EEG ALPHA PRODUCTION IN ALPHA CONDITIONING AND MEDITATION

by

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Abstract

Following training to discriminate their own alpha and non-alpha production, five subjects were tested over five sessions to determine whether EEG alpha autocontrol by this method was similar to that produced in initial meditation practice sessions by five naive meditators. Both groups were compared with a control "resting" group of five subjects. Besides alpha data, an adjective checklist and questionnaire were scored. No significant differences on percent alpha or alpha length were found between groups. However, the interaction effect approached significance. Meditators produced the greatest amount of alpha on the first session only and subsequently decreased alpha production. They also experienced more negative feelings over the sessions. Alpha conditioned subjects increased alpha production slightly as did the controls who produced somewhat less alpha than the former group. Relevance of the results to previous studies was discussed. Suggestions for further controls and methodological improvements were proposed.

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Operant Conditioning of Autonomic Nervous System Events

Miller (1969) pointed out that for the past 2,000 years the nervous system has been dichotomized. Voluntary responses of the skeletal muscles had been associated with reason and hence were regarded from a philosophical standpoint as superior, while the presumably involuntary glandular visceral responses were associated with the unreasoning emotions, constituting the inferior part. Similarly, or perhaps consequently, learning has also been dichotomized. Classical conditioning dealt with the learning of "involuntary" responses and instrumental or operant conditioning was responsible for "voluntary" behavior. Skinner and others concluded from very incomplete evidence that instrumental learning was possible only for "voluntary" nervous system events and that autonomic responses could only be conditioned classically (Kimmel, 1967; Miller, 1969). Miller, interested in the nature of this "dichotomy", began experimental work on the problem of instrumental training of visceral responses. Miller and his co-workers' first conclusive results were obtained in a study using water reinforcement for thirsty dogs in the operant conditioning of salivation (Miller, 1969; Miller & Carmona, 1967). Both increases and decreases in the salivation measure were produced.

To rule out the possibility of skeletal involvement in the learning of a visceral response, Miller and his associates used curare to produce paralysis of subjects' skeletal muscles. In these curare studies direct electrical stimulation of "rewarding" areas of the brain was used as reinforcement. Using this technique together with shaping of the desired responses, Miller and Di Cara produced reliable and significant changes in heart rate in curarized rats (Miller, 1969; Miller & Di Cara, 1967).

These experimenters also used escape and avoidance of electrical shock successfully as reinforcement for learning heart rate changes (Miller, 1969; Di Cara & Miller, 1968a), and demonstrated retention of the trained response for a period of at least three months. Transfer of training to the non-curarized state was also successful, and additional training increased specificity of response (Miller, 1969; Di Cara & Miller, 1969). Learning of a specific visceral response independently of other visceral responses was also found to be possible. Two groups of rats were trained to modify heart rate and intestinal contractions respectively. Rats trained to modify one response showed no change in the other monitored measure. Di Cara and Miller (1967) also obtained highly reliable changes in the rate of urine formation by curarized rats, the learned changes being produced primarily by changes in the rate of blood flow through the kidneys. Changes in blood supply to the stomach wall were also produced by instrumental conditioning. Peripheral vasomotor responses were shown to be conditionable by operant techniques, and conditioning of differential vasomotor responses in the two ears was shown (Miller, 1969; Di Cara & Miller, 1968b). Blood pressure increases and decreases, independent of heart rate, were also conditioned operantly. Without curare, heart rate changes were conditioned and the learned changes were found to persist in subsequent tests when curare was used.

Miller suggested that although instrumental learning of human visceral responses "has not yet been completely proved" (Miller, 1969, p. 443), demonstrations of the specificity of visceral change and similar controls make the cumulative results of a number of experiments with humans "increasingly impressive". In discussing the implications of this research, Miller suggested that therapeutic training of human patients with symptoms which are either functional or organic but under neural control, and which can be continuously monitored by instruments, is a distinct possibility. He and his co-workers have used instrumental training with cardiac arrhythmias and with suppression of abnormal paroxysmal EEG spikes in epileptics.

Kimmel (1967) reviewed the literature of instrumental conditioning of autonomic responses, including studies with human subjects. Like Miller, he concluded that the recent studies on heart rate, vasomotor reflex, salivation, intestinal contractions, and the GSR provided tentative support for the hypothesis that autonomically mediated responses can be conditioned by instrumental methods. Particularly notable are reward training methods where methodological problems of design confounding and possible somatic mediation of observed responses have been dealt with effectively. Kimmel noted particularly one study by Birk, Crider, Shapiro, and Tursky (1966) in which operant conditioning of the GSR was successful in a partially curarized human subject. Although somatic activity was not completely blocked, overt movements were ruled out as contributors to the GSR change.

Operant Conditioning of Electrical Activity in the Brain

Having shown that visceral responses could be conditioned operantly, Miller and his colleagues undertook similar experimentation with electrical activity in the brain. Cats were trained to change their EEG average voltage, using direct electrical stimulation of the medial forebrain bundle as a reward. Curarized rats were successfully trained in the same way (Miller, 1969).

Kamiya (1969a; 1969b) undertook the study of operant conditioning of the electrical activity of the human brain. In Kamiya's first study a subject, with eyes closed, was continually monitored by EEG equipment. He was instructed to respond "A" or "B" indicating in which state (alpha or non-alpha) he thought he was when a signal bell rang. He was told whether he was correct immediately following his response. By the fourth day of training the subject was reporting correctly 100 percent of the time (Kamiya, 1969a). To rule out the contribution of the possible auditory threshold difference between the two states, a further study was undertaken and discrimination of alpha and non-alpha was again found. An attempt to control eye position was introduced. Subjects were instructed to look straight ahead, because it had been found that without this attempt at control a raised position of the eyes occasionally produced alpha bursts and thus introduced skeletal involvement in the discrimination training. With this attempt to control eye position, discrimination performance dropped from 100 to 80 percent correct responses but with a small number of additional training trials performance again reached 100 percent (Kamiya, 1969a). Kamiya and his co-workers found that with successful discrimination training, subjects "seemed to have at the same time acquired the skills necessary for the control of the brain wave states that they had been discriminating" (Kamiya, 1969b, p. 510), but no comparison figures were presented. Kamiya stated that such results were not found in untrained subjects.

