The Psychobiology of Consciousness

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The Psychophysiological Model of Meditation and Altered States of Consciousness: A Critical Review

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> The beginning of knowledge is the realization that interpretation stands for interpretation; the end of knowledge is the decision that interpretation stands for something, or is the interpretation of something.
>
> —Sankara

In recent years, a growing literature has addressed itself to the psychophysiological bases of altered states of consciousness (ASCs). An unprecedented interest in meditation, biofeedback, and other techniques for altering consciousness reflects in part the widespread notion that science has begun to understand the physiological bases of these states. Thus, 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. For example, it has been proposed on the basis of these data that the practice of Transcendental Meditation leads to the experience of a fourth major state of consciousness, distinct from waking, dreaming, and nondreaming sleep (Wallace, 1970).

Major emphasis has been placed on two observations of psychophysiological changes during the meditative state. First, substantial increases in alpha brainwave activity have been observed during the Zazen practice of Zen Buddhist priests (Kasamatsu & Hirai, 1969) as well as in investigations of Yogis (Anand, Chhina, & Singh, 1961) and transcendental meditators (Wallace, 1970; Wallace, Benson & Wilson, 1971). A second major observation concerns changes in alpha blocking response during meditation. Two patterns of response have been reported, apparently varying with the type of meditation: either an absence of alpha blocking to sensory stimuli (Yogic meditation), or a failure of the alpha blocking response to habituate (Zen meditation and TM;

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Anand *et al.*, 1961; Kasamatsu & Hirai, 1969, pp. 501–514; Wallace, 1970). Taken together, these changes in baseline EEG and electrocortical responsiveness to sensory stimulation have been interpreted to be evidence of a unique meditative state of consciousness.

The question arises as to how these EEG correlates should be interpreted in relation to the psychological state of meditation on the one hand and the neurophysiological basis of consciousness on the other. "Meditation" embraces a wide range of mental as well as physical practices, and it may be somewhat premature to jump to any conclusions about the neurophysiology of *the* "meditative state." In the following discussion, an attempt is made to provide an analysis of some of the behavioral features of meditation and how these might relate to the observed psychophysiological correlates. The literature on meditation is critically evaluated with regard to changes in EEG, changes in arousal, the occurrence of sleep, and attentional phenomena. In addition, meditation is compared and contrasted with related psychological states (relaxation, hypnosis, and alpha biofeedback) in order to examine the conclusion that meditation constitutes a unique state of consciousness. The discussion concludes with an analysis of the psychophysiological model of meditation with regard to the necessary and sufficient conditions for altered states of consciousness to occur.

1. The Meditative ASC

Meditation embraces a diverse group of mental and physical practices. It may involve focusing on a mentally generated sound or mantra, as in TM; contemplating an external object; mentally watching the breath; or observing the stream of consciousness. Alternatively, it may be active, as for instance in the flowing movements of t'ai chi ch'uan or the whirling of a Sufi dervish. Although a full discussion of meditation is beyond the scope of this paper (see Goleman, 1977, for an excellent introduction to the varieties of meditation experience), some of the general features may be sketched.

Naranjo (1974, pp. 15–29), for instance, distinguishes three major types of meditation practice: meditations with an external object of focus, meditations with an internal focus (image or thought), and meditations that have no fixed focus. Along similar lines, meditations may be classified (Goleman, 1977) as *concentration* practices and *mindfulness* practices. Concentration involves technques for focusing attention on a particular target and includes the first two categories specified by Naranjo. In contrast, mindfulness simply involves noticing whatever comes into awareness. Different forms of meditation are regarded as resulting in different experiences and/or phenomenological states; Sanskrit, for example, has at least 22 words for different states of consciousness.

One important phenomenological category of experiences induced through meditation includes trancelike states of absorption ("samadhi," "transcendental consciousness") produced through the practice of concentration. Concentration (exemplified in the practice of Yoga) entails becoming perfectly focused to the point where the meditator loses awareness of himself as a subject and becomes totally absorbed in the meditation object. This mode of experience is foreign to normal consciousness and is consequently difficult to communicate, but it is described as a state in which the mind transcends the duality of subject and object; evidently, the meditator experiences sinking into or becoming one with the meditation object, so that there is no longer an experience of being a subject meditating, merely the experience "meditation is." (Samadhi states are discussed somewhat further in the context of trance states in Section 8.) Experience of altered states is also produced through the perfection of mindfulness, a practice in which one learns to continuously observe the contents of consciousness. (The Buddha was said to be able to observe some 10^{21} separate "mind-moments" in the wink of an eye! [Goleman, 1977].) In Zen, for instance, one sits with the intention of just sitting, doing nothing. In this practice, the challenge is to notice thoughts as they come up without allowing them to capture the attention and distract from an awareness of sitting. Ultimately, a state is achieved ("nirvana") in which there is consciousness without subject or object.

Meditation progresses through a sequence of experiences or phenomenological stages. Certain features may be specific to the particular technique practiced, while others may be common to different traditions of meditation practice (cf. D. P. Brown, 1977; Goleman, 1977). It should be emphasized that many of these experiences of altered states are rare and never happen to the majority of meditators (Goleman, 1977). On the other hand, common to all meditation practices and, it would seem, encompassing the variety of experiences that occur during meditation is the goal of *passive awareness*—a state in which the mind becomes still and consciousness transcends thought. *Awareness* describes the focus of attention on the present moment, being with whatever one is experiencing in the here and now; *passive* emphasizes that there is nothing one need *do* in order to experience in this way, merely be receptive and allow the experience to happen. One of the basic tenets of meditation is the notion that passive awareness is a natural, elementary, and direct form of experience that is ordinarily overwhelmed and obscured by the activity of the mind. The purpose of meditation, therefore, is to allow the mind to become quiet and thereby uncover the capacity for this experience.

The state of passive awareness is produced in different ways by different meditation practices. In concentration, one eliminates the distractions of random mind activity; in mindfulness, one seeks to conquer the mind through present-centered awareness. Yet another approach is exemplified in certain types of active meditations, for example Sufi dancing or the "chaotic meditation" of Bhagwan Rajneesh (1976). Here the intent is to create a background of activity against which the experience of inner silence can emerge.

Passive awareness, considered here the *sine qua non* of the meditative ASC, involves a fundamental shift in the frame of reference of experience. Ordinarily, the mind is caught up in its own activity and internal chatter; in the absence of any experience to the contrary, we generally assume this constant mental activity to be both natural and inevitable, and in fact, we tend to identify this mental activity as self or "consciousness." In meditation, one comes to discriminate mental activity as a process added to and apart from direct, conscious experience. In so doing, one transcends the mind and breaks through to another level of awareness. This shift in the frame of reference of experience may be likened to the process of looking in a mirror; in the ordinary scheme of things, our focus is on the images reflected in the glass, but under special conditions we may become aware of the mirrored surface on which the images appear. In a sense, all meditation may be considered a means toward this *transformation* of consciousness—in the terms proposed by Schwartz (1974), an altered *trait* rather than an altered *state* of consciousness.

It is the thesis of this chapter that the meditative ASC can best be understood in terms of the passive awareness of ongoing experience—that is, *the context in which experience occurs*—rather than in terms of any particular experience or psychophysiological state. That is to say, distinct from the particular altered-states phenomena that may be experienced during meditation, the more important aspect of the meditative ASC is seen to be the context or frame of reference in which experience occurs—the *relationship* between the experiencer and his experience (King, 1963). The meditative ASC is thus seen not as a static state but rather as a dynamic process of passive awareness, within which a variety of phenomenological experiences can occur.

A major implication of this view, developed in the body of the chapter, is the idea that the psychophysiological changes observed during meditation reflect changes in *behavior* (including cognitive behavior or mental experience) rather than the meditative ASC *per se*. That is to say, the subject sits in a particular manner, attends to certain things,

adopts a certain cognitive set, consciously relaxes, etc., and changes in psychophysiological functioning come about in consequence of these behaviors. The question then becomes *which behaviors or mental processes* during meditation are related to *which psychophysiological changes*.

The substantive issue, here, has to do with the interpretation of the relationship between the psychological states or experiences achieved through meditation, on the one hand, and their psychophysiological correlates, on the other. In the scientific literature on meditation, psychophysiological changes that occur during meditation have been regarded as defining characteristics of a stable meditative ASC. Alternatively, it may be more reasonable to attempt to understand the behavioral significance of each of the various psychophysiological changes that occur, and whether these are in fact necessary or sufficient for the meditative ASC to occur. For example, certain of the psychophysiological phenomena attributed to the meditative ASC may perhaps be more accurately interpreted as correlates of the "relaxation response" (Benson, Beary, & Carol, 1974) elicited during certain sitting meditations. Such a low arousal state may or may not, however, be a *necessary* component of the meditative ASC. Other meditation techniques might be associated with a very different physiology—Sufi dancing, for instance, with physiological changes of exercise—and yet might engender a very similar result in terms of quieting the mind. According to the present view, what defines the meditative ASC is the quality of awareness brought to these ongoing experiences, the context in which they are held, rather than a particular psychophysiology.

It should be acknowledged here that the experience that occurs during meditation (the content of meditation) is not unrelated to the state of consciousness (the context) in which it occurs. On the contrary, meditation techniques are methodologies for producing experiences that may predictably give rise to transformations of consciousness of the sort described here. Moreover, experiences are a reflection of the state of consciousness in which they occur: a transformation in one's sense of oneself-as-experiencer (context) has a considerable impact on the content of experience. Some of these complexities may be handled in part in terms of a systems approach to consciousness (see Tart, 1975) as discussed somewhat further below. For our present purposes, the point is that the psychophysiological changes that occur during meditation may not be intrinsically related to the meditative ASC.

To anticipate the conclusions developed in the pages to follow, the psychophysiological phenomena associated with meditation seem largely accountable in terms of psychological processes that are in no way unique to meditation, for example, changes in arousal and attention. Demonstrating the psychophysiological correlates of meditation is incomplete without answers to certain key questions. Can a comparable low arousal state occur without the cognitive/experiential changes of meditation? Would focusing attention to an extent comparable to that achieved in meditation produce analogous EEG changes in a behavioral context other than meditation?

Insufficient attention has been paid to the subjective phenomena of the meditation experience. Thus, some studies have concerned correlates of mystical states achieved through meditation, whereas others have involved correlates of meditation without regard to the experience or the level achieved. Differences between meditators and the problem of fluctuations in experience over time have been ignored. Undoubtedly, these factors contribute to the observed variability in the psychophysiological correlates of meditation. Moreover, so long as we are attempting to characterize *the* meditative state, variabilities are construed as discrepancies to be resolved, whereas they may, in fact, represent important data in their own right.

According to the present formulation, there is, at the very least, heuristic value in interpreting the psychophysiological changes of meditation as correlates of specific behaviors and experiences in meditation. This conclusion does not necessarily bear upon the question of whether there *exist* discoverable correlates of the "context component" of the meditative ASC (a few speculations about which appear in the concluding portion of the chapter). Simply, it seems unlikely that the complex phenomenology of meditation can be accounted for in terms of a very few (and rather crudely defined) psychophysiological data.

