THE PHYSIOLOGY OF MEDITATION AND MYSTICAL STATES OF CONSCIOUSNESS

*JULIAN M. DAVIDSON**

If the proper study of mankind is man, it is a paradox worth pondering that consciousness, the receptacle of all that is truly human, has not yet found a place in the life sciences. This is not to imply that neuroscientists are uninterested in physiological correlates and mechanisms of sleep and wakefulness, or that psychopharmacologists are not intensively investigating psychoactive drugs, and so forth. Rather, the experimentalist feels compelled to limit himself to considering physical or behavioral variables in order to comply with the dominant physicalist-reductionist paradigm of modern science. As far as scientific practice is concerned, consciousness is still regarded, at best, as an epiphenomenon. Similarly, if we had a science of consciousness, biochemical, physiological, and behavioral data might appear to it to be epiphenomena, for we have not even an inkling of how physical phenomena are linked to the "subjectively" manifested activity of consciousness.

There is no denying the very real philosophical and practical difficulties impeding the scientific investigation of psycho-physical interactions. But despite these difficulties and the past neglect of the subject, the current unprecedented public interest in the varieties of conscious experience is reflected in a number of research papers and theoretical analyses attempting to deal with physiological correlates of altered states of consciousness (ASCs). This survey is primarily concerned with one subset of this group: studies directed at physiological events during meditation. The specific questions on which I hope to shed some light are: (1) What conclusions can be drawn from existing physiological studies on meditating subjects? (2) How do these findings and other current concepts relate to mystical experience? (3) What, if

*Department of Physiology, Stanford University School of Medicine, Stanford, California 94305. I am grateful to my friend John Sundsten of the University of Washington Medical School for many discussions and helpful suggestions; to the Battelle Seattle Research Center for a year of study during which this paper was written; and to Richard J. Davidson and the members of an informal discussion group on consciousness which met in Seattle in 1975 for having read and discussed the manuscript.

any, reasonable approaches can be suggested for the future scientific study of these states of consciousness, given the currently available methodologies? Before engaging these issues, however, it is necessary to devote some attention to the nature and purposes of meditation and the claims of its proponents.

The Psychology of Meditation

"Meditation" is a term applied to a diverse group of practices having the common goal of producing in the short term desired mental states, and in the long term the promotion of personality growth and mental health (traditionally referred to as "enlightenment"). These practices extend far back in recorded history and were previously most often taught within the context of religious (but not necessarily theistic) disciplines, so that the expected benefits have often been described in terms of spiritual progress. In the last few years, there has been an explosive increase of interest in meditation in the Western world, spearheaded by a variety of organizations operating within, or derived from the Hindu and Buddhist traditions. The most (numerically) successful of these is the (Students) International Meditation Society. While headed by a rather traditional Hindu guru, Maharishi Mahesh Yogi, and resting on ancient Vedic traditions, this organization disclaims any direct religious objective, preferring instead to represent its teachings as scientific [1]. Its professed aims are the transformation of man and the resulting solution of the world's problems [2]. Advocating a brand of meditation which it calls transcendental meditation (TM), it has had phenomenal success in many countries. Between 1968 and May 1974, 360,000 initiates were claimed in the United States alone [3, p. vi]. These include prominent public figures, including scientists, and resolutions of support have been introduced in Congress as well as in several state legislatures.

Since, particularly in the Hindu tradition, the pursuit of consciousness alteration is sought through postural and breathing exercises as well as through the mental practice of meditation, and since experienced yogis have often claimed unusual physical powers, there have been several investigations of physiological events in meditating yogis, as well as in Zen practitioners. The available published reports of these studies are few in number and preliminary in nature. Due to the active encouragement of the TM movement, however, several more authoritative reports have recently appeared in the scientific literature, and this trickle of studies together with others on the lasting effects of TM on psychological variables seems to be growing into a flood [3]. In a series of scientific [3, 4] and other publications [1, 2, 5], it has been proposed that the practice of TM leads to the experience of a fourth major state of consciousness (the first three being waking, dreaming, and nondreaming sleep states). This claim is extensively used in the publicizing and teaching of TM.

Perhaps because of Maharishi's scientific education and perhaps as a device to attract followers in Western technologically oriented countries, the TM movement has placed great stress on physiological responses in meditation and on scientific research on its psychological and medical effects. As a direct result of this, most of the relevant current research on meditation uses TM practitioners, and much of its enjoys the support if not sponsorship of the movement.

The unique value of TM for purposes of research is stated to be the uniformity of training and technique (e.g., [4]). This advantage may, however, be more apparent than real. There is nothing unique about the method itself, which is a simple *mantra* meditation technique involving relaxed sitting with upright spine, and the subvocal repetition of a traditional Hindu word (the *mantra*) with eyes closed in a quiet environment. No active attempt is made by the meditator to direct his experience, but he is encouraged to resist the intrusion of thoughts, albeit with minimum expenditure of effort. These techniques are used in many Eastern (and other) disciplines. Although the *mantra* is supposedly tailor-made for each initiate, it is difficult to check the validity of this claim, since the individual *mantras* and the method of choosing them are kept secret. However, personal contact between teacher and initiate is extremely brief prior to presentation of the *mantra*, and no overt testing procedures are involved.[1]

Beyond the unremarkable nature of the training of initiates and the procedures used in meditation, there is no reason to suspect anything unique or uniform about the *experiential* state resulting from the practice of TM. In addition, resemblances undoubtedly exist between the meditative experience and that induced in various relaxation therapies (such as self-hypnosis, progressive relaxation [7], autogenic therapy [8], and perhaps biofeedback training, particularly where electroencephalographic [EEG] alpha or theta rhythm training is involved [9]).

Proponents of meditation throughout history have aimed to induce certain peak experiences in which consciousness is profoundly altered. The attainability and importance of these experiences (*Satori, Samadhi, Kensho, Nirvana,* Cosmic Consciousness, etc.) is attested by a vast literature from many if not all of the major cultures [10–15], and both religious mystics and others have reported lasting positive effects on their

[1]The presentation of a *mantra* by guru to aspirant is an event of considerable significance in the Hindu tradition [6]. Regardless of any explicit or implicit assumptions about extraordinary powers of the *mantra,* however, it is an effective device for suppressing thoughts and producing inner-directed attention. It should be noted that the *mantra* is meaningless to the meditator, although, in Christian meditation, phrases with religious content are similarly used.

lives (e.g., [16–18]). In fact, the psychiatric application of these experiences (including their usefulness in suicide prevention!) is being discussed [19–21]. Since meditation is recognized as an important (though neither necessary nor sufficient) gateway to the expanded states of consciousness described by the mystics of many traditions, one cannot ignore them in a discussion of meditation. However, any attempt to define these alterations in consciousness (which for want of a better term, I call "mystical experiences") quickly encounters a language barrier. The many descriptions of mystical experience are generally couched in literary-poetic and/or religious terms which are outside the framework of current scientific discourse.

Recent psychological evaluations [22–24] agree in describing certain common elements of mystical consciousness. These seem to be based generally on the list derived from careful analysis of the mystic literature by the philosopher Stace [13]: (*a*) deeply felt positive mood, described as "bliss," "peace," "love," etc.; (*b*) the essential experience of "unity," or "union," which can be expressed as the oneness of all things, or decreased experience of the separateness of self from others or the outside world; (*c*) a sense of ineffability; (*d*) an enhanced sense of reality, authenticity, meaning; (*e*) alteration of time and space perception, experienced as transcendence of time and space; (*f*) paradoxicality, that is, the acceptance of propositions which in normal consciousness seem contradictory. Another characteristic stressed by some authors is a sense of sacredness [13, 23]. Between this and other items in the typology there may be overlap [15], but it would be a mistake to expect categorical uniqueness or precise psychological definition from a list such as this. These characteristics of mystical experience can be present to some extent in ASCs induced by psychopathology or other means [25] and particularly by psychedelic drugs [23]. Other characteristics of nonmystical ASCs would include a variety of alterations in thinking and in emotional expression, the experience of loss of psychological control, changes in body image, perceptual distortion, and hypersuggestibility [25]. Some of these are also present to some extent in "true" mystical experience.

Now, full-blown mystical experiences are clearly not common occurrences [17], apparently not even for full-time "mystics." Furthermore, the experiences are transient, often lasting only for minutes or seconds [17, 23, 24]. Clearly, to catch such an occurrence red-handed, as it were, during an experimental study of meditation in normal subjects, would be a rather improbable happenstance. It is a point often glossed over in the literature on meditation that it deals *primarily* with a less profound alteration of consciousness than that of the full mystical experience, although some shared characteristics are presumably often present [22]. To avoid the resulting confusion, the term "mystical" should be reserved for those unique experiences some of whose psychologic characteristics have just been described, and whose putative physiologic correlates may differ greatly from those of "common" meditation, as we shall see.

A major difficulty in meditation research is that there is no way to validate objectively that a subject is indeed in the presumed meditative state. The problem is not merely the relatively trivial one of deception but, rather, arises from the fact that even practiced meditators are "successful" (in their own terms) only part of the time. Clearly, an important goal of this research should be to establish the kind of criteria which exist for sleep states (EEG, etc.). For the present, however, the only way to validate "successful meditation" is by the statement of the subject himself that he clearly recognizes having experienced the desired change in consciousness. Perception by the subject of qualitative alteration in his normal conscious experience is the description adopted by several authors for defining the term "altered state" [25, 26]. Painful though the reliance on subjective reports is to the scientist for whom all data must be "objective," that is, physically measurable, it cannot be avoided in any consideration of conscious states.

Notwithstanding the growing psychological literature on meditation, there is no agreement on an accepted core of psychological features, perhaps due to the many varieties of meditative practice. Certainly, however, a prominent feature of most, if not all, forms of meditation is a more or less profound sensory detachment from the external environment. This is also true of forms of meditation which involve concentration on a specific visual image (*mandala*) and, I believe, even of those Zen exercises wherein the reception of stimuli may be encouraged but without emotional impact or perhaps any effect except that of awareness itself. In all cases, a common result seems to be the achievement of a state in which the normal relationship between subject and internal or external environmental stimuli is abolished such that the latter do not operate in the normal way to control behavior or thought processes. In this sense, meditation departs from the normal waking state of consciousness which Hilgard defines as one in which we "can report accurately what is happening in the environment about us, and can use this information to control our behavior" [27]. To avoid the question of volition in meditation, the term "can" should be ignored, for our purposes.

