Rao, K.R., Paranjpe, A.C. & Dalal, A.K. (eds.) *Handbook of Indian Psychology*, pp. 163–185, New Delhi: Cambridge University Press India.

Ritskes, R., Ritskes-Hoitinga, M., Stodkilde-Jorgensen, H., Baerensten, K. & Hartman, T. (2003) MRI scanning during Zen meditation: The picture of enlightenment?, *Constructivism in the Human Sciences*, **8**, pp. 85–90.

Rogers, L.J. (1976) *Human EEG Response to Certain Rhythmic Patterned Auditory Stimuli, with Possible Relations to EEG Correlates of Chanting*, unpublished PhD dissertation, Los Angles, CA: University of California.

Rukmani, T.S. (2001) *Yogasūtras of Patañjali: With the Commentary of Vyāsa*, Montreal, QC: Chair in Hindu Studies, Concordia University.

Ryle, G. (1949/1962), *The Concept of Mind*, Chicago, IL: University of Chicago Press.

Schuman, M. (1980) The psychophysiological model of meditation and altered states of consciousness: A critical review, in Davidson, J.M. & Davidson, R.J. (eds.) *The Psychobiology of Consciousness*, pp. 333–378, New York: Plenum Press.

Shapiro, D.H. & Walsh, R.N. (1984) *Meditation: Classic and Contemporary Perspectives*, New York: Aldine.

Singh, P., Vasu, S.C. & Bhatt, G.P. (2004) *The Forceful Yoga: Being the Translation of Haṭhayoga-pradīpikā, Gheraṇḍa-samhitā, and Śiva-samhitā*, Delhi: Motilal Banarsidass.

Smith, J.C. (1986) *Meditation: A Sensible Guide to a Timeless Discipline*, Champaign, IL: Research Press.

Travis, F.T. & Pearson, C. (1999) Pure consciousness: Distinct phenomenological and physiological correlates of 'consciousness itself', *International Journal of Neuroscience*, **100**, pp. 77–89.

Travis, F.T., Tecce, J.J. & Guttman, J. (2000) Cortical plasticity, contingent negative variation, and transcendent experiences during practice of the Transcendental Meditation technique, *Biological Psychology*, **55** (1), pp. 41–55.

Travis, F.T., Tecce, J., Arenander, A. & Wallace, R.K. (2002) Patterns of EEG coherence, power, and contingent negative variation characterize the integration of transcendental and waking states, *Biological Psychology*, **61**, pp. 293–319.

Vakil, R.J. (1950) Remarkable feat of endurance of a yogi priest, *The Lancet*, **259** (2), p. 871.

Wallace, R.K. (1970) *The Physiological Effects of Transcendental Meditation, a Proposed Fourth Major State of Consciousness*, PhD dissertation, University of California, Los Angles, Ann Arbor, MI: University Microfilms.

Wallace, R.K., Benson, H. & Wilson, A.F. (1971) A wakeful hypometabolic physiological state, *American Journal of Physiology*, **221**, pp. 795–799.

Wallace, R.K. & Benson, H. (1972) The physiology of meditation, *Scientific American*, **226**, pp. 84–90.

Warshal, D. (1980) Effects of the Transcendental Meditation technique on normal and jendrassik reflex time, *Perceptual and Motor Skills*, **50**, pp. 1103–1106.

Wenger, M.A. & Bagchi, B.K. (1961) Studies of some autonomic functions in practitioners of Yoga in India, *Behavioral Science*, **6**, pp. 312–323.

West, M.A. (1987) Traditional and psychological perspectives on meditation, in West, M.A. (ed.) *The Psychology of Meditation*, pp. 5–22, Oxford: Clarendon Press.

Woods, J.H. (1914/2007), *Yoga System of Patañjali*, Delhi: Motilal Banarsidass.

Paper received March 2010; revised June 2010.