2. EEG Changes during Meditation

Most attempts to characterize the neurophysiological basis of meditation have generated a picture of EEG slowing and enhanced cortical synchrony during meditation, despite a considerable diversity in subjects, meditation techniques, and EEG methodology (see review by Woolfolk, 1975). A composite picture of the progression of EEG changes during a meditation session, derived from studies of Yoga, Zen, and TM, appears to be, first, an increase in the abundance of alpha rhythm in the EEG, with well-organized alpha activity appearing in all leads, especially frontal and central; second, an increase in the amplitude of alpha potentials; third, a decrease in the modal frequency of alpha; progressing to, fourth, the appearance of rhythmical trains of theta waves (5–7 Hz) (Anand *et al.*, 1961; Kasamatsu & Hirai, 1969; Wallace, 1970; Wallace *et al.*, 1971). Not all features, it should be noted, are necessarily found with every technique, in every meditator, or on every occasion.

The general characteristics of this "alpha–theta" meditation EEG

may be further illustrated by citing a few of the relevant studies. For example, Anand *et al.* (1961) found prominent and persistent alpha activity with well-marked amplitude modulation in four Yogis practicing Raj Yoga, but they observed no theta activity associated with this type of meditation. Kasamatsu and Hirai (1969) observed a sequence of increased alpha abundance, decreased alpha frequency, and theta activity in a population of Zen meditators, which appeared to develop as a function of proficiency and experience in meditation. Wallace and his co-workers (1970, 1971) found an increase in the regularity and amplitude of alpha activity during TM, with a shift toward theta in some but not all subjects. In a study of another mantra practice, Ananda Marga Yoga, Elson, Hauri, and Cunis (1977) found a pattern of EEG slowing consisting of 50% alpha waves or a predominance of theta activity on a low-voltage mixed background.

As evident in this description, theta activity during meditation is a particularly variable characteristic. To make matters more complicated, when theta activity does occur, in some instances it appears to resemble a drowsy or sleep onset pattern (theta on a mixed low-voltage background), while in others is reported to consist of bursts or trains of high-amplitude (60–100 μV) activity at a relatively constant frequency (Banquet, 1973; Kasamatsu & Hirai, 1969) unlike the typical drowsy pattern. These findings are discussed in depth in Section 6.

A recent study by Hebert and Lehmann (1977) systematically investigated theta activity in a good-sized population of transcendental meditators (n = 78) and control subjects. Criterion bursts of generally spindle-form theta activity ($\geq 100\ \mu V$, ≥ 1 sec) were observed in 27% of the meditators (never in controls) and tended to occur synchronously in all leads, although frequently occipital alpha continued during a frontal theta burst; highest voltages were generally recorded in the frontal channel. Longer bursts showed intermittent and irregular amplitude modulation and at times were discontinuous and mixed with high-voltage alpha waves. Contrary to the experience of Kasamatsu and Hirai (1969) with Zen meditators, Hebert and Lehmann found no relationship between the frequency of occurrence of theta bursts and the number of months of meditation in a given subject, nor a significant difference in the amount of meditation practice between subjects who showed theta activity and those who did not. Interestingly, moreover, those subjects who showed theta bursts during meditation tended to show similar activity during pre- and post-eyes open baseline periods, although with less frequency than seen during meditation. Criterion theta activity was also observed during a longer period of relaxation recorded presleep in a subgroup of the meditation subjects, but it was never seen in controls. The functional significance of this finding is considered below.

In contrast to the alpha–theta pattern, a second EEG pattern consisting of high-voltage beta waves is sometimes seen during meditation, though not necessarily in lieu of EEG slowing. Thus, Das and Gastaut (1955), in a study of seven practitioners of Kriya Yoga, noted an *acceleration* of the alpha rhythm by 1–3 Hz, with a decrease in amplitude and the appearance of faster (15–30 Hz) components. Toward the end of and after meditation, these authors also noted the reappearance of alpha rhythm, often slower and more widely distributed than at first (7–8 Hz).

A synchronous fast-wave pattern was similarly observed in a spectral analysis of TM by Banquet (1973). Several stages or phases of meditation were observed, with no clear differentiation among them. First, there was a general tendency for an early shift from the basic alpha rhythm (9 Hz, 10–50 μV) to a more pronounced, higher amplitude (70 μV) rhythm, with slowing of frequency in some subjects. Short bursts of high-voltage (up to 100 μV) theta at 5–7 Hz then occurred, simultaneously in all channels or first in the frontal region. Longer rhythmic trains of theta at 60–80 μV usually followed. In a third stage, seen in only four of the meditators, a stable rhythmic beta activity at 20 Hz was seen. This activity was intermittent at first, spindlelike bursts alternating with alpha or theta rhythms, and tended to become continuous on a persistent background of slow frequencies. Reminiscent of the generalized fast activity observed by Das and Gastaut (1955), this activity reached a voltage of 30–60 μV and predominated in anterior channels. Also similar to the findings of Das and Gastaut, the end of meditation was characterized by the return of alpha, persisting in some subjects into the eyes-open postmeditation period.

Both Das and Gastaut (1955) and Banquet (1973) interpreted the fast-wave pattern as a correlate of subjectively experienced mystical or transcendent feelings ("samadhi") during very deep Yogic or transcendental meditation; an apparent exception to this interpretation, however, are the findings of Anand *et al.* (1961), who reported an alpha-wave correlate of presumed samadhi experience. Alternatively, Peper and Ancoli (1977) suggested that there are two distinct meditational styles characterized by these different psychophysiological parameters: fast beta frequencies corresponding to focused, intentional tasks in their view, and alpha–theta corresponding to relaxation–meditation. A similar formulation, proposed by B. B. Brown (1977), is that differences in arousal may distinguish the two meditational styles. Regardless of the specifics, the important point in these interpretations is the suggestion the EEG patterns during meditation relate to specific cognitive and experiential features of meditation rather than a meditative ASC *per se*.

Beyond changes in EEG frequency and amplitude, recent evidence suggests that meditation may be characterized by changes in inter- and

intrahemispheric coherence. Orme-Johnson (1977) reported coherence values ≥0.8 for 40-sec epochs of EEG activity in theta, alpha, and beta bands in many (and sometimes all) derivations during TM. He regarded this increase in coherence as a correlate of a "low-noise state" of the brain produced during TM, an "EEG signature of the transcendental state." Along somewhat similar lines, Rogers (1976) found significant enhancement of left–right synchrony as a correlate of chanting meditation (Nichiren Shoshu). Rogers interpreted this result as an auditory driving response to a complex auditory stimulus, analogous to the well-known phenomenon of photic driving; she speculated that rhythmic or repetitive elements in a number of meditative and religious practices may function to enhance EEG coherence through a driving mechanism. She also stressed, however, that the phenomenon is complex and is not readily explained as a simple rhythmic response of the brain to rhythmic stimuli. Interestingly, the largest-amplitude rhythmic brain activity in the Rogers study occurred in the 3–8 Hz (theta) band, and in frontal leads, similar to findings in studies of TM.

Measures of phase and coherence may provide particularly meaningful clues as to consciousness or state-related changes during meditation. Adey (1969) suggested in another context that state-dependent EEG effects may be characterized in terms of the probability of Gaussian distributions of EEG amplitude; spindle sleep, for example, is characterized in scalp records by diminished probability of such distributions, indicating increased connectivity between generating elements.

It should be emphasized that not all investigators have been able to confirm the EEG changes of meditation. For example, Bagchi and Wenger (1957) found *no* changes in EEG alpha in comparing meditation and quiet rest in 14 Yogis. Similarly, Tebecis (1975) reported that:

> The EEG changes during TM were rarely as pronounced as previous reports suggest. There was considerable variation between subjects, some displaying no EEG changes at all during TM compared with an equal period of non-meditation. Any changes that did occur in a particular individual were not necessarily repeated in a subsequent session. (p. 312).

Overall, in fact, these investigators found *no* consistent or significant difference between meditation and nonmeditation, despite a trend toward increased theta and decreased beta, and they concluded that "pronounced and reliable physiological changes do not necessarily occur during TM, as has been claimed." This finding parallels a report by Travis, Kondo, and Knott (1976) that occipital alpha production of transcendental meditators did not change significantly during meditation and did not increase over premeditation baselines as previously reported by Wallace. Brown, Fischer, Wagman, Horrom, and Marks (in press) also found no difference between meditation and eyes-closed relaxation in a population of touch healers doing a variety of (unspecified) individual meditations. These negative results belie the robustness of the EEG correlates of meditation, and they underscore the need for careful phenomenological analysis in unraveling the significance of the EEG data.

Many of the issues related to variability in the correlates of meditation have been reviewed in excellent recent articles by Woolfolk (1975) and J. M. Davidson (1976). To mention a few, methodological considerations including EEG recording technique, measurement, and baseline procedures are critical in the proper evaluation of meditation. Many studies of meditation may also be faulted with a number of design errors that render results equivocal (Tebecis, 1975), including baseline procedures, failure to vary the order of conditions (meditation versus rest), and lack of appropriate controls.

Baseline procedures are of particular importance because baseline EEG tends to vary over the length of an experimental session, so that comparison with premeditation control periods is not necessarily appropriate. As Paskewitz, Lynch, Orne, and Costello (1970) have pointed out with respect to EEG biofeedback paradigms, alpha may increase as a result of disinhibition from influences that block alpha, and it has not been unequivocally demonstrated that meditation actually increases alpha above maximum disinhibited levels.

The issue of appropriate baseline and control procedures is a complex one. First, it is probably not sufficient to compare meditation simply with rest, since relaxation is a skill that is enhanced through repeated practice; on the other hand, the use of experienced relaxation subjects as controls may not solve the problem, since regular relaxation may have ASC-inducing effects of its own. Second, premeditation control periods do not take into account the progressive deepening of relaxation that may take place over time within a session. And third, a further consideration in regard to premeditation baselines is that conditioned psychophysiological changes may occur in anticipation of meditation practice, as for instance occurs among practitioners of autogenic training upon assuming the training posture (Luthe, 1969). The meditator may find it necessary to actively inhibit the development of the meditative state once the usual practice position is assumed, or may find it impossible to do so.

Issues related to EEG measurement have not been sufficiently emphasized in studies of meditation. For instance, broadly defined EEG frequency categories (e.g., alpha defined as 8–12 Hz) do not necessarily reflect homogeneous brain processes. Indeed, multichannel recordings suggest that alpha activity may be determined by three or more semi-independent generators (Lehmann, 1971), clearly implying that differences in electrode placement, filter characteristics, and measurement are relevant to results. B. B. Brown (1977) cited no fewer than 11 separate characteristics—abundance, frequency, amplitude, topographical location, phase, synchrony, variability, reactivity, and burst characteristics of rate of onset, duration, and frequency of occurrence—that must be taken into account and concluded that alpha should be interpreted not as a single brain rhythm but rather as a complex or family of brain frequencies.