Clearly, the sensory detachment in meditation is not related to a clouding of consciousness but, rather, to a prominent inner-directedness of attention. Yet a vital characteristic of successful meditation (particularly where concentrative practices are employed) is the active, or more often passive, suppression of thinking. This statement is valid using the most inclusive definition of thinking to comprise all such cognitive activities as daydreaming, dreaming, imagining, guessing, remembering, understanding, and especially problem solving; it refers particularly to verbal thinking (the "internal dialogue") but also, to a certain extent, to various nonverbal thinking processes. These cognitions are ubiquitous in the normal waking state but greatly reduced in successful meditation, and the many different exercises all seem primarily aimed at this end.

Physiological Changes in Meditation

Accepting that the successful practice of meditation may lead to a condition of consciousness whose distinctiveness and intensity vary to the extent that full-blown mystic experience is approached, what is the evidence for physical correlates of this state of consciousness which has led to the claims of psycho-physiological uniqueness [3, 4]? I shall discuss the available published data separately under the headings of autonomic-metabolic and of electrophysiologic variables. Studies on TM and those on Yoga and Zen will be considered together. The literature is at the moment sparse, but TM research is growing rapidly as attested, for example, by the number of theses and unpublished reports listed in a recent annotated bibliography [3]. Most of the original studies on Zen meditation are only generally available through Akishige's book [28].[2]

AUTONOMIC-METABOLIC EFFECTS

Studies on practitioners of TM have recorded the occurrence during meditation of significant decreases in heart rate, respiration rate, oxygen consumption and carbon dioxide elimination, arterial blood lactate titer, and minute ventilation, as well as significant decreases in skin conductance. No significant effects were obtained on systolic and diastolic blood pressures[3] and rectal temperature [3]. The findings are based primarily on the work of Wallace and collaborators [4, 31]. It is important to note that in these original studies the subjects served as their own controls, that is, the experimental session (one per subject) was sandwiched between two periods of control observations when he sat quietly without attempting to meditate; findings were related to the measurements in the preexperimental period. The question to be dealt with is whether these changes are, in fact, connected with the actual practice of meditation rather than being a byproduct of the experimental situation, and, if so, are they related specifically to the state or condition of consciousness during meditation?

First, let us look at the cardiovascular variables. Decreased heart rate has not been consistently found; for instance, a recent unpublished re-

[2]This unique monograph unfortunately presents little "hard" data, and the physiological conclusions are mostly equivocal or uninterpretable. A recent book by Hirai [29] is more clearly written but describes in detail only the author's studies.

[3]But a chronic decrease in systolic blood pressure resulting from meditation has been reported in hypertensive patients [30].

port on TM failed to find a decrease compared to a control group [32]. In the published reports, the changes were either not analyzed statistically [31, 33] or were marginally (if at all) significant [4]. A decrease in cardiac output was reported in the first TM study, but no data were given [33].

Since TM is derived from the Hindu tradition of yogic meditation, it is appropriate at this point to ask what physiological changes are found in meditating yogis. Unfortunately, properly controlled experiments with adequate numbers of subjects are not to be found in the literature. In one widely quoted study, Bagchi and Wenger [34] could find no consistent changes in heart rate. Relevant to this discussion, however, is the well-known claim of yogis to be able to slow or even stop the heart, the evidence for which is mostly anecdotal [35]. There is no proof that the heart can be stopped in this manner, although there seems little doubt that it can be slowed, a phenomenon which Bagchi and Wenger suggested was mediated (in three cases) by a Valsalva maneuver (expiratory movement with closed glottis, which decreases venous return to the heart) or (in one case) some other mechanism involving striated muscle [36]. The recent biofeedback literature is, however, replete with evidence of conscious control of heart rate (as well as blood pressure), and the interpretation by biofeedback researchers is that the effect is obtained by operant conditioning of autonomic nervous control of cardiac function [37]. When subjects are experienced in directly controlling the physiological function being measured, it is not logical to use measurements of that variable in establishing physiological correlates of the state of consciousness under study.

Changes in respiration are another case in point. Marked decreases in respiration rate are reported for Zen practitioners [28] and yogis [34]. It should be noted, however, that both these traditions place great stress on breathing: The breaths may be counted or merely observed and concentrated upon, and in some sects hyperventilation is practiced. Thus, it is again difficult to regard this measure as a dependent variable resulting from the practice of meditation since, in this case, it may be part of the technique used. In TM studies, total ventilation has often decreased, either due to decreased rate or tidal volume [4, 31, 33]. Again, the change (not so great as that cited in some studies of yogic [34] and Zen meditation [28]), was found to be significant in relation to a preexperimental control period in the same subjects. However, in a recent briefly reported study, minute volume (but not respiration rate) was decreased, both during TM and also in a control group instructed merely to sit quietly with eyes closed [38].

A similar situation applies to studies on metabolic rate. Much anecdotal evidence indicates the ability of trained yogis to exist under conditions of restricted oxygen supply—one trick being the incarceration of the yogi in a box or pit for prolonged periods. In one study, a very marked reduction of oxygen consumption (up to 40–50 percent at one point) was reported from a yogi incarcerated in an air-tight box (6 × 4 × 4 feet) for 8 hours [39]. Decreased oxygen consumption is also reported in Zen meditators [28, p. 19; 29].

The decreased oxygen consumption reported for TM subjects was accompanied by a decrease in CO_2 production as well as in blood lactate,[4] with no change in respiratory quotient. The differences were significant in relation to the preexperimental control observations on the same subjects. These results were recently replicated, using an improved continuous recording technique, although the magnitude of change found was considerably less [42]. Although unpublished work (cited in [3, pp. 75, 76]) suggested that control groups did not show the oxygen consumption effect, Treichel et al. [38] have reported decreased CO_2 elimination both in the experimental (TM) and in a separate control group. They concluded that the decreased metabolism "was not necessarily related to the practice of the technique."

There is one recently reported finding which may modify the force of what has just been said. Beary and Benson [43] trained volunteers with a meditative procedure, which produces what they call the "relaxation response." The essentials of the training (which lasted no more than 1 hour in any of the subjects) were: sitting quietly, relaxing deeply, maintaining a passive attitude, and the use of a modified *mantra* procedure in which the breaths were followed and the word "one" was repeated subvocally on each expiration. In this study, a 13 percent decrease in oxygen consumption, a 12 percent decrease in carbon dioxide elimination, and a decrease in respiration rate from 16 to 11 breaths per minute were reported. These differences were statistically significant, and the experiment was well controlled. For the reasons discussed, no great significance can be attached to changes in respiration frequency, which are also not uniformly found in meditation studies. The work of Beary and Benson does, however, indicate that meditative techniques, even when very newly learned, can result in a greater change in metabolic rate than that found in control periods when subjects merely sat and relaxed. The fact that similar effects were reported by Treichel et al [38] in separate control groups and that changes in the same direction are found in relaxation, sleep, and meditation do nevertheless suggest that

[4] The finding of decreased blood lactate during TM has been tied to the hypothesis that increased blood lactate is a, or the, cause of anxiety [40]. However, the "lactate theory of anxiety" has recently been subjected to severe critical analysis [41] in a review which pointed out inadequacies in experimental evidence and interpretation. Thus, in the experimental stimulation of anxiety by infusions of lactate, the nonnatural (racemic) form was used, and conditions were described in which the postulated correlation between anxiety and elevated blood lactate was absent.

judgment be suspended as to any claim for the uniqueness of reduced metabolism in meditation.

Like the other autonomic changes discussed, increases in skin resistance, or reductions in its fluctuations, known as galvanic skin reflexes (GSR), have been related to low levels of anxiety or "arousal" and are, therefore, of special interest. These effects have also been reported for yogic [34] and Zen [28] meditators. The large increases in resistance found in the studies of Wallace and coworkers [4, 31] were impressive, especially since restoration of the control levels was found in the postmeditation period. In a more systematic study, specifically devoted to electrodermal response, Orme-Johnson [44] did not find such striking effects on basal skin resistance, and the study on experienced yogis [34] showed less effect than that found by Wallace. Although Bagchi and Wenger [34] mentioned the occurrence of large spontaneous oscillations of skin resistance, Orme-Johnson's study demonstrated fewer spontaneous GSRs in TM practitioners. Spontaneous GSRs were also low in practiced meditators outside of meditation, and they showed faster habituation and fewer multiple responses during habituation. These findings were taken to imply greater "behavior stability."

Recently studies on circulating levels of hormones and various metabolites before, during, and after TM have been initiated by Jevning and collaborators [45, 46]. No striking changes have been found, although preliminary reports indicate that there is a small decline in plasma cortisol in long-term (3–5 years) practitioners but no change in prolactin level [45]. Phenylalanine concentration increased significantly by 20 percent in the same subjects, but not other amino acids [46]. In a collaborative unpublished study with the author's laboratory, Jevning found no change in plasma testosterone, another hormone known to respond to "stress," although the meditators did not show the decline during the postmeditation period which was found in controls.

How are we to evaluate the significance of these changes in terms of the postulated physiological uniqueness of meditation? As pointed out by Kanellakos and Lukas [3], the autonomic-metabolic changes reported to occur in TM are also found during sleep, although obviously other changes occur during sleep which are not found in meditation. The implication is that the changes in TM are more rapid and, in some cases, more profound than attained with sleep [4; 2, p. 343]. This is not clearly established, at least for the respiratory, cardiovascular, and other autonomic-metabolic functions which have been studied. Of course, considerable variation in these kinds of measures is found in relationship to stages of sleep, and sufficiently extensive and controlled studies comparing sleep and meditation have not yet been published.

A new development is the demonstration in several recent unpublished studies [47–49] that even experienced TM mediators may pass a considerable portion of the session in EEG-validated sleep. In a carefully controlled study [49] with subjects who had 2.5 or more years' experience (including some teachers of TM), blind scoring of the EEG records showed that 23 percent of the time was spent in stage II sleep and 17 percent in stages III and IV. Overall, sleep times did not differ significantly between periods of meditation and other periods when the subjects were asked to nap. It should be noted that these findings are not relevant to the question of the benefits of TM and that trainees are in fact taught not to resist sleep. They are, however, highly relevant to the contention that the experimental findings provide important support for meditation as a unique psycho-physiological state.