In a later series of studies Kamiya trained subjects to induce or suppress alpha on command without prior discrimination training, using a tone as feedback to indicate alpha (Kamiya, 1969a; Kamiya, 1969b). Subjects were given alternate series of five trials each for alpha enhancement and alpha suppression. Between blocks of trials "resting" recordings were obtained for which subjects were instructed to rest while the recording apparatus was supposedly being adjusted. The obtained resting "baseline" for alpha production was not a straight line; percent time alpha increased over blocks of trials (Kamiya, 1969b). Kamiya interpreted this finding as an indication that the experimental tasks set subjects into preferred modes of "waiting" and added that suppress-only subjects produced a decreasing baseline for percent alpha in the "rest" periods, indicating that these subjects were continuing what they were being trained to do. After 40 blocks of trials, eight of Kamiya's ten subjects were "able to control the tone, emitting or suppressing alpha waves in accordance with...instructions" (Kamiya, 1969a, p. 58).

Hart (1968) included a no-training control group in a study which is basically the same as Kamiya's feedback training designed to increase percent time alpha. Subjects in Hart's study were instructed to maintain the alpha feedback tone as long and as steadily as they could in each two-minute trial, and to maintain the same state during preceding and following non-feedback trials. Hart found that subjects who had both in-session feedback training and post-session information about their alpha scores showed greater alpha increases than those who had only feedback training. However, three of the five control subjects, who received post-session information only, also showed significant increases in their alpha scores. Hart concluded that the inclusion of such a control group was therefore necessary in an alpha conditioning experiment in order not to overestimate the effect of the training sessions. He noted also the great variability among individual curves.

In an analysis of variance Hart found a significant sessions effect over the training period but noted that no one group showed a significantly greater linear trend than the other groups. An analysis of the no-feedback trials for the trained subjects demonstrated that these subjects could sustain their alpha gains when feedback was not present.

Hart noted that the different training conditions "seemed to make a difference but the differences between the training conditions are overridden by the variability within each group" (Hart, 1968, p. 14).

Hart concluded that human subjects could be trained to increase their alpha levels in as few as ten training sessions and that in-session feedback training was most effective when information about alpha scores was given. However, he concluded from the performance of his control group that some subjects could increase alpha scores when given only post-session information about their alpha scores.

The subjective reports of Hart's subjects indicated, though with great variability, that a higher alpha level was pleasant, restful, and desirable. Some subjects felt that imagery and mental activity sustained alpha while others felt that subjective content was less important than relation to the content. Passive alertness apparently sustained alpha while selective or focused alertness seemed to inhibit alpha activity. One subject who showed a large increase in alpha activity stated that she imagined herself inside an artichoke, tranquil and detached, while perception of her surroundings seemed to be outside the layers of the artichoke.

These subjective reports are similar to those obtained in Kamiya's studies. His subjects indicated that a high alpha state was generally pleasant with "relaxation of the mental apparatus" and cessation of "being critical about anything, including the experiment" (Kamiya, 1969b). While the alpha state was reported as "not thinking", "letting the mind wander", or "feeling the heart beat", the non-alpha state appeared to occur when "seeing with the mind's eye" or observing various kinds of visual imagery (Kamiya, 1969a). In alpha conditioning when subjects were required to maintain an alpha feedback tone, it was observed that visual imagery was effective in decreasing the tone and an "alert calmness, a singleness of attention, and a passive 'following' of the tone sustained it" (Kamiya, 1969a, p. 58). It is also noted that Kamiya, as previously mentioned, obtained rapid alpha conditioning with attempted control of eye position. Kamiya concluded that alpha waves apparently result from an alert, non-drowsy state, devoid of concrete, visual imagery.

In a review of the literature of the properties of alpha activity, Kreitman and Shaw (1965) noted that alpha activity has been associated with inattention, particularly visual inattention; that attenuation and constriction of alpha activity during mental vigilance was said to be almost invariable; and that some studies showed no one-to-one relationship between alpha blocking and either visualizing or attention. Many confusing individual differences have been found, leading to the postulation of a much challenged classification of types. Kreitman and Shaw had observed an increase in alpha activity in some subjects with eyes open during mental arithmetic, and noted than none of the above views permitted an explanation for this augmented alpha activity. These authors stated that increased alpha activity associated with conditions other than drowsiness had been reported, notably during stimulus expectation, during fear, with "stimuli which cause sudden immobilisation of the reactive mechanisms", in listening to barely audible stimuli, and with some subjects during tactile stimulation, problem solving with eyes open, and mental multiplication. Increased alpha activity was also found with drugs such as atropine, without the presence of sleep (Bradley & Key, 1958).

In their experiment Kreitman and Shaw studied alpha change scores in auditory, visual, and tactile threshold or matching exercises, and a mental arithmetic test, with eyes open and closed for each condition. Significant differences were found between individuals and between tests. The authors emphasized that although visual imagery tended to be associated with alpha decreases, this held only as a trend with numerous and strikingly large exceptions. They suggested that attempts to relate changes in the alpha rhythm to any single process would likely not be successful. More detailed study of adaptation to a constant stimulus might be rewarding because alpha enhancement presumably differs from alpha blocking only quantitatively rather than qualitatively.

Other types of studies have been done with alpha conditioning and control of neural events. Rosenfeld, Rudell, and Fox (1969) trained human subjects with instrumental conditioning procedures to change the amplitude of a late component of the auditory evoked potential with and without oscilloscopic feedback of their performance. This type of procedure was designed to offer a strategy for investigating behaviorally relevant biolectrical activity of the brain by making the electrical activity, in this case the evoked potential, the criterion for reinforcement, as in Hart's (1968) study and Kamiya's later work (1969a; 1969b), rather than the dependent variable as in most previous studies (Fox & Rudell, 1968). Before Fox and Rudell's type of work, the typical experiment involved relating the biolectrical activity of the brain to changes in the behavioral state accompanying learning or differential performance. Fox and Rudell provided a modified approach making reinforcement contingent on the actual occurrence of a change such as modification of the evoked potential. In this way the reinforcement is expected to increase the probability of the occurrence of the response.

Rosenfeld et al. (1969) wanted to show that operant control of neural events was possible in the human subject and to determine by their subjective responses some insight into the subjects' method of control. Subjects were reinforced for increasing the calculated mean difference of the evoked response, then given suppression, reacquisition, and control trials. One group was given oscilloscopic feedback of their performance and a second group was trained in a dim light; the difference in scores was significant in both groups between conditions. The two groups were not statistically compared with each other but a graph of the mean results showed that oscilloscopic feedback produced a slightly higher percent of responses. The subjective data yielded no simple explanation of the mechanism of operant control. To be reinforced, subjects used imagined sights or sounds, or special attention to various aspects of the stimulation. Individual variability in both groups was marked.