These various considerations raise the questions of whether the changes in EEG and other psychophysiological variables attributed to meditation are real and to what extent they may be accounted for in terms of nonspecific relaxation effects. The following discussion examines several factors that influence EEG and that may possibly, therefore, mediate the changes that are observed during meditation.

3. Oculomotor Processes and EEG

One specific behavioral feature of meditation that is of particular importance in the interpretation of the EEG findings is whether the eyes are closed or, if open, "not looking." It has long been known that there is an important relationship between alpha waves and vision. Alpha waves, it will be recalled, are generally most conspicuously associated with the occipital region; they appear in the average subject when the eyes are closed and are blocked when the eyes are opened. An important series of investigations by Mulholland and his colleagues (e.g., Mulholland, 1969, pp. 120–127; Mulholland & Peper, 1971), as well as others, have demonstrated that the efferent oculomotor processes involved in looking (the triad of focusing, accommodation, and convergence of the eye muscles) are the probable major determinants of the presence or absence of alpha in the occipital EEG. Thus, while it is descriptively true that alpha waves are blocked when a subject attends to the environment or when a cognitive process requires effort, the oculomotor hypothesis explains this relationship on the basis that visual mechanisms are an important part of the orienting response. According to this model, occipital cortical activation occurs in association with coordination of the muscular apparatus of the eyes for sensory intake of visual data. Thus, looking blocks alpha, and in the absence of active looking, alpha reappears.

Plotkin (1976) has argued on the basis of EEG biofeedback work that oculomotor behaviors mediate changes in EEG whenever cognitive strategies are successful in producing changes in occipital alpha strength (including, presumably, during meditation). He argued that cognitive processes control alpha only to the extent that they mediate changes in oculomotor functions. One possibility is that when the mind turns inward during meditation, attention is withdrawn from events in the external environment, and visual orienting ceases. It is also interesting to note in this regard that when the eyes are closed, they often turn naturally into an upwardly deviated position, which is known to be associated with occipital alpha. In fact, in some (not all) subjects, alpha can be precisely regulated on or off by the simple expedient of turning the eyes upward (Dewan, 1967). This mechanism may also be relevant to certain spiritual practices in which attention is placed on a point between and slightly above the eyebrows, the so-called third eye; another similar technique stresses concentration on various points at the top of the skull. Possibly, these practices are associated with oculomotor behaviors that mediate the changes in alpha observed during meditation. While this is a plausible explanation of changes in occipital alpha, however, it does not necessarily account for the prominent frontal and central alpha seen during meditation.

An alternative possibility is that oculomotor processes are merely *incidentally* related to more essential cognitive aspects of the meditative ASC. This position has been expounded by Hardt and Kamiya (1976); the oculomotor hypothesis, they have argued, even if true, merely explains how alpha control is made possible physiologically and does not say anything about the specialized states of consciousness in which the requisite oculomotor changes are likely to occur. Hardt and Kamiya further argued that the changes in EEG alpha during alpha feedback (and, presumably, during meditation) occur in two phases. In the first phase, they suggested, alpha increases as a function of eliminating processes that block alpha; in a second phase, there is an increase in alpha above maximum baseline levels, and it is this high alpha state that is associated with the ASC. While this theory potentially circumvents the criticisms of Plotkin and others, it is unfortunately unsupported by any data.

In any case, the significance of changes in eye movements and eye position in meditation is an empirical issue that can be explored in relationship to the hypothesis of Hardt and Kamiya as well as experimental questions such as whether alpha levels during meditation are increased above maximum baseline levels and above levels achieved by instructed oculomotor behaviors ("not looking").

4. Meditation and Arousal

A second factor that may mediate the EEG response during meditation is level of arousal. It is well known that the EEG undergoes a predictable sequence of changes in the transition from wakefulness to sleep. These changes are generally held to be a function of changes in arousal along the sleep–wakefulness continuum (e.g., Lindsley, 1952). These facts raise several questions. First, to what extent can the EEG changes during meditation be explained in terms of decreased arousal? And second, to what extent is the low arousal state of meditation psychophysiologically unique?

Woolfolk (1975) has recently reviewed the data on the electroencephalographic and autonomic correlates of Yoga, Zen, and TM. Although there is not, he concluded, a thoroughly consistent or replicable pattern of responses, most of the psychophysiological data support the view that meditation is associated with a low-arousal psychophysiological state. Signs of reduced arousal in meditation may include greater synchronization and slowing of the EEG; lowering of respiratory rate and/or minute volume; some decrease in heart rate (HR); and a decrease in spontaneous electrodermal activity and/or reactivity. Additionally, some studies have found changes indicative of a slowing of energy metabolism, including decreased oxygen consumption, decreased carbon dioxide elimination, and a decline in blood lactate (Fenwick, Donaldson, Gillis, Bushman, Fenton, Perry, Tilsley, & Serafinowicz, 1977; Wallace, 1970; Wallace, Benson, & Wilson, 1971).

To illustrate the research findings to date, the psychophysiological correlates of several types of meditation practice are summarized in Table 1. In general, most (not all) findings are consistent with the low-arousal interpretation. It should be noted, however, that most studies have not statistically assessed the significance of the physiological changes during meditation, and it is additionally unclear whether changes of the observed order of magnitude merit the inference that a change in "psychophysiological state" has occurred.

The lowering of arousal in meditation can be understood as a shift in autonomic balance in the direction of parasympathetic dominance. Inasmuch as peripheral autonomic balance is not independent of central nervous system and skeletal muscle arousal, the implication is that meditation may be characterized in terms of interrelated changes in the autonomic system (decreased sympathetic arousal), central nervous system (enhanced cortical synchrony), and somatic musculature (general body relaxation). A number of authors have described meditation in these terms. For instance, Gellhorn and Kiely (1972) proposed that meditation consists of a shift in the ergotropic (sympathetic)/trophotropic (parasympathetic) continuum to the trophotropic side. Along similar lines, Benson, Beary, and Carol (1974) theorized that the psychophysiological basis of the meditative ASC is an integrated hypothalamic reaction ("the relaxation response") consisting of a shift

TABLE 1
Psychophysiological Correlates of Meditation and Related Practices: Summary of Studies Cited

Type of practice	EEG	Respiration	Heart rate	Electrodermal	Reference
Yoga	No change	Decrease	No change	Increase SRL[a]	Bagchi & Wenger, 1957
Yoga		Decrease	Increase	Decrease SRL	Wenger & Bagchi, 1961
Yoga	Alpha (samadhi)				Anand, Chhina, & Singh, 1961
Kriya Yoga (n=7)	Beta (samadhi)		Increase (samadhi)		Das & Gastaut, 1955
Ananda Marga Yoga	Alpha-theta	Decrease	No change	Increase SRL	Elson, Hauri, & Cunis, 1977
TM	Alpha-theta		Decrease	Increase SRL	Wallace, 1970
TM	Alpha-theta			Increase SRL	Wallace, Benson, & Wilson, 1971
TM				Decrease SRRs[b] Increase SRR habituation	Orme-Johnson, 1973
TM	Alpha-theta Beta				Banquet, 1973
TM	Alpha-theta (variable)				Tebecis, 1975
TM, autohypnosis	No difference between groups	Decrease	Decrease	Increase SRL Decrease SRRs	Walrath & Hamilton, 1975
TM, progressive relaxation	No difference between groups		Decrease		Warrenburg, Pagano, Woods, & Hlastala, 1977
TM, progressive relaxation		No change	No change	No change	Curtis & Wessberg, 1976
TM, relaxation	No change TM		No change TM		Travis, Kondo & Knott, 1976
Zen	Alpha-theta				Kasamatsu & Hirai, 1969
Zen		Decrease	Decrease		Goyeckhe, Chihara, & Shimizu, 1972
Zen	Alpha-theta	Decrease	Decrease	More stable	Hirai, 1974

[a] SRL = skin resistance level.
[b] SRR = skin resistance response.

toward decreased sympathetic and perhaps increased parasympathetic activity.

Autonomic, central, and skeletal muscle arousal comprise an interlocking system of feedback mechanisms with reciprocal influences, so that changes in one system produce corresponding effects in the others (Gellhorn & Loofbourrow, 1964). That is to say, changes in autonomic balance are seen as correlated with changes in muscle tension, EEG, and behavior on a continuum that ranges from deep sleep to wakefulness to behavioral excitement. Moreover, to the extent that autonomic balance is controlled by the CNS, peripheral autonomic activity can be regarded as an index of central state (Porges, 1976). Despite the close association between somatic, autonomic, and central components of arousal, however, recent evidence suggests that it may be more fruitful to emphasize patterning and specificity in psychophysiological activity (Davidson, 1978). That is to say, arousal is not a unidimensional process, and it is likely that different patterns of activity in various components may occur in different practices.

In an excellent review of this area, Davidson & Schwartz (1976, pp. 399–442) proposed that low-arousal or relaxation states consist of a number of *dissociable* dimensions: cognitive, somatic, and attentional. For example, they pointed out that someone may be physically tired and somatically relaxed and yet be unable to fall asleep because his "mind is racing." This phenomenon implies that it may not be sufficient to characterize meditation simply as a low-arousal state on a unidimensional continuum, nor may it be accurate to suppose it lies somewhere between normal waking consciousness and sleep.

It is reasonably clear from the data summarized in Table 1 that meditation is associated with a decline in autonomic arousal, although minor dissociations are seen among different measures. The central arousal component is less clear-cut. Thus, alpha-theta EEG is interpreted as a sign of reduced cortical arousal, and yet meditation is often accompanied by an experience of enhanced alertness. Along the same lines, meditation (Zen, at least) is associated with increased alpha activity *and* increased attention, in apparent contradiction of the more typical finding that alpha rhythm is inversely related to attention; even theta rhythm in these subjects is coupled with an ability to respond quickly to auditory stimuli while meditating (Kasamatsu & Hirai, 1969), which on the face of it is contradictory to the report of Beatty, Greenberg, Diebler, and O'Hanlon (1974) that theta enhancement is correlated with performance decrement. Clearly, psychophysiological measures alone do not completely specify level of arousal; the significance of an EEG pattern evidently depends on what "state" context it occurs in.

What these data suggest, following the discussion by Davidson and

Schwartz (1976), is that states of consciousness may be characterized only in terms of patterns of somatic-autonomic, cognitive, and attentional factors. In meditation, there is a cognitive or attentional alertness that is not predicted by the pattern of peripheral or even cortical arousal. Gellhorn and Kiely (1972) ascribe this dissociation to sympathetic activity occurring against the background parasympathetic shift; another possible interpretation is proposed by Jevening, Wilson, Smith, and Morton (1975), who inferred from indirect measures that brain blood flow (and therefore, presumably, neural activity) increases during meditation (TM).