In summary, all that is clearly established by the data on autonomic-metabolic measurements during meditation is the hardly surprising conclusion that meditators are in a state of relaxation. The somatic component of this state—muscular relaxation—has been documented in several studies showing very low electromyographic activity [3, p. 11; 28; 50; 51]. The lack of nonmediating control subjects in the most authoritative (and widely publicized) experiments of Wallace was a serious defect, and it is still highly questionable whether some or all of the changes noted might not be regularly present in nonmeditating individuals sitting relaxedly with their eyes closed and occasionally napping. This conclusion is amply confirmed by a study on subjects selected for hypnotic suggestability, published while this manuscript was being prepared [52]. Autonomic measures were compared during meditation (TM) or autohypnosis or in controls simply instructed to relax and "reduce autonomic function." All groups showed significant decreases in heart and respiration rates and GSR (basal and discrete responses). There were no significant differences between the groups, although the decline in heart rate persisted after meditation for at least 10 min, an effect which was not found in the other groups or with the other measures. At any rate, the claims that (*a*) TM represents a state of profound physiological rest, greater than that attainable with sleep of much longer duration; and (*b*) the specific changes in consciousness and the unique (and, in my opinion, unquestionable) benefits of meditation are somehow linked to the physiologic changes discussed above still seem to lack a solid basis in experimental fact.

CEREBRAL ELECTROPHYSIOLOGIC EFFECTS

EEG changes in meditation have been very scantily reported in earlier studies on four yogis by Anand et al. [53], on seven Kundalini Yoga practitioners by Das and Gastaut [51], on 48 Zen monks by Kasematsu and Hirai [54], and in a variety of other studies apparently accessible to the non-Japanese reader only through the rather unclear and inconsistently documented compendium of Akishige [28]. Some EEG data on TM meditators were sketchily presented by Wallace [31] and Wallace et al [4], and a study with spectral analysis has been reported by Banquet [55], the latter being the most detailed study devoted specifically to EEG measurements. A survey of the results of these studies follows.

The most common findings are of changes in incidence and/or properties of the alpha rhythm (8–13 Hz). While considering them, it should be borne in mind that the highest incidence of this rhythm is found in the normal waking state when recordings are made from occipital leads with the subject sitting quietly with eyes closed. The case made by Lynch and coworkers [56] that increases above this base line cannot be obtained even during biofeedback training of the alpha rhythm has not been disproven at the time of writing. Thus the commonly reported high alpha densities in meditation may well result from the same process apparently operating in biofeedback studies: the disinhibition of stimuli (oculomotor, attentional, etc.) which block alpha frequencies. Banquet [55] reports topographical extension of alpha during meditation from posterior to frontal leads and its maintenance into the postexperimental eyes-open condition. The studies of Zen subjects almost invariably report increased alpha density [28, 54] through all regions of the scalp from which EEG is recorded. Zen meditation is conducted with the eyes open, while in TM the eyes are closed. Increases in amplitude of alpha waves were also reported in Zen and TM [28, 31, 55]. Another finding common to various studies is a decrease in alpha *frequency* (i.e., shift to lower end of frequency band) during the course of meditation [28, 31, 54, 55].

These findings on the alpha rhythm are probably reliable, but more because of the frequency with which they have been reported than because of the convincing nature of the individual studies. Although the data of Banquet were quantitatively processed (by spectral analysis), the tendency in all of these studies was merely to report conclusions or samples of the data, and in no case were experimental groups statistically compared to controls. In fairness to the investigators, one notes that until recently this mode of data presentation was the norm for EEG studies. Nevertheless, these weaknesses must affect our judgment of the other EEG findings which, unlike the above changes in alpha, have not been repeatedly observed.

Several investigators have studied the alpha blocking response to clicks or visual stimuli (orientation response). Anand et al [53] reported the absence of alpha blocking during meditation when a variety of stimuli were presented to a small group of yogis,[5] and Banquet [55] obtained similar findings in TM subjects presented with clicks or flashes.

[5]Subjects were also reported to maintain alpha with hands immersed in ice cold water for 45 min.

On the other hand, Kasematsu and Hirai [54] reported absence of habituation of the response following repeated presentation of click stimuli in three Zen masters, and extensions of this study were recently reported [29]. These diametrically opposed findings on Zen and yogic meditators have been interpreted as reflecting differences in the two types of disciplines. It is said that the yogic meditator develops an inner-directed awareness in which external stimuli are excluded, while an objective of Zen is to retain full awareness of the outside world, although remaining "unaffected" by it [57, 58]. The implication is that in the former case afferent stimuli are blocked at below the cortical level, while in the latter case attention is somehow deployed in such a fashion that environmental input is received but without emotional impact [54].

How meaningful this interpretation may be is not the major point at issue but, rather, the need for replication, since none of the reports presented adequate support for their striking findings. Apart from the small number and the absence of statistical validation, there is the question of how to evaluate alpha blocking in Zen meditation with eyes open [54]. The comparison to controls where eyes were closed and whose initial blocking time (before habituation) was longer than in the meditators seems questionable. It should be noted parenthetically that Wallace [31] mentioned finding absence of habituation of alpha, which does not support the above interpretation, since his TM meditators "should" have been in a state of environmental detachment more like that of the yogic than the Zen practitioners.

Another finding in EEG studies on meditation is the occasional appearance of trains of theta waves (4–7 Hz) [4, 31, 54, 55]. In Banquet's experiment these could be blocked by click stimulation, with reappearance of theta within a few seconds. In Zen monks, "the rhythmical theta train (6 to 7 cycles per second 70–100 uV)" was found only in subjects having spent more than 20 years in Zen training and rated as highly proficient in meditation by the Zen master [54].

If the EEG record can indeed reflect simultaneous shifts in conscious experience, it is important that the electrophysiological data be correlated with whatever subjective changes are found during the recording session. In the two best studies [54, 55], account was taken of different "levels" or "depths" of meditation. Banquet asked his subjects to signal major changes in consciousness by pressing a button, using a five-signal code to distinguish occurrence of "body sensations, involuntary movements, visual imagery, deep meditation and transcendence (deepest point of meditation)." Presentation of the last two signals by the subjects was correlated with appearance of generalized fast frequencies of the dominant beta rhythm. The frequency was "almost constant" at about 20 cycles per second, and high-voltage patterns were present in anterior channels. Similar high-frequency patterns were found in yogis in deep meditation in a brief report by Das and Gastaut [51], and these were of high amplitude in the one subject stated to have attained the state of *Samadhi* during the experiment.

From the perspective of this paper, the important question is whether the reported EEG changes are significantly different from those one would expect to find in various conditions of sleep and wakefulness. If meditation were not unique, one might expect initially a background of high alpha (as in a relaxed state with eyes closed) shifting to increasingly slower frequencies when the subject becomes drowsy and sleepy and to faster ones when focused cognitive activity occurs. Banquet [55] argues that the patterns in meditation do indeed differ from the normal drowsy or alert states. Thus, in drowsiness one sees mixed frequencies—alpha, low delta, and discontinuous theta—whereas his mediating subjects (like those of Kasematsu and Hirai [54]) showed continuous trends of dominant theta rhythm at constant frequency, which persisted when the eyes were opened postexperimentally. The low voltage fast activity (in spindle-like amplitude modulation) appeared on a background of slow frequencies, whereas activated EEG's in the control group were found "without any rhythmicity or regularity." In favor of the uniqueness of the EEG findings, he also states that they were accompanied by (*a*) absence or decrease of EEG response to click or light stimulation and (*b*) persistence of altertness which allowed the subject to respond to questions of the experimenter and to push buttons to signal his internal state. In addition, he stresses the topographical alterations, specifically synchronization of brainwaves from anterior and posterior regions: spread of alpha from occipito-parietal to anterior channels and of theta and beta from frontal to more posterior regions.

Banquet's claim of unique electrophysiological phenomena merit serious consideration if the findings are indeed statistically significant. Quantitative comparisons with controls in various stages of wakefulness, relaxation, and sleep are essential, especially in view of the recent findings on sleep during TM.

The scientific importance of such validation goes beyond the need for elucidating the nature of changes in meditation. In the half-century since Hans Berger, establishment of the EEG correlates of behavior and conscious experience has been a will-o'-the-wisp chased frequently and generally fruitlessly. What successes have been obtained are in the area of evoked potential measurements in relation to attention and reactions to stimuli [59] but not to conscious experience per se. If the history of failure is now being reversed, this is an event of sufficient significance to justify attempts at adequate replication of the findings under the most rigorous conditions and with the fullest possible reporting of data.

Résumé

We have seen that, although physiological changes do occur during meditation, it is not yet established that these changes are unique or that they reveal a "fourth major state of consciousness" as has been claimed. What then do these changes mean? How do they relate to alterations of conscious experience? In particular, what is their relationship to the more intense and unique mystical experience to which meditation can lead? Since, as should be obvious by now, the existing data are not sufficient to generate definitive answers to these questions, the rest of this paper will be largely speculative, depending as it does on a meager data base and the few relevant conceptual approaches available in the literature. Although such poorly based speculation is distasteful to most experimental scientists, it is justified by the need for further research in this area whose importance and interest I shall briefly reiterate: (1) Reportedly, hundreds of thousands of individuals have recently begun to practice meditation in the United States alone, and there is a widespread belief based on reasonable evidence that beneficial medical and/or psychological effects result [3, 60–62]. (2) The occurrence of mystical experience in people of many cultures, religions, and historical periods, though presumably rare, is extensively documented, as are its potential profound beneficial effects [10–21]. (3) Despite its undoubted diversity, there are enough common characteristics to allow us to look at mysticism as a definite category of experience [13].

Autonomic-Somatic Integration

The established physiologic changes in meditation are indicative of a level of activation or arousal[6] which is low, but not so low as to preclude maintenance of the waking state. This is manifested (*a*) in various functions related to sympathetic activity (or the presence of a low sympathetic/parasympathetic activity ratio), for example, heart rate, respiration, sweating; (*b*) in function of cerebral cortex (slowing and synchronization of EEG); and (*c*) in skeletal muscle which is maximally relaxed consistent only with maintenance of upright posture.