Although the operant control demonstrated in their study was minimal, Rosenfeld et al. drew several conclusions. They argued against the hypothesis that subjects can learn a simple motor response whose somaesthetic feedback or efferent command generates the rewarded amplitude change, because the verbal reports and types of changes seen in the evoked potential showed too great a variability to be correlated with the occurrence of a simple motor response. The conclusion was drawn that the subjects learned to generate an internal state which probably mediated an altered evoked potential by somehow effecting a change in neural excitability or size of a particular neuron population.

Studies such as that by Fetz (1969) indicate that animals can be trained to increase the activity of individual cells by reinforcement of high rates of neuronal discharge. The systematic approach making the electrical measurement of the neural event the criterion for reinforcement, as suggested by Fox and Rudell (1968), was used in the Fetz experiment with monkeys. Because the cells monitored in the Fetz study were in the precentral motor (hand) area, increases in neural activity were sometimes accompanied by specific coordinated movements. After a number of training sessions, Fetz's monkeys consistently and rapidly increased the activity of newly monitored cells. It was possible to increase electrical activity at one locus with simultaneous suppression of activity at another locus.

Meditation: Overview and Subjective Reports

This short review of operant conditioning of ANS and CNS events suggests that subjects, including humans, can learn to exert some degree of autocontrol over these events. Both Kamiya (1969a; 1969b) and Hart (1968) pointed to the similarity between the reports of their subjects regarding the high alpha condition and description of Zen and Yoga meditation. Such practices are designed to increase autocontrol of mental and physiological processes (Conze, 1959; Eliade, 1958; Herrigel, 1964; Kapleau, 1967; Suzuki, 1956), and will be outlined briefly later. Kamiya (1969a; 1969b) reported that individuals who have some interest in and practice of meditation (including Zen, Yoga, other formal systems of meditation practice, or a "long history of introspection") apparently learned to control alpha, and particularly to enhance it, much more rapidly than other subjects. Kamiya (1969b) reported that he had been training some meditators on "marathon" runs up to 20 hours long. These subjects continued to increase their alpha production with this training. One subject after a total of 50 hours of training reached a plateau at 85 percent alpha from an initial 15 percent level. The author also noted that the "ineffability" of the meditative state, stressed in the mystical literature (Deikman, 1966a; James, 1961; Maupin, 1962; Murphy & Cohen, 1965; Noyes, 1965; Pahnke, 1966), was similar to the statements of many of his alpha conditioning subjects. For example, the alpha state was found difficult to describe but had a certain "feel" about it, and when an attempt at its analysis was made during training the subjects did not perform well. Hart (1968) suggested that the previously mentioned artichoke imagery report becomes more meaningful when related to the EEG investigations conducted with meditating Buddhist Zen practitioners and Indian yogis.

In general, meditation practice involves prolonged motionless sitting with legs fully or half crossed, hands touching each other at the navel or resting joined in the lap, and eyes either closed (in Yoga) or open slightly and looking downwards a short distance ahead (in zazen) (Kapleau, 1967; Kasamatsu & Hirai, 1966; Maupin, 1965). Specific meditation exercises may involve concentration on a word, an idea, or a process such as respiration. Kapleau (1967, pp. 30-62) included a detailed account of the posture and concentration practices involved in zazen, which is translated as "sitting meditation", and Eliade (1958) elaborated on yogic practices.

The practice of meditation is said to produce a state of attentive awareness with calming of mental activity. Ultimately its aim is to promote a changed state of consciousness which is called satori or enlightenment in Zen, and samādhi in Yoga, leading to mukti or liberation. Maupin (1962) presented a review of Zen training methods, resulting experiences, and possible psychological interpretations. Here he described satori as a major shift in the mode of experiencing oneself and the world. Fromm (cited in Maupin, 1962, p. 366) considered satori to be "the immediate unreflected grasp of reality, without affective contamination and intellectualization".

Few psychological studies have been done on the non-physiological aspects of meditation practice. In a study of individual differences in response to a Zen meditation exercise, Maupin (1965) scaled meditation responses of his group of subjects on the basis of post-meditation reports and correlated these with aspects of personality functioning. Correlations were found between level of meditation responses and the Rorschach measures of tolerance for unrealistic experience and capacity for controlled primary process.

Deikman (1963) undertook an exploratory study of "contemplative meditation", designed according to the general descriptions of meditation and incorporating the specific instructions found in the mystic literature. Meditation on an object (in this study, a neutral vase) was chosen as a technique. Attention was to be focused on the vase without analysis or association. Subjective phenomena reported over the 12 or more sessions included alteration of perception of the vase, time shortening, conflicting perceptions, increase in ability to exclude extraneous stimuli, personal attachment to the meditation object, and pleasurable quality of the sessions. Other less general phenomena were also reported, including some "mystical"-sounding experiences (Deikman, 1966b). The hypothesis that contemplative meditation training produces barriers against distracting stimuli was supported by the subjective reports but not by the recognition test presented (Deikman, 1963).

Based on the subjective findings of his exploratory study, Deikman proposed the concept of "de-automatization" to describe the course of meditation phenomena. In his 1963 paper, Deikman emphasized the rapidity with which the phenomena mentioned previously were produced in his meditating subjects. He stated that in less than half an hour phenomena occurred which in other contexts have been described as "depersonalization", "hallucination", "delusion", etc. These experiences are called "makyo" in zazen and there are to be ignored as they arise (Kapleau, 1967). In contrast with Deikman's classification of subjective responses, Maupin's subjects, practicing a Zen breathing exercise, experienced in order of response scaling: dizziness or some "befogging" of consciousness; calmness with relaxation; pleasant body sensations including vibrations, waves, or the feeling that the body was suspended or light; vividness of breathing with almost effortless concentration; and a lucid state of consciousness with a "non-striving" attitude, detachment of thoughts and feelings, and often extensive loss of body feelings (Maupin, 1965).