Patterns of psychophysiological activity in meditation may be quite specific to particular practices. Goyeche, Chihara, and Shimizu (1972), for instance, published results of a pilot study of psychophysiological differences between Zen concentration and a concentration practice called *cotention*. In the Zen exercise, subjects were asked to concentrate their attention on the muscle sensations arising from their abdominal breathing, and in the cotention exercise, on the muscle sensations of their eyes. Within-subject comparisons were made over a 15-min session consisting of 5-min intervals of Zen, cotention, and simple relaxation randomly ordered across subjects. A trend was found for Zen to produce a greater decrease in heart rate than cotention and to produce a diminution in respiration rate, while cotention produced an increase in respiration rate. While these psychophysiological changes appear to indicate a decrease in arousal during Zen, Goyeche *et al.* also found that the amplitude of abdominal breathing tended to increase and that of thoracic breathing to decrease, a result opposite to the pattern associated with decreases in arousal leading to sleep (Timmons, Salamy, Kamiya, & Girton, 1972). Possibly, attention on the breath may enhance abdominal breathing apart from arousal-related effects. Here again, the significance of a particular psychophysiological change needs to be interpreted within a particular state context.

The importance of patterns of psychophysiological activity is emphasized in a study by Pelletier (1974). Pelletier found, in a case study of a Yogic adept, that states of consciousness could be characterized only in terms of the multiple parameters of EEG, respiratory, and cardiovascular functions. Voluntary control of alpha (increased alpha production) was associated with an increase in respiration rate and a decrease in heart rate with no change in electrodermal response (EDR) or EMG, while increased theta production was associated with a decrease in respiration rate and EMG with no change in HR or EDR. Each pattern of activity was associated with distinct subjective correlates.

A number of studies in the biofeedback area are beginning to define the patterns of covariation and potential dissociation between

psychophysiological variables. Thus, we know, for instance, that conditioned EEG changes can occur relatively independently of cardiac and respiratory activity (Beatty & Kornfeld, 1972; Schwartz, Shaw, & Shapiro, 1972), EDR (Suter, Johnson, Franconi, & Smith, 1977), and EMG (DeGood & Chisholm, 1977). Despite the potential dissociability of CNS (EEG) and autonomic variables, deep somatic relaxation tends to be associated with correlated changes in EEG, such as heightened alpha. For instance, DeGood and Chisholm (1977) have shown that frontalis EMG feedback results in a generalized pattern of arousal changes reflected in heart rate and respiration as well as EMG and EEG. Hassett and Schwartz (1975) found a combination of heart rate decrease and alpha "on" elicited more reports of relaxation than other conditions in a 2×2 design.

The relative contributions of sympathetic and parasympathetic influences on the various components of the low arousal state in meditation is an interesting, and unanswered, question. Heart rate appears to be parasympathetically influenced and related to somatic components of arousal, whereas phasic electrodermal activity may be sympathetically mediated and related to emotional arousal (Davidson & Schwartz, 1976). A number of predictions may also be derived from the relationship between autonomic activity and attention. For example, Porges (1976) suggested that sustained attention is characterized by parasympathetic influences on autonomic activity (reduced HR and HR variability). Increased parasympathetic activity in meditation would be consistent with the observation that cholinomimetic drugs produce a slowing of thinking (Davis, Hollister, Overall, Johnson, & Train, 1976). While there are no data that address this point, Porges suggested a methodology (the rationale for which is too complex to go into here) for assessing sympathetic and parasympathetic influences through the quantification of respiratory influences on heart rate.

5. SPECIFICITY OF THE MEDITATIVE ASC

There are four basic elements, according to Benson, necessary to effect the relaxation response: (1) a mental device (constant stimulus or other technique for shifting from logical, externally oriented thought); (2) a passive attitude; (3) decreased muscle tonus; and (4) a quiet environment. These criteria are rather general and suggest that the relaxation response may be rather nonspecific; according to Benson, it can be elicited through autogenic training, progressive relaxation, hypnotic suggestion, and related practices as well as meditation (Benson, Beary, & Carol, 1974). Such a generalization, however, disregards the diversity among meditation techniques, and in regard to subjective experience, at least, it may be inaccurate to regard Yoga and Zen, much less autogenic training and progressive relaxation, as identical states (Mills & Campbell, 1974).

One way to look at this issue is in terms of a "multiprocess" model of relaxation states (Davidson & Schwartz, 1976). According to this view, low-arousal states consist of specific patterns of somatic, cognitive, and attentional relaxation. The general principle of the multiprocess model is that active generation of behavior in a given mode competes with and inhibits unwanted activity and thereby generates relaxation in that mode; different techniques, therefore, may elicit different components of the relaxation response. TM, for example, utilizing a self-generated verbal mantra, is seen as competing with verbally mediated cognitions, whereas Hatha Yoga would have a relatively greater effect on somatic processes. Thus, meditation can be conceptualized as a family of practices that generate particular patterns of somatic, cognitive, and attentional relaxation, dependent on how effectively the particular technique inhibits ongoing activity in these modes. While certain components of the low-arousal state in meditation may be nonspecific, as Benson suggested (somatic and autonomic components especially), others (cognitive and/or attentional) may at the same time be quite specific.

Some evidence relevant to the comparison of meditation and other low-arousal states has been published in the last few years. By and large, it appears to support the position that the autonomic and somatic components of the relaxation response, at least, are nonspecific and can be elicited with a variety of different techniques. For example, Curtis and Wessberg (1976) compared HR, respiration, and EDR level among transcendental mediators, relaxers with a comparable degree of experience in Jacobson's technique, and inexperienced subjects instructed to sit quietly. No statistically significant differences were found among groups, suggesting that meditation is not distinguishable from relaxation. (However, there were also no significant effects from any of the experimental treatments relative to pre- and postexperimental baselines in this sketchily reported study, which renders these results rather equivocal.) In another study addressing the same questions, Warrenburg, Pagano, Woods, and Hlastala (1977) compared oxygen consumption, heart rate, EMG, and EEG in TM and progressive muscle relaxation; both practices produced a significant degree of relaxation from baseline, including a 4% drop in oxygen consumption, a 1.6-BPM (beats/min) drop in heart rate, and a 3.1-μV decrease in frontalis EMG. There were no significant differences between groups. In yet another study,

Walrath and Hamilton (1975) investigated peripheral autonomic correlates of TM, autohypnosis, and control subjects, all selected for a high susceptibility to hypnosis. Again, it was shown that meditation and hypnosis do not differ from each other, nor from instructed relaxation.

Fenwick, Donaldson, Gillis, Bushman, Fenton, Perry, Tilsley, and Serafinowicz (1977) reexamined the drop in metabolic rate during TM observed by previous investigators. Oxygen consumption in TM and relaxation control groups was measured and related to initial metabolic rate and to subjects' self-ratings as "tense" or "relaxed" during the experimental session. It was found that nonspecific relaxation techniques such as listening to music were as effective as meditation in terms of a slowing of metabolic rate. Interestingly, the percentage of change in oxygen consumption during meditation was comparable in magnitude to the 16% observed by Wallace *et. al.* (1971) only in a subgroup of subjects self-rated as "tense" (13.5% drop), while "relaxed" subjects showed a much smaller drop, consistent with muscle relaxation and small changes in body posture, which, according to the authors, is of little physiological significance. This finding tends to suggest that the "hypometabolic state" of TM is not due to meditation alone but rather to an interaction between meditation and initial level of relaxation. In additional support of these conclusions, it was also found that the magnitude of change in oxygen consumption was comparable for "good" and "bad" meditations. Further, in a fasting control designed to reduce metabolic rate to the lowest possible level, meditation failed to produce any significant change in metabolic rate.

In a somewhat related study, Michaels, Huber, and McCann (1976) investigated the effects of TM on plasma norepinephrine and epinephrine and could find no evidence of an effect greater than that produced by relaxation. On the other hand, however, Jevening, Wilson, Smith, and Morton (1975) found TM to be associated with a pattern of decrease in hepatic and renal blood flow and an increase in cardiac output that differed from the pattern in resting controls; relaxation controls were not used, however.

While the combined results of these studies clearly undermines Wallace's characterization of TM as a unique hypometabolic state, it should be recognized that this fact does not in itself prove anything about the uniqueness of the ASC associated with TM (or other practices). Correctly understood, the results cited show, first, that the repeated practice of TM does not routinely enable the practitioner to enter a profoundly hypometabolic state and, second, that the relaxation elicited by TM is not unlike that produced by various relaxation techniques or hypnosis. Data relevant to the uniqueness of the EEG characteristics of TM and other meditations are discussed in the next section, and considerations pertinent to the ASC aspects of meditation are detailed in the remainder of the chapter.

In conclusion, the evidence strongly demonstrates that the practice of meditation tends to elicit a low-arousal psychophysiological state. Although the somatic and autonomic correlates of meditation appear to be satisfactorily accounted for in terms of nonspecific relaxation effects, it is possible that meditation may be unique in regard to the cognitive and attentional components of the low arousal state that occurs. Evidence on this point is unclear; there has been little attempt to delineate these components of meditation vis-à-vis correlated psychophysiological changes, despite the fact that these would *a priori* seem to be the more relevant dimensions of the meditative ASC. It should also be emphasized that although it is clear that low arousal is one of the primary behavioral dimensions of meditation, it does not logically follow that meditation can be *equated* with this psychophysiological state. It is not clear at this time which, if any, features of the meditative ASC are linked to the occurrence of which components of the low-arousal state, nor whether any of these is a sufficient condition for its occurrence.

6. EEG, Arousal, and Sleep

Whether decrements in arousal explain the EEG changes associated with meditation is not clear. As Plotkin has noted (1976), there are at least two dimensions of the variation in alpha with levels of consciousness. On the one hand, the *strength* (amplitude) of the synchronous alpha rhythm diminishes as a correlate of attentional processes and/or increased arousal in the transition to nonsynchronous, low-voltage, fast beta activity. (This desynchronization does not necessarily imply, however, that alpha activity has ceased at the neuronal level [Lindsley, 1952].) On the other hand, a shift in the *dominant frequency* of alpha characterizes the shift toward sleep, with alpha slowing into the theta band. While meditation has been described in terms of both an increase in alpha strength and a decrease in alpha frequency, Plotkin suggested that only the shift in frequency should be regarded as an index of (diminished) arousal. This is an interesting point in light of a recent suggestion that the change in alpha strength (amplitude) may be the more essential feature of meditation (Kamiya, 1975–1976).

A related question concerns the relationship between the EEG changes associated with meditation and the phenomena of sleep. Changes in arousal are generally held to be associated with the functions of the reticular activating system and the sleep–waking continuum (e.g.,

Lindsley, 1952). Covariations in EEG, EMG, and certain aspects of respiration activity occur along this dimension. For example, amplitudes of abdominal and thoracic respiratory movements covary with shifts in arousal and level of muscle tension as a subject falls asleep (Timmons, Salamy, Kamiya, & Girton, 1972), and there is a marked and sudden drop in frontalis EMG coincident with the alpha–theta transition (Budzynski, 1972; Sittenfeld, Budzynski, & Stoyva, 1976). Of additional interest in this context is the fact that certain psychological changes occur predictably as a consequence of low arousal with a variety of practices, for example, in autogenic training (Luthe, 1969) or when EMG levels fall to sufficiently low levels in the course of frontalis biofeedback training (Budzynski, Stoyva, & Adler, 1970). These changes—notably a decline in organized, secondary-process thinking and the appearance of progressively more free-associative, primary-process types of cognition—are similar to the hypnagogic period between sleep and waking.