That this triad of cerebral, peripheral-autonomic, and skeletal muscle functions is far from a random assembly has been amply demonstrated in the extensive and fascinating, but neglected, work of the neurophysiologist Gellhorn [65, 66], who elaborated the concepts of autonomic-somatic relationships originated by Hess [67]. Based on Hess's pioneering investigations on hypothalamic stimulation in freely

[6] I prefer to avoid the term "arousal." This concept, so widely used in psychology, is of dubious ontological status [63] and explanatory value [64]. Both it and "activation" are too often applied to systems (e.g., the whole organism) which seldom, if ever, respond globally.

moving cats, it was shown that conditions leading to increased sympathetic nervous discharges (environmental, visceral, or brain stimulation) are accompanied by cerebral cortical activation. To characterize this coordinated complex of sympathetic-visceral, cerebral, behavioral, and skeletal muscle reactions (which are adaptive for emergency situations), Hess [67] coined the term "ergotropic activation." Rage induced by hypothalamic stimulation represents an extreme point on the ergotropic continuum. In contrast, stimuli which increase parasympathetic activation are associated with effects (presumed to be adaptive for cellular restitution) which include sleep-like EEG activity, decreased muscle tone, and behavioral quiescence. This complex of events, the mirror image of ergotropic activation, was termed "trophotropic." The two sets of events were presumed to depend on the activity of two anatomically separate systems represented at all levels of the nervous system.

Gellhorn made a major contribution to the neurophysiological validation of this scheme. He also devoted much effort to working out presumed relationships between ergotropic and trophotropic activation under a variety of circumstances and applying these concepts to emotional behavior in animals as well as (more speculatively) to human emotions. Admittedly, his attempt to show that wide areas of behavior and consciousness depend closely on the balance between activation of the two systems remains speculative, and the applications to specific situations are often vague. Nevertheless, Gellhorn's thinking on these problems, often heavily documented by data from his and other laboratories [65, 66], remains unique, and there seems to be no other comparable framework from which to consider the psychophysiology of meditative and mystic experience.

Gellhorn's concept of ergotropic-trophotropic "tuning" assumed that peripheral or central ergotropic or trophotropic stimulation alters the reactivity of the central nervous system. During ergotropic or trophotropic activation within a moderate range, a principle of reciprocity between the two systems is manifested, such that activation of one tends to suppress activity in the other. Furthermore, there is congruence between the cerebral or peripheral-autonomic and somatic components of the system, that is, in normal circumstances they are activated in concert. However, at more intense levels of activation (or in "stressful" circumstances), there is a breakdown of reciprocity and congruence. The resulting "imbalances" result in paradoxical responses to stimuli (with high ergotropic activation, trophotropic stimuli may have ergotropic effects and vice versa), and finally simultaneous ergotropic and trophotropic discharges occur. These breakdowns of reciprocity and congruence form, in Gellhorn's opinion, the physiological basis for many types of psychopathology and altered states of consciousness (see examples below). The changes which Gellhorn presents as resulting from noxious stimuli are fitted to Pavlov's behavioral descriptions of experimental neurosis [68], although he replaces emphasis on the cortex with a more hypothalamically centered mechanism. Thus Pavlov's "equivalent," "paradoxical," and "ultraparadoxical" phases of experimental neurosis correspond to changes in hypothalamic "tuning," with corticopetal discharges influencing behavior and "downward discharges" affecting somatic-visceral functions. The common theme is that, in stressful situations producing aberrant behavioral-conscious states, there are major shifts in responses to stimuli, and Gellhorn has documented this for many situations such as anoxia, hypoglycemia, fever, pain, sleep deprivation, sensory deprivation, and narcolepsy, wherein departures from ergotropic-trophotropic reciprocity and congruence occur [65, 66].

Meditation and the Ergotropic-Trophotropic Systems

Procedures used in meditation are well adapted to elicitation of trophotropic reactions. Common to many meditative disciplines are sensory isolation and physical immobility with maximal relaxation of the skeletal muscles consistent with an upright spine. In the Hindu-Buddhist traditions, this is obtained by sitting in the lotus or similar positions[7] in a nondisturbing environment. However, the advanced practitioner can dispense with the need for maximal environment isolation, presumably due to skillful application of selective attention.

Based on various lines of evidence from his own and other laboratories, Gellhorn demonstrated rather convincingly the central role of proprioceptive input from muscle spindles in maintaining ergotropic activation. Thus, stimulation of these afferents increase heart rate, while curare-like drugs which immoblize skeletal muscle inhibit ergotropic responsiveness [65, 70]. A positive feedback loop appears to be operating here in that increased muscle tone produces diffuse ergotropic activation, while the latter, induced by other means, results in increased muscle tone. According to Gellhorn, the ergotropic-trophotropic balance may be determined to a considerable extent by the intensity of proprioceptive discharges.[8] It should be pointed out parenthetically that the resulting low level of muscular activity in meditation may be the cause of the reported decrease in oxygen consumption. This suppres-

[7]Though Westerners most often meditate while sitting in chairs, the skilled lotus sitter is presumably at an advantage in being able to sit with maximum stability for prolonged periods of time. The importance of the stable, balanced, relaxed posture is often stressed (e.g., [28, pp. 26–27, 105–134]). It prevents sleep as well as supposedly having other desirable effects on respiration and physiologic functions [69].

[8]Apart from the general effects, the possiblity was discussed that proprioceptive input from facial muscles may have a specifically important role in emotional experience [66], a suggestion supported by recent psychophysiologic work (see n. 10).

sion of muscular activity, widely used in meditation as well as in a variety of relaxation therapies (autogenic, hypnosis, progressive relaxation, systematic desensitization, etc.), is thus viewed as facilitating a state of trophotropic dominance, with resulting cerebral, metabolic, and visceral changes. The same end is served by restriction of other sensory inputs in meditation, for example, environmental isolation, avoidance of the postprandial period, and eye closing. Attending to the respirations or a *mantra,* etc., blocks normal cognitive activity, incidentally preventing the intrusion of emotionally arousing thoughts, which again reinforces the trophotropic state.

In a rather sketchy and somewhat confusing paper published shortly before his death, Gellhorn in fact attempted to apply his concepts to meditation and mystical states of consciousness [19]. Apart from pointing out the generally trophotropic nature of the meditative state, it was suggested that "some degree of ergotropic excitation exists" in meditation. This mention of a measure of ergotropic drive in the face of a predominantly trophotropic situation was said to be reflected in the nonhabituation of EEG alpha block [54]. On the other hand, the mystical state of yogic ecstasy was characterized as predominantly ergotropic, based on the findings of Das and Gastaut [51]. However, the low EMG with desynchronized EEG and increased heart rate reported by these authors was interpreted [19, 65] as an example of "imbalance" in the two systems, very similar to that existing in REM sleep.

The article by Gellhorn and Kiely [19] was sharply criticized by Mills and Campbell [58] on the following bases: (1) The concepts of ergotropic and trophotropic activation are vague, difficult to validate experimentally in man, and therefore not experimentally testable. In general, the inadequacy of current scientific data on this subject was stressed. (2) There was a failure to recognize the difference between different forms of Yoga and Zen. Particular stress was placed on the extrapolation of the nonhabituation of alpha block in Zen subjects to all forms of meditation, ignoring the very different reports on yogis showing absence of alpha block [53]. (3) It was pointed out that the report of Das and Gastaut [51] was the only one in which "acceleration" of the EEG was found during meditation. In the absence of replication, Mills and Campbell reject the evidence of ergotropic activation in *Samadhi.*

Clearly the first point of Mills and Campbell is well taken. But the inadequacy of available data is a two-edged sword in this debate, for the authors also support their contentions with an uncritical acceptance of poor data. As to the differences among various meditative disciplines, the interpretation [11, 29, 57, 58] that the discrepant findings of Kasematsu and Hirai [54] and Anand et al. [53] reflect differences in philosophy, practice, and goals of Yoga and Zen is a premature conclusion in terms of the existing data, as we have discussed earlier.

More so, however, this kind of interpretation implies that we are dealing with well-defined differences in psychological state, to which physiological mechanisms can be applied. But rather than supplying precise descriptions of the nature of meditative or mystical experience, the writings of the mystics are clothed in metaphor and symbolism. Traditional Zen literature particularly shies away from psychological descriptions of the mystic experience. Even the writings of modern academic scholars of Zen (e.g., [28, 71]) are not easily translatable into the terms of modern scientific discourse. This literature is often more concerned with the desirable characteristics of the enlightened individual than with the psychological phenomenology of the *Satori* experience. The many different Hindu, Buddhist, and other disciplines certainly differ in their philosophies, and no doubt there are psychological differences in the experiential results obtained. But as pointed out by Kiely [72] in his rebuttal to Mills and Campbell [58], there is no acceptable evidence of parallel physiological differences.

That mystical states are experientially and presumably physiologically quite different from meditative ones is often not sufficiently recognized. Mills and Campbell [58] make much of the difference between the usual EEG findings in studies on meditation and those of Das and Gastaut [51]. But the latter is the only experimental report in which it was frankly claimed that data were obtained during actual mystical experience (*Samadhi*), though similar claims are tentatively advanced for some of the findings of Hirai [29, 54]. Certainly, the brief report of Das and Gastaut on increased heart rate, hyperaroused EEG, and flat EMG, though striking, is rather insufficient evidence on which to base the conclusion that yogic *Samadhi* shows (*a*) a strong ergotropic component and (*b*) noncongruence between the different components of the system reflecting the breakdown of ergotropic-trophotropic balance [19, 65]. However, other lines of evidence can be found to support this thesis, and these will now be discussed.

As mentioned earlier, Banquet [55] also reported desynchronized EEG in advanced meditators during very deep meditation. Second, from a large variety of first-hand descriptions of enlightenment experiences from Buddhist, Hindu, or other sources, the subject appears to be in a state of great excitement [16–18, 73]. The assumption seems reasonable that their autonomic-somatic condition is ergotropic. The suggested progression from trophotropic meditation to ergotropic ecstacy quite possibly involves mechanisms of the type described by Gellhorn: either "imbalance" resulting from intense prolonged trophotropic activation, or the postulated "rebound" of the ergotropic system, whereby after *cessation* of trophotropic excitation, strong ergotropic activation supervenes.

Unfortunately, this "model" of the induction of mystical experiences does not by any means cover all the known situations. Thus, among the many practices of the many mystical sects are some which certainly induce ergotropic rather than trophotropic conditions in the subject. Two examples will suffice: the circling dances of the Sufi Whirling Dervishes [11, p. 155] and the practice of *Ishiguro* Zen, which includes prolonged shouting and violent abdominal contractions [28]. In these cases, the *approach* to the mystical experience would be ergotropic, although we know little if anything about physiological conditions *during* the experiences induced by such means. They may well be trophotropic; at least, this is suggested by analogy with a variety of situations described in a recent interesting semi-scientific book by Sargant [74] which merits some discussion.