Physiological Studies of Meditation

Physiological aspects of meditation practice have been studied more extensively and systematically than its subjective aspects, providing some basis for comparison with results of CNS and particularly alpha discrimination training. Kasamatsu and Hirai (1963; 1966) recorded EEG changes continuously before, during, and after zazen in 48 disciples and priests of the Soto and Rinzai sects in Japan, along with pulse rate, respiration, and GSR. These investigators divided the EEG changes found into four stages: appearance of alpha waves with eyes half open, increase of alpha amplitude, decrease of alpha frequency, and the occasional appearance of theta trains. These changes did not occur in control subjects. Compared with a control group, Zen masters showed little or no habituation (decreased alpha blocking time over trials) to a repeated click stimulus. These changes were closely related to length of training and Zen master's progress evaluation (Kasamatsu & Hirai, 1966). These authors noted that the disciples sometimes fell into a drowsy state during meditation but when the click stimulus occurred the drowsy EEG pattern changed to the alpha pattern, showing an alpha arousal reaction. However, Kasamatsu and Hirai (1966) systematically compared the EEG changes of meditation with those of sleep and hypnotic trance, showing the divergence of the meditation pattern from the other two states. The authors called the meditation state "relaxed awakening with steady responsiveness", a report which is in agreement with Kamiya and Hart's descriptions of the alpha state.

In their series of studies of zazen Kasamatsu and Hirai found that the respiratory rate during meditation decreased rapidly to about four per minute, the tidal volume increased and oxygen consumption decreased by about 20 to 30 percent of the normal rate. Metabolic rate also decreased to a level lower than that shown in control subjects whose respiration rate was decreased to the same level paced by a metronome. Nakamura, Iwasaki, and Akishige (1961) noted a decrease in blood pH during zazen, indicative of the "tranquillizing effect of the regulation of respiration". Sugi (cited in Sugioka, Nara, Yokowo, Sasaki, & Kasai, 1962) examined physiological effects of zazen in the Soto sect and obtained similar findings. Respiration rate fell to one to two per minute, the basic metabolic rate decreased, sweating ceased, and both alpha and theta waves rapidly appeared with the onset of meditation.

Anand, Chhina, and Singh (1961) found persistent alpha activity with well marked increased amplitude modulation in four yogis practicing Raj Yoga meditation. No external stimuli, including strong light, loud noises, touching with a hot glass tube, and the vibration of a tuning fork, produced blocking of the alpha rhythm when the yogis were meditating, but this loss of alpha blocking was not shown when the same subjects were resting. This finding is in contrast with EEG findings regarding alpha blocking during zazen (Kasamatsu & Hirai, 1963; Kasamatsu & Hirai, 1966), and probably reflects the effects of different meditation practices. Two of the subjects immersed their hands in cold water, during which time alpha activity persisted (Anand et al., 1961). These experimenters also noted that beginners in Yoga meditation practice who had well marked alpha activity in their resting records showed greater aptitude and enthusiasm for maintaining Yoga practice.

Okuma, Takenaka, Koga, Ikeda, and Sugiyama (1957) found similar EEG changes in practitioners of zazen and yogic meditation. With the progress of meditation performances, alpha waves increased "remarkably" even with eyes open. Control subjects at the same stage in EEG recording did not show this alpha increase. These experimenters reported that the alpha activity was "hardly depressed" by auditory stimuli such as claps or bells, but gave no figures.

In a study of autonomic functioning in Yoga practitioners (principally Hatha Yoga), Wenger and Bagchi (1961) found somatically mediated changes in cardiac functioning. Greater sympathetic nervous system activity was found during meditation, with the exception of respiration which was greater during resting sessions, slowing to four to seven per minute during meditation. Older yogis showed faster heart rates, lower finger temperatures, greater palmar conductance, and higher blood pressure than students during meditation, suggesting an active process rather than a passive, relaxed contemplation although some muscular relaxation occurred.

No definite EEG changes were found during meditation; subjects reported discomfort with the recording apparatus and the presence of foreigners, resulting in lack of depth in meditation.

Wallace (1970) studied the effects of "transcendental" meditation practice on oxygen consumption, heart rate, GSR, and EEG, finding significant changes between the control period and the meditation period in all measures. Because of the difficulty in obtaining expert practitioners of zazen or yogic meditation, and the claim that practitioners of transcendental meditation immediately experience beneficial physiological changes with no difficulty, Wallace selected for his study 15 college students whose practice of transcendental meditation had ranged from six months to three years. Visual and auditory stimulation was given during several recordings to test habituation of alpha blocking. Oxygen consumption decreased about 20 percent from the control period in all subjects within five minutes after the onset of meditation. Skin resistance increased markedly at the onset of meditation with some rhythmical fluctuations during meditation but decreased to the resting level following meditation. Heart rate showed a mean decrease of five beats per minute during meditation. Regularity and amplitude of alpha increased in all subjects and four showed alpha frequency slowing and occasional theta waves. The study reported that in almost all subjects, alpha blocking caused by repeated auditory or visual stimulation showed no habituation, as in Kasamatsu and Hirai's (1966) study. From his physiological findings Wallace concluded that the state produced by transcendental meditation "seems to be distinct from commonly encountered states of consciousness, such as wakefulness, sleep, and dreaming, and from altered states of consciousness, such as hypnosis and autosuggestion" (Wallace, 1970, p. 1754), and that its clinical applications should be further investigated. Wallace mentioned two studies investigating the therapeutic value of meditation in relieving mental and physical tension and in controlling arterial blood pressure.

In an EEG, EKG, and EMG study of seven yogic meditators, Das and Gastaut (1955) found no muscular electrical activity during the meditation practice. Definite acceleration of the cardiac rhythm during profound meditation occurred especially in samādhi, interpreted here as "ecstasy", with slowing after the end of this period paralleling EEG changes. Acceleration and decreasing amplitude of the alpha rhythm was also found, with generalized very fast (25-30 to 40-45 cps) activity of small amplitude increasing during samādhi. This state of "intense generalized cortical stimulation" is in contrast with the EEG findings in zazen (Kasamatsu & Hirai, 1963; Kasamatsu & Hirai, 1966) and other types of yogic meditation (Anand et al., 1961; Okuma et al., 1957).

Although EEG findings in meditation studies differ somewhat, most show an increase in alpha activity often with eyes open, and a difference from EEG patterns characteristic of states such as sleep and hypnosis (Anand et al., 1961; Kasamatsu & Hirai, 1963; Kasamatsu & Hirai, 1966; Okuma et al., 1957; Sugioka et al., 1962; Wallace, 1970). Kasamatsu and Hirai (1966) indicated that the sleep EEG pattern diverged from the meditation pattern in that further EEG changes occurred in the sleep pattern, such as fast activity and the appearance of spindles, which did not occur in meditation. Kasamatsu and Hirai described meditation as a prolonged continuation of the pre-sleep pattern but accompanied by alertness.