The possibility that EEG and psychological phenomena associated with meditation might be accounted for in terms of sleep-onset phenomena in a low-arousal state was recently brought into particularly sharp focus by a report in *Science* by Pagano, Rose, Stivers, and Warrenburg (1976). These investigators reported that experienced practitioners of TM spend up to 40% of the meditation period in stages II, III, and IV sleep, with no significant difference between meditation and nap sessions. In agreement with these findings, Younger, Adriance, and Berger (1973, p. 99) reported that a group of eight TM subjects spent half of a typical meditation in waking alpha, slightly less asleep, and the remainder alert. Also along similar lines, Fenwick and colleagues recently reported that experienced judges could not evaluate any difference on a blind basis between meditation and drowsy EEGs. Raters evaluated EEG records for increased alpha amplitude, decreased alpha frequency, spread of alpha activity to frontal or temporal leads, frontal and temporal bursts, and concurrent alpha and theta activity; if slow, rolling eye movements were present, these changes were considered indicative of drowsiness, and if not, the changes were rated as meditation-related. On the basis of these criteria, judges failed to discriminate meditation-related EEG (Fenwick *et al.*, 1977).

Not all investigators have been in agreement on this point, however. Travis, Kondo, and Knott (1976) found EEG signs of sleep in 13 of 16 controls but in only 1 of 16 transcendental meditators. In a spectral analysis of the EEG during TM, Banquet (1973) recorded theta activity but found it to be dissimilar to the pattern observed during sleep. The theta pattern associated with TM, he argued, does not occur against a background of mixed frequencies, as is typical of drowsiness, and tends to consist of continuous runs of theta at a relatively constant frequency.

Perhaps part of the resolution of this mass of conflicting evidence has to do with variability in the experience of meditators. No one denies that sleep may occur during meditation; the subjects studied by Pagano *et al.* (1976) *reported* having slept during meditation. Another source of disagreement may have to do with the EEG criteria for sleep. Thus, for instance, diffuse theta has been considered the hallmark of drowsiness or sleep onset (Liberson & Liberson, 1966), but as Elson, Mauri, and Cunis (1977) have pointed out, the alpha–theta pattern of meditation is distinct from Stage I sleep onset in the fact that it is nondescending—stage II does not necessarily follow. This conclusion, based on findings in Ananda Marga Yoga meditation, like TM a mantra technique, is, however, at variance with the report of Pagano *et al.* (1976), who found substantial amounts of Stages II, III, and IV sleep in TM.

The transition from the waking state to the sleep state is marked by a diminished awareness of external reality, disorganization of normal waking consciousness into a free-associative mode, and the occurrence of spontaneous visual, auditory, and kinesthetic images that may have a hallucinatory or dreamlike quality. The psychophysiological correlates of this hypnagogic period include, first, the fragmentation of the alpha-dominant waking pattern, with intermittent alpha blocking occurring, together with the appearance of low-amplitude theta and low-voltage fast activity; changes in respiratory pattern; and low frontalis EMG (Schacter, 1976). The electroencephalographic response to sensory stimulation during this latter phase, in contrast to the alpha-blocking response during waking, is the appearance of alpha waves (the "alpha arousal reaction").

Kasamatsu and Hirai (1969) argued in their study of Zen meditators that the theta pattern of meditation could be distinguished from that occurring in the transition to sleep by two criteria. First, they reported that responses to sensory input during meditation theta consisted of desynchronization to a low-voltage fast pattern, resembling the alpha-blocking response of waking and not the alpha arousal reaction of drowsiness. Banquet (1973) described an apparently similar response during theta activity of TM. This observation suggests a possible method for empirically resolving the relationship between the meditation theta pattern and the hypnagogic theta pattern, and it should be replicated.

A second factor to be considered in comparing meditation with the hypnagogic state is the subjective experience of the subjects. Kasamatsu and Hirai (1969) and Banquet (1973) have commented on the subjective inequivalence of Zen meditation and TM, respectively, and drowsiness or sleep. One difficulty in sorting out these ideas is that it is not clear whether the occurrence of theta during meditation corresponds to fluctuations in psychological state along the sleep–wakefulness continuum or along some other psychological dimension. An empirical study of the mental experiences correlated with the occurrence of theta during meditation could be compared with similar data on subjective correlates of theta under other conditions (drowsiness, biofeedback, etc.) and might help to clarify the functional significance of its occurrence.

Some information is available relevant to this question. Hebert and Lehmann (1977) investigated the subjective experiences coincident with topographically diffuse theta bursts in four transcendental meditators selected for abundance of large-amplitude theta bursts; inasmuch as interruption of meditation was considered bad practice, however, this investigation was conducted during a period in which subjects were instructed *not* to meditate. Subjective state reports elicited during theta bursts included probable references to "peaceful, comfortable, and pleasant" experiences and "drifting or sliding" as well as "shifts of attention and reality-connected thoughts going on by themselves." Subjects reported being awake, with intact self-awareness and reality orientation, although they were not necessarily attending to the experimental situation. There were no consistent alterations in heart rate or phasic skin or muscle activity associated with the theta bursts, although bursts of eye movements sometimes occurred. In another report, episodes of theta in an adept meditator (Pelletier & Peper, 1976) corresponded to periods of reverie with rich imagery. And in yet another, albeit anecdotal, report, investigators at the Menninger Clinic quoted an Indian swami tested by them to the effect that theta is a "noisy" mental state produced by "stilling the conscious mind and bringing forward the unconscious" (Green, 1972). All of these findings appear to fit with descriptions of typical hypnagogic phenomena.

Subjects queried about their subjective experiences during meditation periods in which theta activity was prominent generally deny having been asleep (e.g., Kasamatsu & Hirai, 1969). The validity of subjective report in this regard is problematical, however. In sleep experiments, subjects showing definite EEG signs of drowsiness (occipital alpha blocking and central theta activity) will frequently deny drowsiness (Liberson & Liberson, 1966). Similarly, as Elson *et al.* (1977) have noted, sleep onset as assessed by unconsciousness to environmental stimuli generally occurs during the high alpha phase of Stage I sleep, and yet subjects will typically report being awake rather than asleep during this period. Clearly, there is a great deal of variability in the correspondence between the psychological phenomena of sleep onset and EEG correlates.

The most effective assessment of sleep onset is achieved with the combined measurement of EEG and eye movement (EOG) activity.

Foulkes and Vogel (1965) defined four distinct stages between waking and sleep in this way: a stage of alpha with rapid eye movements (REMs); a stage of alpha with slow rolling eye movements (SEMs); "descending Stage I," consisting of low-voltage, fast, random EEG with SEMs; and "descending Stage II," occasionally with SEMs. Hypnagogic phenomena occurred in all EEG-EOG stages of sleep onset. The associated psychological or mental activity has been characterized further by Vogel, Foulkes, and Trosman (1966) and by Liberson and Liberson (1966) in terms of the degree of reality content and of regressive (primary-process) content of each phase. Both of these ego functions were found to be usually intact in the presence of EEG alpha and absent in the later stages of drowsiness, although there is not a perfect correspondence. The duration of drowsiness, for example, accounts for some of the variance in subjective report.

It is obviously both appropriate and necessary to consider as many variables as possible in attempting to compare meditation and sleep, not merely EEG. A consideration of eye movement data as well as the relative amplitudes of abdominal and thoracic respiration (Goldie & Green, 1961) and phenomenological data would be helpful in clarifying the relationship between these states. While there is no quantitative study adequate to answer the question fully, some data are available in this regard. For instance, Hebert and Lehmann (1977) argued against a hypnagogic interpretation of meditation, citing the absence of SEMs as well as the lack of unresponsiveness to environmental stimuli, drowsiness, or other psychological phenomena of sleep onset during TM. Conflicting evidence was cited by Fenwick *et al.* (1977), however, who observed SEMs during TM as well as gross myoclonic jerks, which they interpreted as pathognomic of drowsiness. Tebecis (1976) also reported SEMs in a proportion of subjects experienced in TM, which were, however, not consistent between sessions. He interpreted the eye movements as similar to those seen during passive hypnosis.

Given the available evidence, there are several possible interpretations of the relationship between meditation (specifically TM) and the process of sleep onset. The first possibility, supported by Elson *et al.* (1977) and by Fenwich *et al.* (1977), is that meditation consists in practice in "freezing" the hypnagogic process, first in the predominantly alpha stage, later in the theta stage. That is, meditation may be a method of holding the level of consciousness at stage "onset" sleep. A second interpretation, a slight variation of the first, interprets the occurrence of theta during meditation in different terms (Hebert & Lehmann, 1977). According to this second hypothesis, the high-alpha phase of sleep onset is cultivated and prolonged by the practice of the TM technique,

with theta bursts corresponding to transient fluctuations in level of arousal:

> Apparently the prolonged maintenance of the low arousal state which is compatible with meditation is not always successful, particularly when subjects are tired: subjects' reports as well as EEG studies have shown that sleep may occur during meditation. The theta bursts may represent a mechanism which adjusts the cerebral functional state compatible with meditation by widespread, brief neural activation. (p. 403)

This theory suggests, then, a functional interpretation of theta in terms of arousal homeostasis. This interpretation may have some bearing, also, on the occurrence of frontal theta of brief duration in normal (non-meditating) subjects (Lutzenberger, Birbaumer, & Steinmetz, 1976; Yamaguchi, 1977).

One possible interpretation of all of these data, similar to others that have been offered but somewhat different in emphasis, is that the occurrence of theta during meditation may represent a subjective point during meditation where the sleep process begins to intrude into meditation, experienced subjectively as the mind's drifting pleasantly or as a moment of reverie. In a recent review, Schacter (1976) emphasized that the hypnagogic state is defined by a particular pattern of psychophysiological changes occurring *in the context of the drowsy interval between sleep and waking* [italics added]. Perhaps in the context of a different cognitive set, meditation, the same events do not necessarily culminate in sleep and are subjectively interpreted as distinct from falling asleep. Some support for this conjecture may be found in the fact that EEG findings alone are insufficient criteria for defining the occurrence of sleep. According to Evans (1973, pp. 43–83), "there are no specific EEG criteria that define Stage I sleep; it is recognized as such only if subsequent records reveal Stages II or III sleep." Thus, EEG findings alone take on meaning only in a particular context that includes behavior.

From a psychological point of view, the hypnagogic state involves a loosening of cognitive controls, which allows the free-associative, primary-process, reverie sort of mentation to emerge. Drowsiness is only one way that such a destructuring of thought can come about. A variety of deliberate induction techniques are known that can facilitate these "altered-state" phenomena, including sensory deprivation, hypnosis, and autogenic training. A combination of features in meditation, including the passive-volitional set, the deep relaxation, and perhaps mild sensory deprivation aspects, may likewise facilitate the occurrence of hypnagogic phenomena.