Based on Pavlov's descriptions of experimental neurosis in dogs and his own experiences with abreaction therapy for treating battle neuroses, Sargant proposes a succession of events which, among other effects, leads to profoundly altered states of consciousness. When people undergo extreme excitation, induced either by psychologic or intense sensory stimuli, a stage is reached when the subject collapses, and extreme changes of mental and physical state supervene involving altered states of consciousness and greatly heightened suggestibility. Sargant points out that similar techniques have been used in many cultures for thousands of years in the successful treatment of psychosomatic or mental illness (as in exorcism) or to induce altered states of consciousness for religious or other purposes.

The relationship of these events to hypnotic suggestion is stressed, and Sargant draws an interesting analogy to sexual activity (a temporary state of extreme "brain excitation" leading to collapse and transient inhibition). His major concern, however, is the religious-type conversion. In a survey of shamanistic rites in many tribal cultures, he shows the ubiquity of such methods as dancing, chanting, and hyperventilating leading to frenzied states which result in collapse and "trance" states. In our own culture, preachers (or pop music heroes!) may whip people into a frenzy of excitement by charismatic evangelistic oratory, singing, dancing, etc. In the resulting organismic switch into a state of mental and physical collapse, the subjects may be in a hypersuggestible condition and may also experience extreme alterations of consciousness, which can be interpreted in a religious context. Both of these are conducive to religious conversions or changes in belief systems. Other authors have described the important role of altered states of consciousness in shamanistic healing [75]. A recent example is seen in the current revival of shamanistic rites among the Salish Indians of British Columbia which reportedly is achieving therapeutic success in cases where Western psychiatry has failed [76].

The points of resemblance between the Pavlovian phenomena and those described by Gellhorn and by Sargant are certainly sufficient to indicate that all were describing essentially similar *physiologic* states although interpreted in different terms. A point of commonality is sudden shifts in organismic state related to prolonged or intense autonomic activation or other "stressful" forms of stimulation. I would postulate that such conditions in general tend to be correlated with experience of altered states of consciousness and that they may be approached either from the ergotropic or trophotropic side. For instance, a rapid ergotropic to trophotropic shift is found in orgasm, which can be regarded as an altered state of consciousness, albeit short-lived. The opposite switch from trophotropic to (relative) ergotropic dominance is seen in the transition from slow wave to REM sleep, which is accompanied by a profound alteration in consciousness, and in sensory deprivation experiments [77, 78] where hallucinogenic activity is correlated with increased ergotropic activation (increased heart rate, EEG arousal, etc.). A shift in the same direction can be induced by raising and then rapidly lowering body temperature. Unpublished experiments by R. Crist have demonstrated that when the oral temperature is raised to about 103° F by immersion in a hot bath and then the subject is immediately transferred to a cold bath, a major alteration of consciousness occurs, including kinesthetic sensations (tumbling) and perceptual alterations.[9]

Now it is not being argued that the circumstances described by these workers necessarily involve mystical experiences but only that profound altered states of consciousness may result, leading to equally profound effects on the individual's behavior and future belief system. That similar physiological phenomena may be common to mystical and other forms of altered states of consciousness is a major theme of this essay that I shall develop further in due course. Sargant himself extends his analysis to traditional mystical states, but to fit them into his Pavlovian scheme he has to create a rather strained analogy between concentrative meditation and focal excitation of one area of the cortex in the experiments of Pavlov [68]. But Sargant's work is not helpful to us in terms of specific or up-to-date physiologic thinking.

To return to the major question under consideration, it appears that mystical states may be experienced (or approached) during either ergotropic- or trophotropic-dominated conditions; at least there is no adequate rationale for limiting it to either condition. In a rather fanciful though interesting article, Fischer [79] in fact claims that the mystic may switch between extreme ergotropic and extreme trophotropic forms of mystical experience. This is equated to the rebound phenomenon concept which Gellhorn developed; it is basically Pavlov's mechanism of

[9]This phenomenon is enhanced by (and may require?) small doses of sympathomimetic drugs. It may not be irrelevant to mention the recent tragic death of Crist from drowning while experimenting with this procedure.

protective inhibition which is conceived as a homeostatic device encountered in experimental neurosis. Unfortunately, Fischer presents no direct evidence for what he calls the "loop connecting the two extreme exalted states." But the important question at this point is: How is it possible for mystical experiences (which we know to have important common features regardless of when, where, and by whom experienced) to be related to such diverse physiological circumstances? The next section deals with considerations bearing on this issue.

The Psychology of Emotions

In order to appreciate the likely constraints on the relevance of physiological variables to conscious experience in meditative and mystical states, it will be helpful to note how psychologists have dealt with similar problems in the context of emotions. A tradition dating back through Cannon to William James has attempted to "explain" feelings and emotions in terms of the commonly observed, concomitant activation of autonomic nervous activity. The ubiquity of these visceral phenomena in affective states suggests a role in humans beyond Cannon's and Hess's characterizations of sympathetic/parasympathetic events as preparatory for fight-and-flight or for restitution of bodily functions. However, the general nonspecificity of autonomic changes makes them unlikely candidates as specific mediators for the great variety of emotional experience. In fact, despite many attempts [80, 81], there is no satisfactory classification of emotions in terms of visceral events [82], that is, no known physiological event(s) is (are) diagnostic for a given type of conscious experience or of emotional behavior.

The way in which psychophysiology has dealt with this problem in the last decade or so has been to postulate an interaction between visceral phenomena and cognitive variables in the determination of affective state and emotional behavior. The key experiment is that of Shachter and Singer [83]. These investigators injected epinephrine (adrenaline) or a placebo into groups of subjects who expected vitamin injections. The subjects were then exposed to a confederate who feigned either anger or euphoria about the experiment and the investigator. Some of the subjects were told to expect sympathomimetic effects of the "vitamin." Subjects not receiving the epinephrine *or* warned about the physiological effects did not become emotional. Those receiving epinephrine *and* exposed to the angry confederate felt angry and behaved accordingly, while those injected *and* exposed to the euphoric confederate became euphoric. The conclusion was that the presence of physiological-autonomic responses influence the extent to which emotion in general is felt, while social influences can determine the type of emotional response accompanying the physiological changes. A considerable body of literature (see [84]) has grown up around this now classic study. Emotions depend on a large variety of real and imagined internal and external cues[10] interacting in a complex evaluative process. The emotional experience "is particularly affected by a person's attributions of the causality, intent and extent of these factors" [88].

The (conscious or potentially conscious) attitudes, expectations, and desires (which shall be referred to collectively as cognitive variables) play an important role in emotional experience and behavior in normal waking consciousness. Can we expect similar effects in conditions of profound alterations of consciousness such as are seen in mystical states? To support the positive answer which I would give to this question, the following are examples of experimentally demonstrated situations in which altered states of consciousness, presumably dependent on physiological changes, are profoundly affected by such cognitive variables.

The crucial importance of psychological set and envrionmental setting in determining the nature of the experience of major and minor psychedelic drugs is well known [26, 89–91]. Conscious experience and behavior under hypnosis are largely determined by cognitive variables, so much so that there are no demonstrated specific physiologic correlates of hypnosis [90]. Investigations on the experimental control of dream content show that the setting of the experiment and the relationship between experimenter and subject have important effects on the dream experience [92]. Other areas where the conscious or quasi-conscious attribution of meaning or significance importantly affects experiential (and physiological) aspects of emotion are sexual arousal [93], anxiety [41], pain [69], and, most dramatically, collective psychoses [94].

At this point, I feel the need to respond to the anticipated criticism of those who believe that all psychological phenomena will ultimately be explained in neurophysiological terms (as probably do the great majority of biologists). To these, the distinction between physiological and cognitive variables may appear artificial, since the latter can be thought of as phenomena which have simply not yet been reduced to physiologic terms. A slowly increasing number of philosophically inclined biologists seem to be arriving at a position which lies somewhere between the classical reductionist viewpoint and the old vitalism [95, 96]. Without taking a stand on this issue, I would simply point out that, since we have no concept of what might be the physiological counterpart of the cognitive variables under discussion, it is of no consequence, in the present context, how this class of variables is labeled. For those who will be more comfortable with such a formulation, however, we can speak of "overt

[10] These may include the individual's behavioral responses themselves [85]; *false* information on his autonomic responses [86]; and his facial expression: arranging a person's features in a happy position will tend to make him feel happy [87]!

physiological variables" for these physiological correlates which have been identified, and "covert physiological" can be substituted for the word "cognitive."

Finally, there are some experimental observations which might be thought of as providing an animal model for these phenomena. The identical electrical stimulation of a single brain locus can be shown to have very different effects on behavior depending on the "motivational" state of the animal at the time of experimentation [97]. This is equivalent to the "set" mentioned in the above examples; "setting" (concurrent environmental influences) also plays an important role in the outcome of intracerebral stimulation in animals [98]. This kind of observation may be regarded as a starting point for research which might begin to convert some of the covert physiological variables to overt ones, without regard for the (philosophic) issue of whether such conversion could ever be total.

Cognitive Variables and the Mystical Experience

If identical autonomic changes are consistent with such different experiences as anger and euphoria [83], but the threshold for either experience is lessened in the absence of those changes, then what is the role of the physiological events? We may assume that they supply some level of nonspecific activation (often referred to as "arousal"), although the specific nature of the experience is determined by cognitive variables. It seems likely that this is what is happening in meditation. Thus, the physiologic variables (which can be described in terms of ergotropic-trophotropic balance) are unlikely to be the determining factor in the "success" of meditation. In this regard, the TM movement is seriously misled when it attaches importance to the known physiological changes in relation to successful attainment of meditational states. The extent to which the TM movement is confused on this point is seen when they propose to use physiological measures as indices of educational-spiritual progress in students of meditation. Thus, in the Maharishi International University it is proposed to use metabolic rate, oxygen consumption, blood chemistry, EEG recordings, etc., "to objectively validate" the student's "subjectively experienced improvement in physical health, the stability of his intellect and emotions, his inventiveness, intelligence and breadth of awareness" [2, pp. 6, 7].