However, all of these physiological studies of meditation have used relatively experienced meditators as subjects. No physiological investigations of the initial stages of meditation practice have been published, although inexperienced subjects were used in the clinical research studies of Deikman (1963) and Maupin (1965). It would be informative to make a longitudinal study of the physiological changes produced during meditation practice, starting with naive subjects.

Kamiya (1966a) noted the close resemblance of the description of the "high alpha state" and reports of Zen and yogic meditation, and as indicated previously, found that Zen meditators learned his alpha conditioning tasks more rapidly than his average subjects. It appears that the state promoted in conditioning studies designed to increase alpha output closely resembles that produced after some meditation practice. As Kasamatsu and Hirai (1963; 1966) reported, other changes also occur in meditation besides increased alpha output. Because these two practices appear to share some characteristics, however, including some physiological changes and subjective similarities, it would be appropriate to study parallel stages in their development of alpha autocontrol. Kamiya (1969a), noting the similarity between the two processes, stated that "the fact that for many centuries mystics have been doing something measurably real suggests that the meditative tradition is worth examination" (p. 59).

Consequently an exploratory investigation was designed to compare the effects of alpha conditioning on the production of alpha in subjects trained to discriminate their own production of alpha and non-alpha, and the effects of meditation practice on the production of alpha in subjects' initial meditation sessions. A control group completing the same number of EEG recording sessions would be included. Findings from this type of study would be useful in developing autocontrol training procedures and possible therapeutic applications.

Method

Subjects

Subjects were 15 volunteers from an introductory course in religious studies at the University of British Columbia. About 75 students volunteered to participate in "a study of meditation and alpha conditioning" after a short lecture by the experimenter explaining the nature of meditation and alpha conditioning as used in this study, EEG recording techniques, and the duration of the experiment. However, the experimenter did not reveal the specific nature of the experiment itself or its hypotheses. All subjects who participated in the training and test sessions were female as there were insufficient males who could be matched on the basis of the resting recording sessions. Subjects ranged in age from 18 to 24 with a median of 19 years. Most (11) of the subjects were enrolled in second year arts and most had chosen the religious studies course for interest. None had ever seriously practiced meditation; one subject (JM) had tried meditation over a period of several months but at the time of the experiment had not meditated for over one year. She was assigned to the alpha conditioning group.

Apparatus and Procedure

From the list of volunteers about 30 were chosen at random to participate in the resting recording sessions. Subjects sat in a straight backed chair with a Peerless dental headrest adjusted to keep the head relatively immobile but comfortable during the recording. Parieto-occipital EEG recordings were made on a Grass Model 7 polygraph, using a single pair of cup electrodes filled with Grass electrode cream. The occipital electrode was placed approximately 2-3 cm. anterior to the inion on the midline, roughly corresponding to electrode placement OZ according to the

10-20 system. The parietal electrode was placed slightly posterior to the midline central point near position PZ. The electrode ground was filled with electrode cream and clipped to the subject's right earlobe. The signals were amplified by a Grass 7P5A wideband EEG pre-amplifier. A Krohn-Hite Model 330B band pass filter, attached in series, restricted the recorded signal to a frequency range of 8-12 Hz. Recording sessions were conducted with the single overhead light turned down so that there was sufficient light to see the ink recording but not enough to distract the subject.

Each of the selected volunteers was given three one-minute resting recording sessions to determine the basal rate of alpha production with eyes closed. These sessions were given during one hour with rest periods between each session in which the experimenter recorded personal data in an informal manner from the subjects, including age, reason for taking religious studies, course of studies, year, major, and previous meditation practice and "mystical" or "peak" experiences.

The polygraph records of the resting sessions were scored for each subject, using a criterion of a minimum of four regular waves of a higher amplitude than the irregular surrounding waves to determine where alpha would be marked. Keesey and Nichols (1967) used different criteria for each of their two subjects with respect to amplitude, frequency, and duration of the alpha rhythm. One subject in their study had to have five full waves to be counted as alpha. A single criterion was used for the present experiment as it appeared to be the simplest scoring method which included the greatest number of potential alpha bursts and excluded obviously non-alpha waves better than other possible criteria.

All records were scored by hand by the experimenter, with an independent scorer checking records at random to determine the consistency of criterion application. The alpha bursts were measured in cm. and totalled for each session. Obvious muscle artifacts, usually of very short duration, were measured and this length of time was added to the recording session and also scored. To allow for this possibility, recording was continued about 20 sec. over the desired limit for each subject. The total percent alpha for each session was calculated on this basis. The "resting alpha" score was obtained for each subject by calculating the mean percent alpha over the three one-minute sessions. A mean alpha burst length score was also obtained.

On the basis of ease of scoring of the resting recordings and matchability of the percent of resting alpha with other subjects', 15 subjects were then assigned to groups according to the percent of alpha in their resting recording. On this basis the subjects fell into five non-overlapping groups with the following percent alpha ranges: 13-19%, 27-33%, 34-42%, 46-59%, and 78-88%. One of the three in each group was assigned to each experimental condition, alpha conditioning, meditation training, and a control condition.

Alpha Conditioning Procedure. Subjects assigned to the alpha conditioning group were trained individually, following Kamiya's early discrimination training procedure (Kamiya, 1969a; Kamiya, 1969b). Each was trained in the same experimental room under the conditions of the resting recording sessions, except that the headrest was omitted because subjects had noted that it was uncomfortable and that they could remain as motionless without it. Electrode placement was also the same as during the resting recording sessions.

Alpha conditioning subjects were trained to discriminate their own alpha and non-alpha production to a criterion of 90% correct responses in the final training run. At the first session subjects were instructed to reply "X" or "Y" immediately following each click signal (see Appendix I). The click was produced at random intervals by the experimenter's release of the EEG timer button, automatically marking the subject's recording. The click was clearly audible but occasionally varied in intensity if the experimenter released the button at a different angle, obviating the necessity of controlling for threshold differences as in Kamiya's (1969a) experiment. "X" and "Y" were alpha and non-alpha respectively. (These letters were chosen so that the experimenter could readily discriminate the two sounds and so that the subject would not associate them with alpha or non-alpha states as would be suggested by using the letters "A" and "B".) Immediate verbal feedback was given regarding the correctness of the response. Each training session lasted 20 min. to 1 hr., depending on the subject's available time, with a varying number of runs in each session. Periodic breaks between runs were taken so that the subject could verbalize her changing conceptualizations of the nature of X and Y. During these periods the experimenter was noncommital but supportive regarding the subjects' hypotheses about the two states. Subjects took three to five sessions, each including a number of runs, to reach a criterion of 90% correct responses.