Even if true, however, it does not follow that the occurrence in meditation of either hypnagogic phenomena, the theta EEG that presumably is their correlate, or for that matter outright sleep is necessarily the goal of meditation. Rather, the "goals" of meditation, as has been suggested above, have to do with the quality of awareness that is brought to whatever cognitive process goes on during meditation. Indeed, in many Eastern schools, disciples are warned not to get too drawn into hallucinatory phenomena; in Zen meditation, when the roshi perceives that the student has fallen asleep or into a trancelike state, the student is brought back to present-centered awareness with a sharp blow (or a light tap) across the back and shoulders.

7. Meditation and Attention

As suggested in the discussion earlier, meditation differs from other relaxation practices along the dimension of attention. Beyond the variety among different meditation practices, all meditations involve the selective deployment of attention. In fact, Davidson and Goleman (1977) *define* meditation as the self-regulation of attention.

As mentioned in an earlier section, two basic types of meditation that have been identified in the literature are *mindfulness* and *concentration*. Goleman (1977) summarized the differences between these methods as follows:

> In meditation, method is the seed of the goal: The contours of the state the meditator reaches depend on how he arrived. The concentrative path leads the meditator to merge with his meditation subject . . . and then to transcend it. As he reaches deeper levels, the bliss becomes more compelling, yet more subtle. In the way of mindfulness, the meditator's mind witnesses its own workings, and he comes to perceive increasingly finer segments of his stream of thought. As his perception sharpens, he becomes increasingly detached from what he witnesses, finally turning away from all awareness in the nirvanic state. In this state, there is no experience whatever. (p. 114)

Mindfulness and concentration meditations may also be distinguished in terms of the passive and active attentional strategies that typify them (Davidson & Goleman, 1977). As previously noted, mindfulness entails a passive witnessing of experience, whereas concentration involves a more active focusing of attention. These two meditational strategies have been related to alpha–theta and fast-wave EEG patterns, respectively (B. B. Brown, 1977; Brown, Fischer, Wagman, Horrom, & Marks, in press; Davidson & Goleman, 1977, Peper & Ancoli, 1977). Thus, Brown *et al.* suggested that the beta pattern in meditation connotes an active state in which there is considerable directed thought and attention, whereas slower frequencies are related to passive states of internal attention.

Case studies of individuals adept in various techniques of meditation and voluntary control of autonomic function provide some additional support for this interpretation of the EEG data. Pelletier and Peper (1976) reported on several such individuals in a recent paper. One subject, R. C. T., demonstrated his ability in the laboratory to push a sharpened bicycle spoke through one cheek and out the other in the presence of an occipital alpha density of 100%-time and an increase in alpha amplitude of 73% relative to eyes-closed baseline. Comparable psychophysiological findings occurred in J.S., while he pushed an unsterilized, sharpened knitting needle through his left bicep. Both of these individuals reported detaching their awareness from the insertion point. In contrast, J.S.L. accomplished a similar feat using a meditative process in which he intensified his focus on the sensation, and in this case, the investigators found an occipital EEG consisting mainly of beta activity with some low-amplitude alpha and some slowing in frontal leads.

As indicated in the quote from Goleman (1977) above, mindfulness and concentration practices are regarded as resulting in different experiences of altered states. In addition to differences in ongoing EEG, alleged objective correlates of this difference in state have also been identified in terms of the alpha-blocking response. Depending on the type of meditation, it has been reported either that alpha blocking fails to occur (TM: Banquet, 1973; Yoga: Anand *et al.*, 1961) or that it occurs to a repeated series of stimuli without the expected habituation (Zen: Kasamatsu & Hirai, 1969; TM: Wallace, 1970). These data have been widely interpreted as reflecting decreased reactivity to the external environment during concentration, on the one hand, and the maintenance of an unusual degree of alertness during mindfulness practices, on the other.

There are, however, substantial difficulties with this interpretation. In the first place, as J. M. Davidson (1976) has pointed out in his excellent review, the characterization of these phenomena has been based on a very few subjects and has been very sketchily reported. By and large, these have been incidental rather than systematic observations: stimulus parameters and procedures have not been reported, criteria for alpha blocking have not been described, and the number of subjects has been quite small (three in the Kasamatsu & Hirai study and four in the Anand *et al.* study). Moreover, the results even as described are quite variable: the two reports on TM are inconsistent, for example.

Important methodological considerations appear to have been overlooked in these studies.[1] One important factor is the ongoing EEG (and

[1]A number of substantive comments were contributed to this discussion by David Becker.

experiential state) at the time of stimulus onset. For example, in Banquet's (1973) study of TM, a stimulus during alpha resulted in no alpha blocking; a stimulus during theta produced a brief desynchronization; and a stimulus during beta produced no change. Another point concerns the evaluation of the alpha-blocking response when the eyes are open, as in Zen meditation. For example, the figures in Hirai's monograph on Zen (1974) show what appear to be prominent eye-movement artifacts in response to clicks, and it may be that these are related to the persistence of the alpha-blocking response during this eyes-open practice; control subjects were tested with eyes closed. (Anand *et al.*, 1961, found blinking responses to external stimuli in the absence of any blocking of the alpha-blocking rhythm, however, although these subjects kept their eyes closed.)

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. Mulholland and Runnals (1962) have shown, for instance, that different attentional sets may determine whether alpha blocking or alpha facilitation occurs even in the normal waking state. Transitory alerting to an external stimulus tends to produce alpha suppression, whereas a set for continuous or sustained attention to a stimulus tends to be associated with an absence of alpha blocking or alpha facilitation. Voluntary attention to a stimulus, and whether it has signal value, may also mean the difference between the habituation and the nonhabituation of an orienting response (e.g., Luria & Homskaya, 1970, pp. 301–330). Thus, alpha blocking and habituation might conceivably vary as a function of attentional variables quite apart from the effects of the meditation process, the meditative ASC, or even the attentional skills acquired through meditation. A number of different control procedures would be needed in order to distinguish among these possibilities.

Davidson and Goleman, in a recent review (1977), have summarized the evidence relating to psychophysiological differences between mindfulness and concentration practices. They concluded that both meditation strategies are associated with autonomic quiescence but that concentration enhances cortical specificity to a greater degree than passive meditations. In a study by Schwartz, Davidson, and Margolin (cited in Davidson and Goleman's 1977 review), EEG changes were related to two different forms of meditation, TM (a passive meditation) and a Gurdjieffian meditation, in which attention is actively focused on a series of somatic and proprioceptive stimuli. It was predicted that the skills acquired in the Gurdjieffian practice would show up in terms of a

relatively greater activation in the appropriate cortical areas when the subjects were asked to attend to visual and kinesthetic stimuli. Cortical activity was assessed as the ratio of activation in occipital and sensorimotor-region EEG. As predicted, differential activation was greater in the Gurdjieffian group. These results show that different meditation practices cultivate different attentional skills. As predicted, it was also found that active attention (the Gurdjieffian exercises) produced greater EEG activation at both sites than did passive attention (TM). The success of this paradigm in discriminating *trait* effects of meditation suggests possible applications in the study of meditation itself. For example, a single meditator might be asked to meditate on some target actively and passively in turn, so that the contribution of the attentional strategy can be evaluated.

Thus, the available evidence supports the notion of *specificity* in cortical activation and suggests that EEG correlates in meditation may, in fact, be explicable in terms of specific cognitive behaviors, that is, in terms of the *content* rather than the *context* of meditation. Specific predictions follow from the nature of the behaviors involved in different meditation practices. For example, mantra meditation involves a repeating verbal loop that presumably should differentially involve the left hemisphere. Zen koan meditation, as opposed to Zazen, involves an active thinking process and should therefore result in an EEG more similar to the waking state. And so on. There may, however, be limitations inherent in this approach. As Adey (1969, pp. 194–229) commented in another context, the evaluation of EEG even by simple automated techniques may be inadequate for elucidating correlates of processes such as focused attention, in that mental processes are so rapid and changing that our windows on these processes must be equivalently refined and effective with epochs of only a second or so in duration.

It is surprising to find no experimental work on the effects of meditation on evoked potentials or contingent negative variation (save a brief note by Legrand, Toubol, Barrabino, Darcourt, and Fadeuilhe, 1977 remarking changes in amplitude, particularly late components.) Changes in reactivity to stimulation would seem to hold promise as a potential means of characterizing the meditative ASC, above and beyond changes in baseline psychophysiology. The evoked-potential method would be useful, for instance, as a direct test of the notion that concentration meditation results in an attenuation of afferent input below the cortical level (cf. Davidson & Goleman, 1977). Amplitudes of evoked potentials are known to vary with degree of attention (Tecce, 1970), so this parameter seems likely to be sensitive to meditation. Another general prediction is that there should be less associative "noise" in response to input during meditation. That is to say, if the mind is calm, it is theoretically less reactive to stimulation, and this effect might be characterized by changes in amplitude, latencies, or especially distribution of the evoked response in different cortical areas.

There have been surprisingly few direct or systematic studies of the attentional phenomena of meditation. One exception is the study of Van Nuys (1971), who reported a very simple technique applicable to the assessment of attention in meditation; the subject simply presses a telegraph key or other manipulandum every time he notices that his attention has wandered from its intended focus ("intrusions"). Kubose (1976) applied this method to an experimental investigation of Zen breath-counting meditation. Meditators showed decreased thought intrusions over 15 experimental 15-minute sessions, indicating a learning or practice effect of the meditation. There were also more intrusions within a session as the session progressed.

One of the problems in characterizing the nature of attention in meditation is that attention is not a unitary phenomenon. Pribram and McGuinness (1975) delineated three neurally distinct systems that are involved in attention: a system for visceroautonomic *arousal*, a system for somatomotor *activation*, and a system that organizes the relationship between the two. This latter mechanism, termed *effort*, is conceived of as an attentional mechanism that organizes information processing and thereby operates on the constraints that ordinarily maintain a "tight join" between arousal and activation. It is viewed as the substrate of changes in central representations of the sort called *state*, *set*, or *attitude*. Meditation may be associated with changes in arousal and activation, as has already been discussed, but it is a change in "effort" that seems more important to an understanding of the meditative ASC. In Pribram's words, here is a mechanism whose function it is to "*operate on the context in which . . . informational content is processed*" (italics added).

Another aspect of this theory that is relevant to meditation concerns the role of the frontal cortex, where, it will be recalled, the most prominent EEG changes are seen in meditation. Pribram and McGuinness theorized that the frontal system acts to increase internal redundancy in input channels, so that the information being processed becomes chunked into one unit (the opposite of discrimination); phenomenological descriptions suggest that just such a process takes place during meditation (Deikman, 1966, pp. 317–326). A role of the frontal system in the regulation of arousal is also described, underlying sustained attention to goal-directed behaviors (Luria & Homskaya, 1970); the activity of this system might presumably be inhibited by attention "here and now."

In summary, attention appears to be a major psychological process involved in meditation. Attentional skills are enhanced through the practice of meditation and are associated with enhanced specificity in

cortical activity (cf. Davidson & Goleman, 1977). In order to further elucidate the attentional phenomena of meditation, however, there are a number of component processes that must be taken into account, including what Pribram and McGuinness (1975) termed *arousal*, *activation*, and *effort*.