As to mystical experience, whatever physiological correlates may finally be established, it is a reasonable assumption that they will only supply a backdrop on which the cognitive set and the setting superimpose direction, quality, meaning, and effects. Cognitive variables presumably determine both the content of the mystic experience and, at a higher level, its interpretation in terms of different religious or philosophical beliefs (see [13, p. 37]). Included, too, would be the ultimate effect of the experience on the individual's life-style, personality, and behavior. We also have to consider that an identical set of overt physiological events may in different subjects or at different times lead either to mystical experience or to quite different altered states of consciousness. A relevant example is the psychedelic experience, whose relationship to mystical states will be discussed later. Here the same physical stimulus in the form of, say, LSD can induce a psychotic state or an experience which, in the opinion of various authorities, is remarkably close if not indistinguishable from the mystical state [99–102]. Finally, there is ample evidence for "spontaneous" mystical experiences [14, 17], and it seems not unlikely that these, and the experiences of the great mystics whom one might (facetiously!) describe as chronically enlightened, need not be preceded by unusual physiological conditions. If so, this merely reaffirms the argument that conditions of altered ergotropic-trophotropic balance, though conducive to these experiences, are not crucial or necessary for their occurrence.

Too little is known to attempt to detail the specific cognitive variables of importance in meditative and mystical experiences. However, I might mention two factors. First, there is the religious and philosophical framework within which mystic experience is sought. Particularly relevant also is the emphasis in many mystic disciplines on the dependence on a teacher or guru [6, 16] in whom the subject vests his trust and hopes for enlightenment. There is certainly reason to believe that the capacity for psychological surrender ("letting go"), which is somehow paradoxically linked with personal realization and autonomy [103] is a major factor in attainment of mystical states. But it is not clear that either of these factors plays a role in spontaneous "unsolicited" experiences of "everyday mysticism" [14] whose etiology is indeed mysterious.

Finally, there is one point which emerges from this discussion of cognitive variables which has immediate relevance to the interpretation of studies on physiological correlates of transcendental meditation. All TM practitioners receive detailed instruction which includes rather heavy emphasis on the physiological changes to be expected in meditation. The possible effects of "demand characteristics" of this sort on experimental results merit consideration.

Mystical Experience and Hemispheric Lateralization

The thesis which has been presented is that ergotropic-trophotropic shifts may be conducive to various kinds of altered states of consciousness, that these may include meditative and mystical experience, and that the *specific* determining factors of the conscious experience are cognitive set (and to a lesser extent setting) rather than specific (overt) physiologic events. From the physiological point of view, this model is unsatisfyingly vague in that virtually nothing has been said about possible mechanisms relating to the switch from normal to altered consciousness. I shall, therefore, now explore one such hypothesis: that during mystical experience cerebral function is dominated by the right ("minor") cerebral hemisphere.

The realization that the use of language is a function for which the left hemisphere is specialized originated from early observations of the effects of brain lesions [104]. More recently, Sperry's work with epileptics subjected to therapeutic commissurotomy ("split brain") provided a basis for the concept that each hemisphere has "its own private sensations, perceptions, thought, feelings and memories" [105]. Though the concept of two minds in one body is difficult to digest,[11] it is now well established that each hemisphere is specialized for a different form of cognition. Current views indicate that the left is better qualified to deal with verbal, arithmetic, sequential, conceptual, analytic thinking and is the side primarily involved in directing motor function. The right hemisphere, on the other hand, seems specialized to deal with spatial relationships: relating parts to wholes—nonverbal, holistic thinking, based on direct perceptual, "intuitive" experience [105, 107, 108]. On the information-processing model, hemispheric specialization may be conceived as involving sequential processing for the left and simultaneous for the right. If the latter is in a sense the "nonrational" hemisphere, it is likely the one which seems to dominate in creative activity of various kinds, as well as aesthetic, artistic, and musical appreciation. Undoubtedly, under normal conditions (in healthy individuals), both hemispheres function together continuously, either by rapidly alternating or simultaneous operation [105, 107, 108]. Nevertheless, one can demonstrate by several methods the *relative* hemispheric dominance in normal subjects in verbal-analytic versus spatial holistic cognition or musical perception. These methods include dichotic listening experiments and observation of lateral differences in the ongoing EEG or evoked electrical activity in normal subjects presented with appropriate tasks (reviewed in [107]).

Reports of mystical experience invariably include reference to its ineffability. Even highly literate individuals sense a large discrepancy between the experience and their capacity to verbalize it. In considering this problem, we may distinguish among four possible elements: (*a*) amnesia for the details of the experience; (*b*) the simple absence of linguistic terms adequate to describe it; (*c*) a basic inarticulateness of the individual *during* the experience; and (*d*) a post hoc inability to express

[11]The philosophical difficulties which arise from conclusions based on "split brain" work are ably discussed by Nagel [106]. He argues, however, that though there is presumably more than one mind per individual, there is no reason to limit the number to two!

the remembered experience in words. Although experiences during many altered states of consciousness are frequently not remembered, mystical experiences are in fact often vividly remembered and may have a permanent influence throughout life [16–18, 73]. As to the poverty of language, this may seem to be particularly applicable to our culture. In the East, however, these states of consciousness have been widely pursued for thousands of years, presumably enough time for appropriate language to develop (see [26, p. 3]). Nevertheless, Eastern mystics make the same complaint of ineffability as do the Westerners. It therefore appears that mystical ineffability cannot be accounted for by the factors of amnesia or language but that it depends, rather, upon a real difficulty with verbal expression during and/or after the experiences.

If a careful analysis of this problem, Stace [13] argues that the use of language is inconceivable during mystical states, simply because the mode of experiencing at that time differs from normal consciousness in ways that make verbalization impossible. Specifically, the experience of "undifferentiated unity" is inherently contradictory to the function of language, which is the conveying of discrete concepts in words. As to the remembered experience, the subject is then in his normal state of consciousness, and Stace sees no reason why the mystic should not be able to describe it at least by comparing the difference between the mystic experience and his normal conscious experience at the time of reporting. In fact, he does describe it—albeit often metaphorically or poetically. But he has the *conviction* of its ineffability because he is attempting to describe an experience that defies the logical structure which underlies language; it paradoxically eliminates dualities; it sees opposites as identical.

Such arguments are not easy to follow, since the "advanced" mystical state which Stace describes—that of "undifferentiated unity" or the "void"—is so far from the experience of most people. Perhaps easier to grasp is the account of Deikman [22], who describes mystical experience as taking the form of a "vertical organization of concepts." By this he apparently means an enhanced capacity for simultaneous perceptions or understandings, as opposed to the normal mode of sequential (i.e., horizontal) organization of cognitions. Thus whole sets of relationships may be simultaneously grasped—an experience not translatable into language, which deals in the orderly succession of single concepts.

But whether the stress is on departures from logic, independence of space and time, simultaneous (holistic) versus sequential processing, or nonverbalizable perceptions, the resemblance to current concepts of right-hemisphere functioning is apparent. I should pause to reiterate the speculative nature of these arguments, while emphasizing one clear correlation: there is no disagreement that most of the language function is "in" the left hemisphere and that mystical states are invariably described as ineffable.

Now since the proposed model suggests that common physiological mechanisms may precipitate a variety of altered states of consciousness, it is relevant that other altered states have been linked to right-hemisphere function. Thus lesions which disrupt or destroy right-brain function seem to interfere with dreaming, and there is other evidence which suggests the possibility of right-hemisphere dominance in dreaming [107]. But dreaming is only one manifestation of the type of mental function described by Freud as primary process, that is, that type of cognition which characterizes the so called sub- or unconscious mind [109]. Avoiding psychoanalytic terminology, this mode may be described as extralogical, independent of normal rules of causality, of spatial and temporal sequence, and uses nonverbal representation by multimodality images. These features of the primary process are in fact those which are believed to characterize right-hemisphere function [107].

The right hemisphere most likely functions continuously in the normal state of consciousness, and right-hemisphere specialized functions, such as perception of part-whole relations, are certainly necessary for normal mental function. So also primary process thinking has a role in our normal waking consciousness. Apart from daydreaming and fantasy, it is a fair assumption, for instance, that intuition (decision making on the basis of "inadequate" information) is an essential component of all normal thought processes and particularly of symbolizing. However, the validation of intuitions requires logical analysis [110], that is, secondary process cognition. The importance of the primary processes in creativity is well recognized, although again it requires integration with secondary processes for expression in a work of art or science. This is described by Arieti [111] as the "tertiary process."

The mystic element in creative art or science is well described by Scharfstein [14], and Ehrenzweig [112] demonstrates the role of primary process in musical comprehension, for which the right hemisphere is apparently specialized [104, 113]. Ehrenzweig describes a form of scanning common to the artist looking at a canvas and the musician listening to polyphonic music, in which one may "grasp in a single act of comprehension several mutually incompatible constellations" [112, p. 386]. This mental act is said to be "unconscious"; perhaps the essence of mystical experience is to become aware of such processes. At any rate, the element of experiential *simultaneity* or holistic perception is a common feature connecting artistic and mystical consciousness to current notions of right-hemisphere function.

It remains to attempt to link the hypothesis of right-hemisphere dominance in mystical experience to the conclusions about the etiology of these states arrived at in our previous discussion. The consciousness of the psychotic is dominated by the primary process; and experiences which approach the mystical in nature may be more common in the psychotic than the sane [14, 114]. This being so, we may ask two questions about the psychotic-mystical analogy. What differentiates the two experiences, and what relationships can we find in the etiology of the two conditions?

The model which I am developing postulates that overt physiological variables predispose to altered states of consciousness, but the nature of the individual experience is determined by such cognitive variables as beliefs and attitudes resulting from experience and training. These factors (and the presence of brain dysfunction, mental disorder, etc.) would decide whether a right-hemisphere-dominated experience would be classified as hallucinatory or psychotic or mystical, etc. As to etiology, the conditions leading to acute schizophrenic episodes, whose onset is characterized by "psychedelic" or mystical experience, will sound familiar. As described by Bowers [115], these psychoses often arise acutely out of a desperate struggle resulting in impasse, hopelessness, and the despairing abandonment of the struggle. This is reminiscent of the experiences of mystics emerging from "the dark night of the soul" into "ecstatic union" [22]. And the model fits well with the sequence defined by Sargant as common to conversion, shamanistic, and other similar experiences resulting in altered states of consciousness. It corresponds to the conditions precipitating Pavlovian experimental neurosis, that is, in physiologic terms, ergotropic activation leading to trophotropic collapse.