When this criterion had been met and the subjects felt they knew what "produced an X state in themselves", test sessions were given. EEG recording procedures were the same as previously detailed. The alpha-conditioned subjects were instructed to produce as much X as possible using any method they could find for as long as possible during the test session, and to remain as motionless as possible with their feet flat on the floor, hands in their lap, and eyes closed (see Appendix I). The test sessions consisted of two 10-minute recording sessions conducted on the same day with a short rest period between the two, and subsequently three 15-minute recording sessions conducted at different times convenient to the subjects. After the first session instructions were given in an abbreviated form. On completion of the five test sessions the subjects completed a brief questionnaire and adjective checklist recording their subjective feelings overall and reactions to each test session (see Appendix II).

Meditation Procedure. Training for the meditation group consisted of meditation practice during the two 10-minute and three 15-minute recording sessions, with no practice previous to or between these test sessions. The meditation exercise chosen was the breathing exercise used by Maupin (1965) in his meditation study. Subjects were instructed to sit up straight with their feet flat on the floor, hands in their lap, and eyes closed, and to remain as motionless as possible during the test session, as in the alpha-conditioning test sessions. The meditation subjects were instructed to focus their attention on the breathing movements in the region of the abdomen, to disregard all other stimuli, and to bring their attention back to the breathing each time it focused on any other stimulus (see Appendix I). Meditation subjects completed the same questionnaire and adjective checklist as the alpha-conditioning subjects.

Control Procedure. Subjets assigned to the control group received the same preliminary instructions regarding posture during EEG recording as those in the other two groups. Control subjects were instructed to try to maintain an observing attitude (i.e., not to fall asleep) during recording but to let their thoughts "wander" as in the resting sessions. The same questionnaire and adjective checklist was administered.

<u>Analyses</u>. The test session data for all three groups was scored in the same way as the resting session data, to yield two measures, mean length of each alpha burst and total percent time spent in alpha for each session. The scores thus found were analyzed according to a repeated measures analysis of variance design comparing treatment conditions and test sessions. Further, the 15-minute sessions were converted to 10-minute session scores by subtracting from the total the lengths of alpha bursts occurring in the first and last $2\frac{1}{2}$ min. of recording. This transformation was made because subjects in a pilot study reported that it took a few minutes to begin meditation practice and subjects occasionally became bored or restless towards the end of the 15-minute sessions. The obtained data was also analyzed. To determine whether the alpha criteria used were adequate discrimination measures, an independent scorer re-marked the first test session for all subjects, using the alpha criterion of five regular waves of greater amplitude than the surrounding irregular waves. These modified-criterion scores were compared with the original scores. The adjectives checked on the checklist were also compared between groups.

Results

As noted in the Method section, the 15 subjects fell into five non-overlapping groups according to the amount of alpha in their resting recording. Alpha burst mean lengths also varied over individuals. However, when subjects were matched according to their mean alpha length scores in the resting sessions, it was found that the five original groups overlapped slightly. Groups 2 and 3 overlapped somewhat, as did groups 3 and 4. In general, an increase in alpha length score was accompanied by an increase in mean percent alpha. Alpha amplitude varied across individuals. However, those producing the most alpha generally had the highest amplitude alpha waves.

Alpha Discrimination Training Results

The subjects who participated in the alpha discrimination training sessions took between three and five sessions to reach a criterion of 90% correct responses on the last training run. The percent of correct discrimination responses (X or Y) for the first and final runs is shown in Table 1.

Table 1

Percent Correct Responses on First and Last Alpha Training Runs

Subject	First Discrimination Training Run	Last Discrimination Training Run
WR	75.6	92.2
LA	68.0	95.8
NF	70.1	96.4
JM	79.7	93.5
PH	86.4	96.4

Subjective Alpha Conditioning Results

During alpha discrimination training subjects varied in the length of time taken to reach what they thought was an adequate description of the subjective distinction of X (alpha) and Y (non-alpha). Subject WR described Y as seeing a cloud over a city or a tunnel with a light at the end, and X as the fading of the cloud or the disappearance of the tunnel. Subject LA described Y as seeing things in front of her eyes and X as concentrating on the sound of the EEG machine; this subject also noted that if she did not clearly remember the click or was "not with it", she was in X. Subject NF distinguished Y as being associated with a floating feeling while X was heavier. Subject JM, the girl who had had some previous meditation practice, was the only subject who verbalized a definite distinction between X and Y on the first training run. This subject noted that in X her head from the eyes up felt light and empty as if "impulses were shut down" although in this state "thinking on a low level was still possible". Y occurred when she was "thinking about how empty" her head was, an "ego trip". Like subject LA, she also noted that with a "really big X" she could not even remember the click. Subject PH described Y as "tighter, more of a sensation than X". Because this subject originally had almost 90% alpha in her resting recording, discrimination training was difficult. However, several training runs were made with eyes half open to lessen alpha production. Subject PH said that this training definitely helped and compared the feeling of X with being at the bottom of a staircase with high steps, the steps being more difficult to climb as they neared Y, which she "burst into" near the top. To retreat to X required "effortless sliding" but to get deeply into it required "slow downward stepping".

It is noted that because the experimenter was giving immediate feedback on the correctness of the subject's response while the polygraph recording was being made, with no concurrent computer analysis of the record as in many alpha conditioning studies (e.g. Kamiya, 1969a; Kamiya, 1969b), the occasional error was made or a "not sure" or a "just between" response was given. Rather than confusing the subjects, this type of response seemed to clarify the distinction between X and Y because several subjects reported that they experienced some "deeper" X states and were often not sure themselves about transitions from one state to the other such as at the end of an alpha wave.

Comparison of Test Sessions on Mean Percent Alpha

The mean percent alpha scores for the resting and test sessions are shown in Tables 2a and 2b.