Self-regulation of attention in meditation takes place in a particular context of psychophysiological arousal and cognitive set. In order to determine whether the specific features of this process are unique to meditation, it would be important to contrast attention in meditation with attention-vigilance in other contexts. One-pointed attention may itself engender changes in cognitive functions usually ascribed to the meditative ASC. Indeed, vigilance is one of the conditions frequently associated with the spontaneous occurrence of ASCs—for example, a pilot flying his plane or a drummer playing his drums (Ludwig, 1966).

8. MEDITATION AND TRANCE

States of highly focused attention in meditation bear enough resemblance to trance states to warrant some discussion of the similarities and differences between meditation and trance. Indeed, several contributors to the scientific literature on these topics have taken the position that meditation and trance are in some respects similar or even identical phenomena (Das, 1963; Aaronson, 1973).

Trance has been defined as any state in which there is a functional nonawareness of the "structured frame of reference in the background of attention which supports, interprets, and gives meaning to experience" (Shor, 1959). (Hypnotic trance is a special type of trance state in which, through interaction with a hypnotist, there is formed a special, temporary orientation to a small range of preoccupations). Various states of mystical consciousness achieved through complete absorption in meditation seem clearly to qualify as trance states, at least according to this definition. Thus, the devotee becomes totally lost in his inner experience—motionless, eyes transfixed, apparently out of touch with external reality. This is described as a state of mind in which thinking stops and consciousness both of the world and of the body disappears:

> When the state of one-pointed, quiet and yet attenuated awareness of "I-ness" becomes so deep, or the absorption of "I-ness" in the meaning of an idea, in a God-concept, in a syllable (like the sacred syllable Aum), in some body zone (like the middle of the eyebrow), in a color, form, sound (and) or experience in the internal representation thereof becomes so drastically complete that irrelevant and fluctuant specificities of perception or thinking disappear, only the identified "I-ness" with the object of thought remains, and

> stimuli from the somatic system or external world do not reach the consciousness of the meditator for a long or a short time. (Bagchi & Wenger, 1957, p. 134)

In the final stage, the mystical consciousness itself presumably disappears as well. It is said that in such states of high samadhi, bodily functions including breathing, heartbeat, and metabolism cease, or nearly so, and that one cannot survive longer than seven days in this state. Interestingly, the philosopher Stace commented on the occurrence of "abnormal bodily states" of "rapture or trance" in mystics but considered these "accidental accompaniments" of mystical consciousness (Floor, 1976).

Trancelike states are produced by various religious practices that involve rhythmic or repetitive elements such as chanting, drumming, and dance (e.g., Bourgignon, 1972, pp. 331–334). For instance, a trancelike ASC produced among the dervishes by whirling is described by Burke (1973), who experienced a state of heightened perception and loss of all sense of time. Indeed, the rhythmic element in these practices suggests the possibility that they may in some way entrain the activity of the CNS in a manner analogous to that of photic driving (cf. Rogers, 1976).

Attention appears to be a conceptual bridge between trance phenomena and meditation. According to Goleman (1972, 1977), the capacity for one-pointed attention is the gateway of access to mystical states of consciousness. Similarly—according to some writers, at least—a key feature in trance appears to be a narrowing of the scope of attention, though not necessarily one-pointed (Krippner, 1974).

If hypnosis and meditation involve in any sense similar psychological processes, one might expect to find similar psychophysiological correlates. To the contrary, however, no empirical criteria for determining when (or if) a trance exists have ever been established. In the case of hypnosis, the most widely studied example of trance, there does not appear to be any unique set of psychophysiological correlates that comprise a "scientific basis" for trance (as claimed for meditation). Rather, the psychophysiology has been found to vary with the content of the experience evoked during trance. The lack of EEG findings in hypnosis comparable to those in meditation therefore suggests that the two states are not entirely equivalent.

A further difference between hypnotic trance and meditation is suggested by the following comparison. In hypnosis, there is often a dissociation between experience and physiology; for example, a subject may fail to experience a painful stimulus as painful and yet may react physiologically in a manner appropriate to pain (increased heart rate, etc.) (Hilgard, 1976). That is, information is processed but is unavailable

to consciousness. In concentrative meditation, on the other hand, the evidence tends to suggest an inhibition of information processing itself, for example, the absence of alpha blocking or autonomic response to pain (Pelletier & Peper, 1976). Davidson and Goleman (1977) have elaborated a signal detection model of this difference, regarding meditation as affecting stimulus set (d') and hypnosis as affecting the criterion for reporting pain (β).

Another important link between hypnosis and meditation (at least, TM) is the low-arousal state produced. Thus, as Paul (1969) pointed out, a typical hypnotic induction procedure is similar to relaxation training and tends to be associated with physiological measures of reduced arousal, such as decreased heart rate, muscle tension, and skin conductance in response to suggestions of being sleepy, drowsy, and relaxed; Edelman (1970), in fact, has hypothesized that neutral hypnosis and relaxation are the same phenomenon.

Hypnosis and TM have, additionally, been compared with regard to long-term effects of practice (termed "altered *traits* of consciousness" by Schwartz, 1974). Tebecis (1975) reported that in comparison with a group of nonmeditators, TM subjects exhibited significantly more theta EEG during *both* TM *and* nonmeditation control periods. A similar effect was found in a group of subjects who practiced self-hypnosis (Tebecis *et al.*, 1975). The authors interpreted these data to mean that frequent experience with self-hypnosis or TM facilitates entry into a zone of consciousness (a low-arousal state) in which hypnagogic phenomena emerge. They regarded this trait effect as evidence of a shift in equilibrium toward lower arousal produced by these practices, which accords well with the popular literature on TM (Campbell, 1974).

Tebecis *et al.* (1975) further believe that the similarity in long-term EEG effects of hypnosis and TM practitioners justifies the conclusion that both TM and self-hypnosis should be regarded as trance states. In support, they remark on the subjective reports of experienced meditators hypnotized in their laboratory to the effect that passive hypnosis and TM are similar; self-hypnosis subjects beginning to meditate reported the same thing. Along the same lines, Greenfield (1977) reported a significant correlation between hypnotizability and intensity of meditation experience. These data concur with the theoretical formulation that ASCs are a family of trance states that occur under conditions in which attention is shifted away from the *external* to an *internal* frame of reference, regardless of what specific technique is involved (Aaronson, 1973).

For the majority of meditators, it seems probable that the "altered state" experienced in meditation is a trancelike state accounted for in terms of low arousal and a shift to an internal frame of reference. In a recent study by Hunt and Chefurka (1976), it was shown that simple instructions to attend to one's subjective state coupled with "sensory deprivation" as mild as 10 minutes of isolation in a darkened room resulted in reports of altered-states phenomena such as cognitive disorganization, perceptual anomalies, and feelings of strangeness and unreality. The trancelike state produced during meditation, then, constitutes one set of conditions under which ASC phenomena might be expected to occur.

9. Meditation and Brain-Wave Biofeedback

Following the documentation of brain wave changes during meditation, the question naturally arose whether the meditative ASC could be induced through the expedient of brain wave control. It had been shown by Kamiya (1969, pp. 507–518) that subjects could learn to discriminate whether they were in brain wave "state" A or B (alpha or beta), and with the advent of brain-wave biofeedback techniques, it became possible for subjects to learn to produce alpha brain waves at will. The subjective reports of these subjects suggested that the so-called alpha state was indeed an ASC akin to that achieved through meditation, and brain wave biofeedback was soon hailed as nothing less than a revolutionary advance, the "Yoga of the West." Maslow (1969), for example, stated:

> What is seminal and exciting about this research is that Kamiya discovered quite fortuitously that bringing the alpha waves to a particular level could produce in the subject a state of serenity, meditativeness, and even happiness. Some follow-up studies with people who have learned the Eastern techniques of contemplation and meditation show that they spontaneously emit EEGs that are like the "serene" ones to which Kamiya was able to educate his subjects. That is to say, that it is already possible to teach people how to feel happy and serene. The revolutionary consequences not only for human betterment, but also for biological and psychological theory, are multitudinous and obvious. There are enough research projects here to keep squadrons of scientists busy for the next century. The mind–body problem, until now considered insoluble, does appear to be workable after all. (p. 725)

The general scope of these conclusions was affirmed in many popular articles and experimental studies (e.g., B. B. Brown, 1970, 1971; Nowlis & Kamiya, 1970) and became widely accepted, with, however, little critical consideration of the data on which the conclusions were based. Many of the relevant issues in regard to the alpha state have been raised in other articles in recent years (e.g., Lynch & Paskewitz, 1971; Plotkin, 1976; Plotkin & Cohen, 1976; Plotkin, Mazer, & Loewy, 1976; Travis *et al.*, 1975; Walsh, 1974), and the details are beyond the scope of the present paper. To recapitulate briefly, the conclusions to be drawn from these various studies is that the alpha experience is not linearly related to

alpha strength in the EEG but is determined by the interaction of several factors including (a) the subject's expectations; (b) the instructions given; and (c) the demand characteristics of the situation. Controlled investigations have not only failed to confirm the relationship between the alpha experience and brain wave activity but have also cast doubt on whether authentic conditioning occurs in the brain-wave biofeedback paradigm. Indeed, it has not been reliably established that brain wave feedback is associated with an increase in alpha activity.

Among the variables that can influence or potentiate biofeedback effects and that pertain especially to the ASCs under consideration here, sensory deprivation deserves particular mention. As previously mentioned, a study by Hunt and Chefurka (1976) recently demonstrated that mild sensory deprivation coupled with instructions that sensitize subjects to their subjective state produce ASC phenomena. This sort of sensitization is clearly present in the biofeedback situation and relates back to the formulation presented above that altered states occur under conditions that involve a shift from the external to the internal frame of reference (Aaronson, 1973).

One implication concerning the relationship between the "alpha state" and the meditative ASC is that biofeedback as a practice may not be essentially different from meditation. Like meditation, biofeedback involves a focusing of attention on internal (subjective) events. One might also argue that in the biofeedback paradigm, the biofeedback signal is tantamount to a meditation object—the ideal meditation object, in the sense that it provides built-in information as to the success of the meditation. Like meditation, the practice of biofeedback involves concentration and the sustained monitoring of attention. Thus, the similarity between the alpha state and the meditative ASC may derive from the behavioral similarities between biofeedback and meditation rather than the common denominator of enhanced alpha waves.

There are several possible functions served by the feedback signal vis-à-vis the biofeedback paradigm as meditation. First, as Stoyva and Kamiya (1968) pointed out, the feedback provides an explicit cue that the "correct" internal process has been found; if a measurable physiological event is associated with a discriminable mental event, they argued, then the mental event will be reinforced in the presence of the physiological event; and as a result, the subject will be able both to discriminate better whether the physiological event and the associated mental event are present and perhaps to control the occurrence of these events. Second, feedback assists in generating the low-arousal state that is prerequisite to the psychological phenomena of meditation. Yet a third function, according to Shapiro's (1977) analysis, relates to the point that "the ability to generate a given psychophysiological state and to maintain it ver a course of time appears to facilitate the process of identifying and abelling certain aspects of conscious experience" and to "fix" that state f consciousness in experience, in this case the meditative ASC. It would e interesting to see an experimental investigation of the interactions etween biofeedback and meditation, with regard, for instance, to vhether biofeedback facilitates or impedes training in meditation and he relative effectiveness of the combined procedures.