Conclusions and Research Prospects

The several lines of circumstantial evidence supporting the link between right-hemisphere function and primary process cognition supply a basis for the hypothesis that links the right hemisphere to mystic experience. Conditions which predispose to the dissolution of normal waking consciousness and the predominance of primary process thinking can lead—depending on the psychological status of the individual and the circumstances in which he finds himself—to dreaming, hallucinations, frank psychosis, meditative states, or (rarely) to mystical experience. The precipitating conditions include switches or unusual combinations of ergotropic-trophotropic activation, which may switch hemispheric function by affecting neural conduction in the corpus callosum or by other means. This hypothesis is frankly speculative, and such speculations earn a well-deserved fate on the refuse heap of sterile ideas unless they are amenable to research capable of examining their validity. I believe such experimental validation to be feasible and will now attempt to substantiate this within the framework of a brief consideration of experimental prospects in the field of meditation research in general.

The major objectives facing this area of endeavor in its present essentially neonatal stage of development are the elucidation of (*a*) possible medical-psychological benefits of meditative experience, (*b*) its physiological correlates, and (*c*) the relationship between physiological variables on the one hand and conscious experience as well as lasting effects in the meditator on the other.

As to the benefits, it is to be expected that further examination of changes in personality, life-style, psychosomatic health, etc., will continue to show positive effects of meditation. These results are predictable mostly on the basis of traditional knowledge and of recent research findings [3, 30, 60–62]. Since true mystical experience is rare, the evidence for lasting benefits in this area will remain largely anecdotal, unless the present surge of interest in meditation leads to a whole new generation of experimentally available mystics! One area of considerable interest is the application of meditation in psychotherapy [20]. The extent to which meditation can be used in a traditional Western psychotherapeutic context, and the implications for the role of the therapist need to be clarified. The lasting effects of traditional meditative practices should be compared with relaxation therapies, such as autogenic training. The variables of age, sex or personality characteristics, and organizational, philosophical, or religious affiliations should also be investigated.

As to physiology, the first requirement is to determine whether the various results already obtained can be replicated and statistically validated in quantitative experiments under well-controlled conditions. Second, we need to know if the autonomic-metabolic–EMG findings differ from those in relaxation and what, if any, is the role of intermittent napping in their production. This will involve comparisons within and between subjects in the presence and absence of sleep. The *mantra* variant should be compared with other forms of meditation, especially Zen. Of particular interest would be comparative studies within one laboratory of various Zen and yogic meditations, in terms of responses to sensory stimuli. In addition to EEG-orienting reflexes from different baseline conditions, evoked potentials should also be measured. To determine whether meditators showing EEG signs of sleep are indeed behaviorally asleep, thresholds of arousal to sensory stimuli and subjective reports on "awakening" may be investigated. Among the variables of blood chemistry which merit study, biogenic amine metabolism may be of particular interest.

Temporal correlations between ongoing measurements of different physiological variables in meditation have hardly ever been reported.

Simultaneous measures of EMG, heart and respiration rates, GSR, etc., can indicate whether the departures from congruence among autonomic, somatic, and EEG variables are correlated with changes in conscious experience. This will allow conclusions as to the proposed triggering role of "switches" in autonomic-somatic integration. In addition, Schwartz [116] has recently contended that the patterning of physiologic responses is the important dimension for identification of psychophysical states in relation to biofeedback regulation and its applications to psychosomatic problems and meditation.

The extent to which the various physiological variables may have bearing on conscious experience cannot be understood without attempting to obtain reports as complete as possible of experiences during (and after) meditation and to correlate these with physiological events. It will be necessary to identify common experiential effects and to score meditations within and between sessions in terms of these criteria. The problem of interference by the experimenter in the process of meditation is real but not insuperable, as shown by Banquet [55], who used button pressing to score categories of experience, albeit crudely. Retrospective reporting can also be used, if done immediately after the experiment. From studies involving these types of observation it may be possible to separate the experiential effects of relaxation, posture, lack of thinking, and sensory detachment.

To elucidate the role of cognitive variables in meditative and mystic experience, it would be of initial interest to compare the conscious experience of "traditional" meditators with that of subjects in relaxation therapies and Benson's technique [43], which resembles meditation but lacks a philosophical-religious set. To the extent that physiologic differences between these techniques are less than the differences in reports of conscious experience or the lasting effects, the role of cognitive variables will become apparent. Such studies will, of course, require careful investigation of subjects' attitudes if we are to understand the nature of the "attributions" involved.

As to true mystical experience, the prospects for scientific investigation are poor, to the extent that it requires the availability and cooperation of individuals who can predictably experience these unusual states of consciousness. In the circumstances, the best strategy may be to study effects of psychedelic drugs such as LSD, mescaline, and psilocybin, which provide the best available experimental models. While most psychedelic "trips" certainly do not result in mystical experience, the probability of precipitating something which approaches or approximates it [99–102] can be greatly increased by using predisposed subjects and optimizing the environmental situation, that is, by making maximal use of set and setting. This is exemplified by the unique experiment of

Pahnke in which seminarians ingested psilocybin while listening to a Good Friday service piped in from an adjoining chapel [23]. Similar situations could be designed in different religious and other contexts.

Without underestimating the difficulties, under such circumstances, of obtaining physiologic measurements which could be correlated with subjective report, experiments of this kind would be of such major interest as to justify considerable effort. For instance, small transmitters could be employed to obtain measurements of lateral differences in cerebral activity, with minimal disturbance to the subject. Such a set-up could be used for studying on-going EEG, evoked potentials, etc., as well as for the monitoring of extracerebral physiologic events. Present noninvasive techniques of measuring relative hemispheric dominance (see [107]) may be unsatisfactory, but new ones will surely evolve as a result of the considerable current interest in this topic. The problem of eliminating irrelevant drug effects when psychedelic experiences are used as models can be dealt with by careful cataloging and temporal correlation of the physiologic data with reports of mystic-like experiences, which will only occur during a small portion of the session. This simple approach should permit confirmation or denial of hypotheses, such as the one proposed here of a link between certain extracerebral physiologic events, right-hemisphere dominance, and mystical experience.

In conclusion it remains only to express the hope that the past opposition to this kind of psychopharmacologic investigation on the part of those who control biomedical research will not remain an insuperable barrier to the study of the physical correlates of man's most unique and treasured experiences.

Dr. Gordon Globus has suggested in a personal communication that, since the mystical experience is "acognitive at its core," it is misguided to suggest that it can be determined by cognitive variables, though he concedes that they do determine the way people talk about these experiences. This criticism would not affect the point that the initiation of the mystical experience (or other altered states) may be determined by preexisting cognitive variables. In addition, however, the descriptions of the mystics show that the contentless experience of the "void" may be accompanied by a variety of hallucinatory phenomena whose content is undoubtedly influenced by the factors we have discussed.

REFERENCES

1. MAHARISHI MAHESH YOGI. The science of being and art of living. London: Unwin, 1963.
2. Maharishi International University Catalog. Los Angeles: MIU Press, 1974/75.
3. D. P. KANELLAKOS and J. S. LUKAS. The psychobiology of transcendental meditation: a literature review. Menlo Park, Calif.: Benjamin, 1974.

4. R. K. WALLACE, H. BENSON, and A. F. WILSON. Am. J. Physiol., **221**:795, 1971.
5. A. CAMPBELL. Seven states of consciousness: a vision of possibilities suggested by the teaching of Maharishi Mahesh Yogi. New York: Harper & Row, 1974.
6. P. BRENT. The godmen of India. Harmondsworth: Penguin, 1972.
7. E. JACOBSON. Progressive relaxation. Chicago: Univ. Chicago Press, 1938.
8. J. W. SCHULTZ and W. LUTHE. Autogenic training. New York: Grune & Stratton, 1969.
9. B. B. BROWN. New mind, new body: bio-feedback: new directions for the mind. New York: Harper & Row, 1974.
10. W. JAMES. The varieties of religious experience. New York: Modern Library, 1929.
11. C. NARANJO and R. E. ORNSTEIN. On the psychology of meditation. New York: Viking, 1971.
12. A. HUXLEY. The perennial philosophy. New York: Harper & Row, 1944.
13. W. T. STACE. Mysticism and philosophy. Philadelphia: Lippincott, 1960.
14. B-A SCHARFSTEIN. Mystical experience. New York: Bobbs-Merrill, 1973.
15. R. C. ZAEHNER. Zen, drugs and mysticism. New York: Random House, 1972.
16. P. KAPLEAU (ed.). The three pillars of Zen: teaching, practice and enlightenment. Boston: Beacon, 1965.
17. R. M. BUCKE. Cosmic consciousness. Philadelphia: Dutton, 1901.
18. G. KRISHNA. Kundalini. Berkeley: Shambhala, 1971.
19. E. GELLHORN and W. F. KEILY. J. Nerv. Ment. Dis., **154**:399, 1972.
20. W. KRETSCHMER. Psychologia, **5**:76, 1962.
21. P. C. HORTON. Am. J. Psychiatry, **130**:294, 1973.
22. A. J. DEIKMAN. Psychiatry, **29**:324, 1966.
23. W. PAHNKE. Int. J. Parapsychol., **8**:295, 1966.
24. R. PRINCE and C. SAVAGE. Psychedelic Rev., no. 8, p. 59, 1966.
25. A. M. LUDWIG. Arch. Gen. Psychiatry, **15**:225, 1966.
26. C. T. TART (ed.). Altered states of consciousness. New York: Wiley, 1969.
27. E. R. HILGARD. J. Nerv. Ment. Dis., **149**:68, 1969.
28. Y. AKISHIGE. *In:* Y. AKISHIGE (ed.). Psychological studies on Zen. Kyushu psychol. studies no. 5, p. 1, 1968.
29. T. HIRAI. Psychophysiology of Zen. Tokyo: Igaku Shoin, 1974.
30. H. BENSON, B. A. ROSNER, B. R. MARZETTA, and H. M. KLEMCHUK. Lancet, p. 289, February 23, 1974.
31. R. K. WALLACE. Science, **167**:1751, 1970.
32. A. VASSILIADIS. Unpublished report, 1972 (cited in [3]).
33. J. ALLISON. Lancet, **1**:833, 1970.
34. B. BAGCHI and M. WENGER. Electroencephalogr. Clin. Neurophysiol., **7**:132, 1957.
35. B. K. BAGCHI. J. Am. Soc. Psychosom. Dent. Med., **16**:1, 1969.
36. M. WENGER, B. BAGCHI, and H. ANAND. Circulation, **24**:1319, 1961.
37. P. A. OBRIST, R. A. WEBB, J. R. SUTTERER, and J. L. HOWARD. Psychophysiology, **6**:569, 1970.
38. M. TREICHEL et al. Physiologist, **3**:472, 1923 (abstr.).
39. B. K. ANAND, G. S. CHHINA and B. SINGH. Indian J. Med. Res., **49**:82, 1961.
40. F. N. PITTS, JR. Sci. Am., **220**:69, 1969.
41. S. H. ACKERMAN and E. J. SACHAR. Psychosom. Med., **36**:69, 1974.
42. A. H. BENSON, R. F. STEINART, M. M. GREENWOOD, H. M. KLEMCHUK, and N. H. PETERSON. J. Hum. Stress, **1**:37, 1975.
43. J. F. BEARY and H. BENSON. Psychosom. Med., **36**:115, 1974.