Table 2a

Percent Alpha by Sessions

	S	Resting Session	First Session	Second Session	Third Session	Fourth Session	Fifth Session
Control Group	LP	19.4	17.6	19.6	26.5	34.5	15.9
	SB	30.6	38.9	37.3	45.7	44.1	58.4
	BBr	42.1	25.7	30.6	15.9	37.3	36.0
	BBa	46.8	50.7	75.8	81.9	77.5	87.7
	JL	78.0	86.4	87.6	85.5	80.9	88.5
Alpha Conditioning Group	WR	13.6	15.1	18.5	25.7	29.1	18.3
	LA	27.8	50.4	64.9	49.8	44.4	39.2
	NF	34.3	19.4	30.8	43.2	24.1	37.4
	JM	59.4	72.1	92.8	89.6	92.4	90.5
	PH	87.3	94.8	95.3	95.2	95.2	92.8
Meditation Group	DMc	14.4	25.9	19.6	21.9	15.4	20.6
	WS	33.6	56.9	52.3	58.4	63.0	64.4
	DV	39.3	50.4	46.0	41.7	27.0	30.7
	CD	56.0	57.0	61.9	53.2	74.4	41.5
	MN	88.6	93.3	92.7	91.2	89.0	87.9

Table 2a shows the scores used in the main analyses of this study. Table

2b, which follows, includes the percent alpha scores obtained by the independent scorer for the first 10-minute session using the more stringent alpha criterion and the reduced 10-minute percent alpha scores for the last three sessions, as detailed in the Method section.

Table 2b

Modified Percent Alpha by Sessions

	S	First 10 Min. (Modified Criteria)	First 15 Converted to 10 Min.	Second 15 Converted to 10 Min.	Third 15 Converted to 10 Min.
Control Group	LP	9.5	26.8	35.1	14.7
	SB	29.9	43.4	49.0	61.3
	BBr	19.3	13.6	38.2	38.4
	BBa	71.7	85.7	80.1	87.9
	JL	80.3	89.7	82.4	91.1
Alpha Conditioning Group	WR	8.1	25.6	28.6	18.1
	LA	44.1	47.3	35.9	38.9
	NF	13.0	42.3	23.6	34.3
	JM	68.7	90.0	91.5	90.6
	PH	93.2	95.2	95.4	94.9
Meditation Group	DMc	21.4	19.3	12.6	18.1
	WS	51.3	59.8	64.3	65.2
	DV	43.4	40.4	23.6	30.7
	CD	40.7	53.6	74.1	36.4
	MN	86.1	92.6	90.2	87.2

These scores were analyzed only to determine whether the original scoring was adequate, and were not further analyzed.

Figure 1 graphically compares the first 10-minute session scored by the original and the more stringent criteria. The original criterion for alpha scoring (see Table 2a for results) was used throughout because it was found that with the more stringent criterion, although most alpha scores were reduced, 10 of the 15 subjects remained in the same rank order

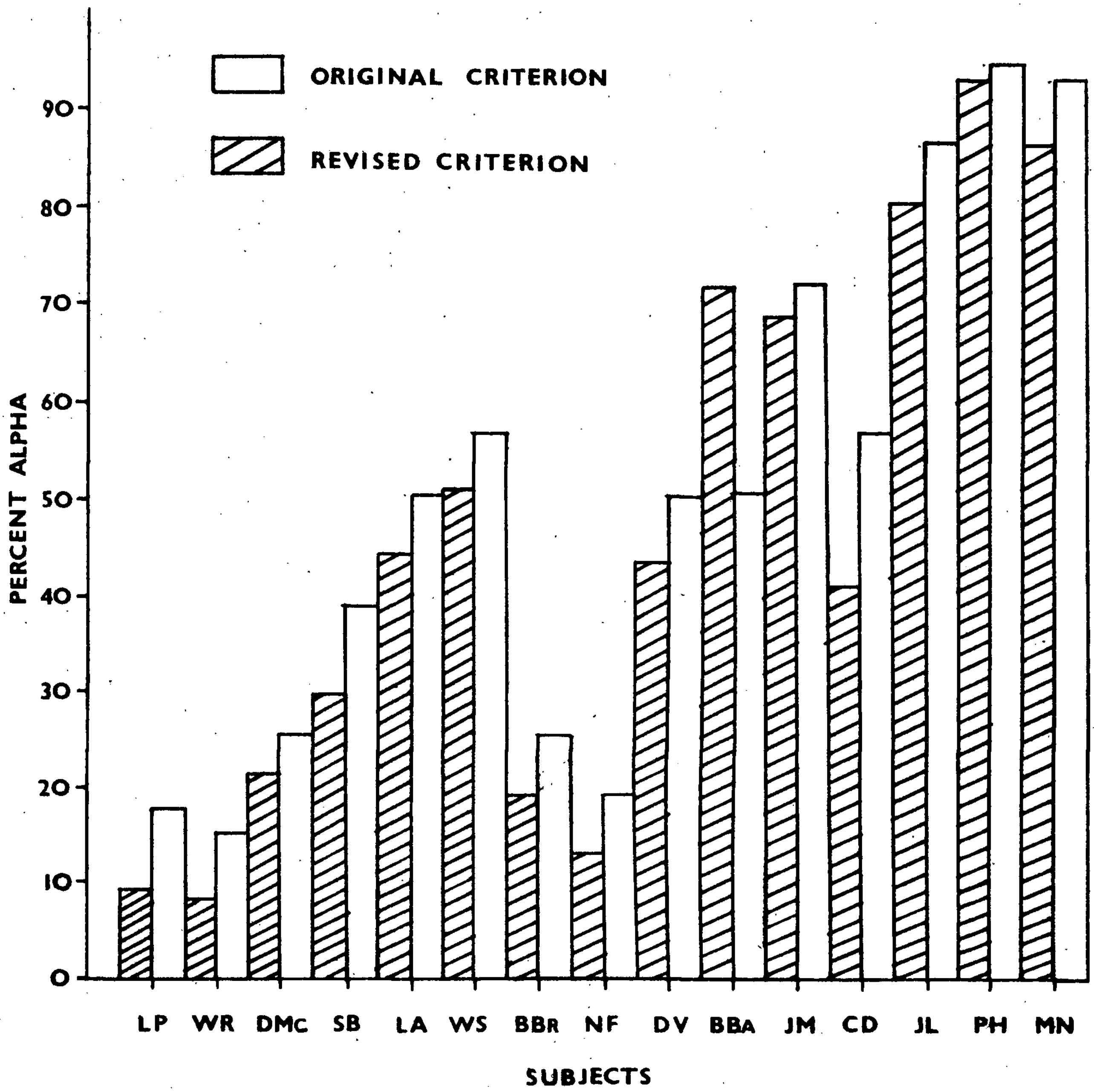

Fig. 1. Comparison of scoring criteria.

for mean percent alpha. A comparison of ranked data on the first 10-minute session showed only one rank changed in the control group, and two in the alpha conditioning and meditation groups.