10. The Psychophysiological Principle

It seems clear from the foregoing that the presence of alpha in the EEG is not a sufficient condition for the occurrence of either the alpha experience (alpha "state") or the meditative ASC. This fact raises anew the question of what defines an ASC in the first place. The ASCs associated with meditation and biofeedback have, in a sense, been egitimized in terms of the brain states presumed to underlie them; measurable physiological correlates have imparted a degree of reality and scientific status to these states that hypnosis, for example, has yet to earn, despite the fact that it is subjectively just as real.

Closer examination of this model suggests that there are two assumptions involved here: (a) that an ASC is (or is associated with) a discrete brain state and (b) that a discrete brain state is identifiable in the EEG. Brain wave feedback, for example, stems directly from this model. It is based on the proposition that a particular set of experiences (the meditative ASC) implies a particular brain state, and its converse, that reproducing the brain state suffices to reproduce the experience. From this proposition comes the hope that biofeedback technology "will eventually become an effective, reliable, and objective method for monitoring and eventually altering private events . . . through the alteration of their objective correlates (Wickramasekara, 1976).

The above propositions reduce to what Elmer Green has termed "the psychophysiological principle," which states that "every change in the physiological state is accompanied by an appropriate change in the mental–emotional state, conscious or unconscious, and conversely, every change in the mental–emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state" (Green, Green, & Walters, 1970). Implicit in this statement, and its application in biofeedback, is the belief that brain states *cause* mental experiences; the assumption appears to be that physiological correlates are the *real* or underlying basis of psychological phenomena and consequently that to produce the physiology is to cause the mental event. Even if there were a close correspondence between changes in heart action, for example, and reports of fear or anger, we would no doubt be quite reluctant to conclude that heart changes produce anger, or that anger was located in the heart. Only our *a priori* belief that brain states cause mental states allows us to give special weight to neurophysiological correlates (Grossberg, 1972).

Thus, while it may be true that a particular experience is associated with certain EEG correlates, correlation does not imply causation, and it does not necessarily follow that duplicating the same EEG pattern will always be associated with the same experience. (See Rechtschaffen 1975, pp. 135–191) for an excellent discussion of the correlation–causation issue.) While in principle there may be isomorphism between brain state and experience, it is limited by the degree to which our techniques of measurement adequately assess and describe the state of the brain. Further, events in the brain are not in theory separable from events in other physiological systems, so that ultimately all bodily activities are relevant to a description of a state of consciousness. One might also extend this argument beyond the physiology of the individual to include events in the environment and, ultimately, all events (Deikman, 1973). As Grossberg (1972) pointed out, a complete accounting of experience requires full consideration of situational and historical components rather than a narrow focus on biological events.

The underlying issue here is none other than the old mind–body problem, recurring now in the biofeedback context. For as Green (1972) has pointed out, "in actuality there is no such thing as training in brain-wave control; there is training only in the elicitation of certain subjective states that are accompanied by oscillating voltages in the cerebral cortex." Since brain waves have no known sensory representation by means of which they could possibly be detected, no direct control of brain waves is even theoretically possible. What *are* detected are attentional processes, thoughts, and feelings; physiological self-regulation is merely a by-product of the regulation of psychological events.

The use of a biofeedback strategy as a test of the psychophysiological model thus entails a rather interesting circularity; for if there *is* an isomorphism between subjective state and physiological state as the psychophysiological model supposes, and if what we are really doing in biofeedback is conditioning the occurrence of a subjective state, then by definition the only subjective state that will suffice to produce the desired physiological state is the meditative state! In other words, only the meditative state will suffice to produce the meditative state!

11. Meditation and the Psychophysiological Model

We return then to the issue of the significance of the psychophysiological correlates of ASCs.

On the one hand, the literature abounds with the suggestion that psychophysiological states underlie altered states of consciousness and are their objective correlates. The clear implication here is that psychophysiological events are not merely correlated with altered states but are in some way necessary to their occurrence; that is, that psychophysiological events (increased alpha, altered respiratory pattern, decreased skin conductance, etc.) are integrally rather than incidentally (or even artifactually) related to these states of consciousness. The strongest statement of this psychophysiological model of ASCs would be the hypothesis that certain psychophysiological events (or a pattern of such events) are *both necessary and sufficient* for the occurrence of a particular ASC. The empirical evidence reviewed above thus needs to be reconsidered in terms of the "necessary" and "sufficient" criteria.

Although there is some consistency in the reports of psychophysiological changes during meditation, the data are clearly not sufficiently robust to warrant the conclusion that any particular pattern of psychophysiology is invariably associated with the meditative ASC. Thus, there is considerable psychophysiological variation between individuals practicing the same meditation technique and within the same individual at different times. Very likely, much of this variation reflects variabilities in experience. Lacking an adequately defined phenomenology of meditation experience, we are obviously in a poor position to spell out either experiential or psychophysiological criteria for the occurrence of the "meditative ASC."

Meditation is most often associated with one or more signs of reduced autonomic, somatic, and/or cortical arousal. The evidence suggests that this low-arousal state is not substantially different from that produced by other practices (progressive relaxation, etc.). This relaxation state has trancelike features, and in all probability, this state is the main component of the experience of many meditators.

While the evidence suggests that a low-arousal state is conducive to the experience of passive awareness, the meditative ASC does not *invariably* emerge, given a background of low arousal and relaxation. Very likely, there may be important determinants of the meditation experience that are cognitive rather than specifically physiological (J. M. Davidson, 1976), including the intention and set brought to meditation. Thus, it would appear that psychophysiological variables are one class of variables associated with the meditative ASC but are not sufficient for its occurrence.

Psychophysiological processes appear to be involved in facilitating the emergence of certain psychological phenomena and/or making them accessible to being identified and labeled within awareness (Shapiro, 1977). This process may perhaps be illustrated by analogy with drug-induced ASCs. As is well-known, the marijuana experience has a learning component to it in the sense that the user must learn to discriminate the drug's effects and to label and identify the various elements of the psychoactive experience (e.g., Becker, 1967). Analogously, meditation involves a process of learning to experience in a new way, and this learning is facilitated when the body is relaxed and the mind is quiet. The possibility is left open, however, that with practice, the meditative ASC may also be experienced against a background of other psychophysiological states. There are few data that bear upon this essentially empirical question. One strategy that might be employed, for instance, would be to investigate whether the meditative ASC, *once trained* with TM or other practice, could be maintained in other psychophysiological states. On the whole, the evidence does not strongly support the conclusion that a state of low arousal is necessary for the occurrence of the meditative ASC, since it can occur during active meditations and religious practices (or spontaneously). Rather than *identifying* consciousness with the psychophysiological process, an alternative formulation might be in terms of what psychophysiological states are *compatible* with what modes of experience.

Among the specific correlates of meditation that have been discussed, one group—alpha–theta EEG and reduced autonomic/somatic arousal—appears to be related to a nonspecific relaxation response. Other findings, specifically the high-amplitude fast-wave EEG and occurrence of marked EEG coherence, appear to have some relationship to specific phenomenological features of meditation. These EEG findings are more typical of advanced meditators and concentrative meditation practices, and both have been interpreted as correlates of "samadhi" or transcendental consciousness (Das & Gastaut, 1955; Banquet, 1973; Orme-Johnson, 1977). As emphasized by Pribram and McGuinness (1975), focus of attention ("effort") acts to organize neural processes into coherently interacting patterns, which may explain the high energy in the beta band; it is not entirely clear that this phenomenon should occur only in meditation, however. Enhanced coherence, if replicable, may be a key finding. According to Orme-Johnson (1977), it represents a "low-noise" state in the brain; that is to say, it reflects that the mind–brain system has become quiet, which in turn allows the meditative ASC to emerge. Following Deikman's discussion (1973), consciousness (awareness) is "known" or appreciated through systems of organization, such as thought, which permit "knowledge of awareness"; when the mind–

brain system becomes quiet, consciousness is not bound by thought, and cosmic consciousness can occur.

States of consciousness have been viewed as stable patterns of activity among various functional subsystems that underlie perception, cognition, and behavior (Tart, 1975). In this theoretical framework, meditation can be viewed as a methodology for destabilizing the structures of normal waking consciousness, thus allowing altered patterns of activity to emerge. According to this "systems approach" to consciousness, "states" can be fully described in terms of specific patterns of cognitive activity, physiological activity, and associated dispositions to process input and to respond in particular ways ("content"); the "state" (context) is simply the total configuration of activity among subsystems at a particular time. Thus, it may be that "context" is most closely equivalent to the configuration of the mind-brain system as a whole and is ultimately specifiable only by specifying the activity of every element.

On the other hand, it is conceivable that there may be specific neural correlates of the meditative ASC. To speculate on a couple of possibilities, there might be a feedback network within the attention mechanism which resonates or "rings" in a distinct manner when the system is tracking perfectly in present time. Alternatively, there might be a neurochemical change with meditation that supplies a particular feeling-tone to experience above and beyond any altered pattern of cognition.

A thorough description of meditation on the psychophysiological level will, in all probability, ultimately depend on careful phenomenological analysis of the meditation experience—specifying the variations of physiological indices most likely to occur at different levels of practice (D. P. Brown, 1977). In the meantime, we are led, full circle, back to the conclusion of Johnson (1970) that "EEG and autonomic data cannot be used to define states of consciousness; the state of consciousness of the subject must first be known before the physiological significance and possible behavioral meaning [of these measures] can be inferred."

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Toward a Psychobiology of Transcendence: God in the Brain

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1. AN ARGUMENT FOR IMPLICIT KNOWLEDGE IN THE BRAIN SCIENCES

Since the time of atomists like Democritus, forerunner of Plato and Aristotle, two modes of scientific explanation have been used to fill the conceptual space between mind and brain, a dualism more grudgingly resistant to resolution than that of energy and matter. One method assumes a world of hidden realities, impenetrable, to be understood by conjecture and test, observations evaluated for their consistency with hypothetical constructs. The other requires an intuitive grasp of the essence, insightful awareness of the thing itself. The first approach defines a unification of mind and brain out of the possible; the second assumes it. Feelings about these orientations still run strong. In a recent book, the philosopher of science Sir Karl Popper expressed irritation with Plato for intermixing these two thought styles without acknowledging the intermixture, concluding that only the conjectural-test approach is valid; the other kind of knowing Popper dismissed as a "will-o-the-wisp" (Popper & Eccles, 1977).

When it comes to the movements of planets and other "out-there" things, not knowing seems more likely than when we speak of the properties of the human brain, a world hidden from others but one in which we spend our days. Plato's use of myth as verisimilitude represents a tradition of model building developed most elegantly by Newton in *Principia Mathematica*, in which logical consistency and fit with observable data are mixed with a disclaimer about knowing; "Not that I affirm gravity to be essential to bodies" (Popper, 1963).

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