44. D. W. ORME-JOHSON. Psychosom. Med., **35**:341, 1973.
45. R. JEVNING, A. WILSON, E. VANDERLAAN, and S. LEVINE. Program, 57th annual meeting, Endocrine Soc., p. 257, 1975 (abstr.).
46. R. JEVNING, A. F. WILSON, and W. R. SMITH. Paper presented at Int. Conf. Psychophysiol. of Sleep, Edinburgh, Scotland, June 1975 (abstr.).
47. J. A. WADA and A. E. HAMM. Am. Electroencephalogr. Soc. 27th annual meeting, 1973 (abstr.).
48. J. YOUNGER, W. ADRIANCE, and R. BERGER. Program, 13th annual meeting, Assoc. for Psychophysiol. Study of Sleep, San Diego, Calif., May 1973.
49. R. R. PAGANO, R. M. ROSE, R. M. STIVERS, and W. S. WARRENBURG. Science, **191**:308, 1975.
50. K. K. DATEY, S. N. DESHMUCKH, C. P. DALVI, and S. L. VINEKAR. Angiology, **20**:325, 1969.
51. N. N. DAS and H. GASTAUT. Electroencephalogr. Clin. Neurophysiol., **6**(suppl.): 211, 1955.
52. L. C. WALRATH and D. W. HAMILTON. Am. J. Clin. Hypn. **17**:190, 1975.
53. B. K. ANAND, G. S. CHHINA, and B. SINGH. Electroencephalogr. Clin. Neurophysiol., **13**:452, 1961.
54. A. KASAMATSU and T. HIRAI. Folia Psychiatr. Neurol. Jpn., **20**:314, 1966.
55. J. P. BANQUET. Electroencephalogr. Clin. Neurophysiol., **35**:143, 1973.
56. J. J. LYNCH, A. PASKEWITZ, and M. T. ORNE. Psychosom. Med. **36**:399, 1974.
57. L. C. JOHNSON. Psychophysiology, **6**:501, 1970.
58. G. K. MILLS and K. CAMPBELL. J. Nerv. Ment. Dis., **159**:191, 1974.
59. W. C. MCCALLUM and J. R. KNOTT (eds.). Electroencephalogr. Clin. Neurophysiol., suppl. 33, 1973.
60. L. A. HJELLE. Percept. Mot. Skills, **39**:623, 1974.
61. K. R. PELLETIER. Percept. Mot. Skills, **39**:1031, 1974.
62. R. HONSBERGER and A. F. WILSON. Respir. Ther., **3**:79, 1973.
63. L. HENDERSON. Br. J. Psychol., **63**:1, 1972.
64. R. J. ANDREW. Behavior, **51**:135, 1974.
65. E. GELLHORN. Principles of autonomic somatic integrations. Minneapolis: Univ. Minnesota Press, 1967.
66. ———. Psychol. Forsch., **34**:48, 1970.
67. W. R. HESS. Functional organization of the diencephalon. New York: Grune & Stratton, 1957.
68. I. P. PAVLOV. Conditioned reflexes and psychiatry. London: Lawrence & Wishart, 1961.
69. S. BRENA. Pain and religion. Washington, D.C.: Thomas, 1972.
70. E. GELLHORN. *In:* E. GELLHORN (ed.). Biological foundations of emotions, p. 56. Glenview, Ill.: Scott Foresman, 1968.
71. D. T. SUZUKI, E. FROMM, and R. DEMARTINO. Zen Buddhism and psychoanalysis. New York: Grove, 1963.
72. W. F. KIELY. J. Nerv. Ment. Dis., **159**:196, 1974.
73. J. T. HUBER. Through an eastern window. Boston: Houghton Mifflin, 1965.
74. W. SARGANT. The mind possessed. New York: Lippincott, 1974.
75. A. LUDWIG. Int. J. Clin. Exp. Hypn., **12**:205, 1964.
76. W. G. JILEK and N. TODD. Can. Psychiatr. Assoc. J., **19**:351, 1974.
77. W. KEUP (ed.). Origin and mechanisms of hallucinations. New York: Plenum, 1970.
78. J. P. ZUBEK (ed.). Sensory deprivation: fifteen years of research. New York: Irvington, 1969.
79. R. FISHER. Science, **174**:897, 1971.

80. D. H. FUNKENSTEIN, S. H. KING, and M. E. DROLETTE. Mastery of stress. Cambridge, Mass.: Harvard Univ. Press, 1957.
81. M. B. ARNOLD. Emotion and personality. New York: Columbia Univ. Press, 1960.
82. D. BINDRA. *In:* P. BLACK (ed.). Physiologic correlates of emotion. New York: Academic Press, 1970.
83. S. SCHACHTER and J. E. SINGER. Psychol. Rev., **69**:379, 1962.
84. H. LONDON and R. E. NISBETT (eds.). Thought and feeling: cognitive alteration of feeling states. Chicago: Aldine, 1974.
85. D. J. BEM. *In:* ref. [84], p. 211, 1974.
86. S. VALINS. Jour. Pers. Soc. Psychol., **4**:400, 1966.
87. J. LAIRD and M. CROSBY. *In:* ref. [84], p. 44, 1974.
88. J. E. SINGER. *In:* ref. [84], p. 3, 1974.
89. C. T. TART. On being stoned: a psychological study of marijuana intoxication. Palo Alto, Calif.: Science and Behavior Books, 1971.
90. T. X. BARBER. LSD, marijuana, yoga, and hypnosis. Chicago: Aldine, 1970.
91. A. WEIL. The natural mind: a new way of looking at drugs and the higher consciousness. Boston: Houghton Mifflin, 1973.
92. P. C. WALKER and R. F. Q. JOHNSON. Psychol. Bull., **81**:362, 1974.
93. M. ZUCKERMAN. Psychol. Bull., **75**:297, 1971.
94. S. ARIETI and J. M. METH. *In:* S. ARIETI (ed.). Handbook of psychiatry, p. 546. New York: Basic, 1959.
95. A. KOESTLER and J. R. SMYTHIES (eds.). Beyond reductionism. Phoenix: Hutchinson, 1969.
96. F. J. AYALA and T. DOBZHANSKY (eds.). Studies in the philosophy of biology. Berkeley: Univ. California Press, 1974.
97. J. KOPA, I. SZABO, and E. ARASTYAN. Acta Physiol. Acad. Sci. Hung., **21**:207, 1962.
98. E. VALENSTEIN. Brain control. New York: Wiley, 1973.
99. A. HUXLEY. The doors of perception. London: Chatto & Windus, 1954.
100. A. WATTS. *In:* A. WATTS (ed.). What does it matter? New York: Pantheon, 1968.
101. H. SMITH. J. Philos., **61**:517, 1964.
102. R. E. L. MASTERS and J. HOUSTON. The varieties of psychedelic experience. New York: Holt, Rinehart & Winston, 1966.
103. G. BERMANT. A psychological perspective on autonomy. Unpublished manuscript, 1975.
104. R. J. JOYNT and M. N. GOLDSTEIN. *In:* W. J. FRIEDLANDER (ed.). Adv. Neurol., **7**:147, 1974.
105. R. W. SPERRY. *In:* F. J. MCGUIGAN and R. A. SCHOONOVER (eds.). The psychophysiology of thinking. New York: Academic Press, 1973.
106. T. NAGEL. Synthese, **22**:396, 1971.
107. D. GALIN. Arch. Gen. Psychiatry, **31**:572, 1974.
108. R. D. NEBES. Psychol. Bull., **81**:1, 1974.
109. S. FREUD. The interpretation of dreams. (1900) Westminster, Md.: Modern Library, 1938.
110. J. R. ROYCE. *In:* E. C. CARTERETTE and M. P. FRIEDMAN (eds.). Handbook of perception, p. 149. New York: Academic Press, 1974.
111. S. ARIETI. *In:* S. ARIETI (ed.). Handbook of psychiatry, vol. 3, p. 712. New York: Basic, 1966.
112. A. EHRENZWEIG. *In:* W. NEUSTERBERGER and S. AXELROD (eds.). The

psychoanalytic study of society, p. 373. New York: International Universities Press, 1964.
113. J. E. BOGEN. Los Angeles Neurol. Soc. Bull., **34:**135, 1969.
114. M. B. BOWERS and D. X. FREEDMAN. Arch. Gen. Psychiatry, **15:**240, 1966.
115. M. B. BOWERS. Arch. Gen. Psychiatry, **19:**348, 1968.
116. G. E. SCHWARTZ. Am. Sci., **63:**314, 1975.

THOUGHTS ON VIETNAM SPRING 1975

I

Jane Fonda, does your breast give milk?
And Hayden, are you angry still?

Where are the peacemakers
who wept and bleated for Bach Mai
but did not mourn ten thousand skeletons
at Hue?

Sing!
Sing cradle songs!
Sing to the torn and bloody children
of Da Nang!

II

Rage speaks no pity or remorse,
grief spills away in tears,
shame wears a multicolored cloak.

We have washed our hands in blood:
are they cleansed and pure?
Come, feel the sun and breathe Spring air!

They say that Judas hanged himself
and Cain became a wanderer.
Each ended with his treachery.

Wax corpulent and smug, O great
America. Deny the orphans
reaching for dead breasts!