An analysis of variance for repeated measures was performed with the original data and with the modified five 10-minute sessions' percent alpha data, following Winer (1962). Neither of these analyses showed significant main effects in conditions or test sessions (see Appendices III and IV). In both analyses the probability of occurrence of the interaction effect was between .25 and .10; this effect is noticeable in Figure 2, showing the group means over resting and test sessions. In order to determine whether an overly conservative estimate of group variance was obtained, an analysis removing the matched-group correlation component was calculated for the first test session (after Courts, 1966, pp. 280-285). The obtained $F_{2,8}$ of 2.59 was not significant.

While the control group means for percent alpha consistently increased over the five test sessions, the alpha conditioning group means started at a higher level than control scores, increasing for the first three sessions and then decreasing for the last two test sessions. The meditation group showed the highest first-session percent alpha mean but from there consistently decreased mean percent alpha over sessions.

An analysis of simple effects was done, following Kirk (1968), to determine which main effects contributed to the interaction effect. A summary of this analysis is shown in Appendix V. It showed a significant difference on the first test session at the .05 level, with an F of 3.17. Examination of Figure 2 shows that the meditation group produced the greatest amount of alpha on this session, and the differences between groups is greatest for this test session. An inspection of the individual

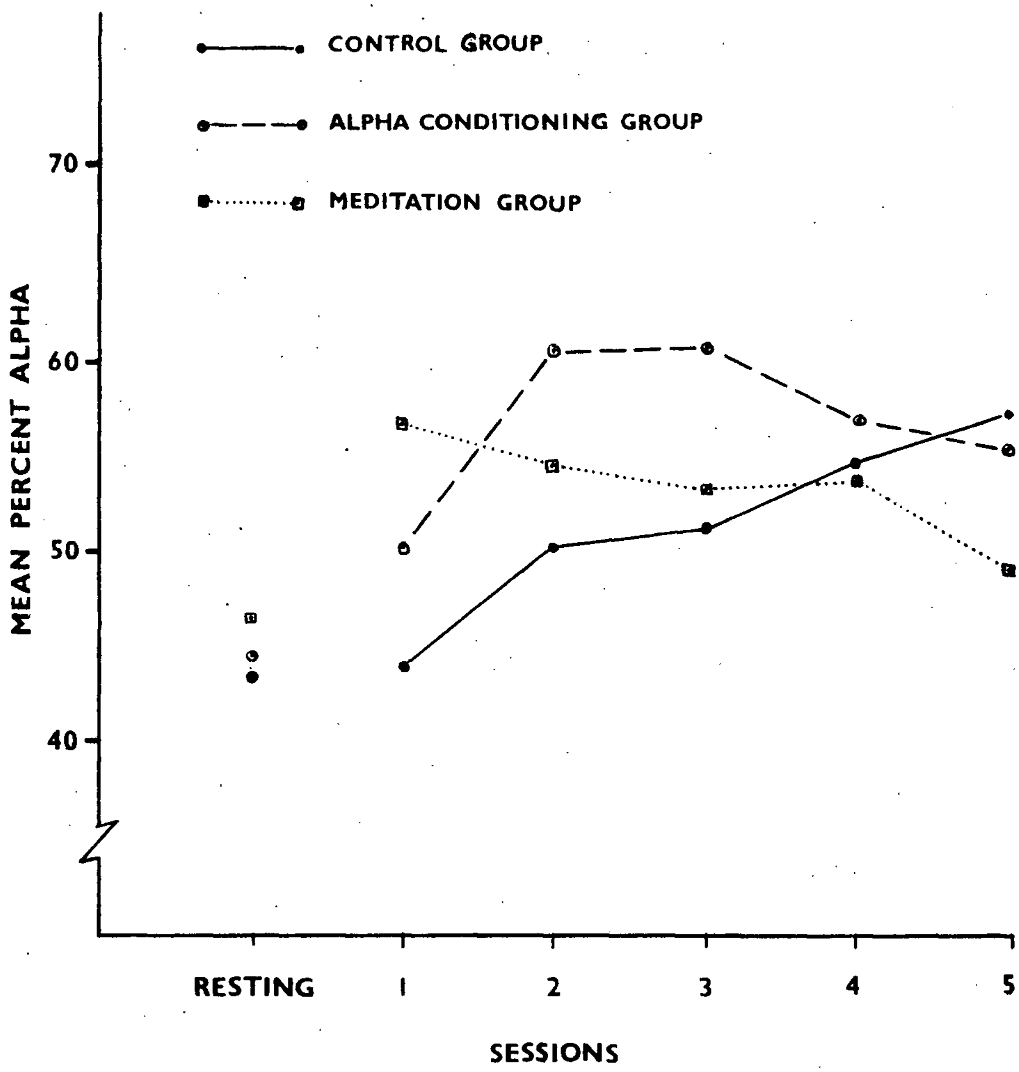

Fig. 2. Percent alpha over sessions.

scores (Table 2a) shows wide individual variability over sessions. In order to make inter- and intra-individual comparisons more readily, difference scores were calculated for each subject, subtracting the resting session percent alpha from the test session score. Although the groups were matched originally on the basis of percent resting alpha, this procedure made it easier to observe magnitude of changes over sessions (see Appendix VI). An analysis of variance performed on this data was essentially the same as those previously discussed, with an interaction effect having a probability of occurrence between .25 and .10. Although difference scores customarily produce less significant statistical results, the comparison between the two analyses showed little difference.

Comparison of Test Sessions on Mean Alpha Length

Mean length of alpha for each subject over sessions (see Appendix VII) was also analyzed according to a repeated measures design. Main effects (experimental conditions and sessions) were not significant. The significance of the interaction effect was between .25 and .10. The analysis of variance summary is shown in Appendix VIII. Figure 3 presents this comparison of groups over sessions. It is notable that the alpha conditioning group showed the greatest increase in mean length of alpha and also in percent alpha, while the meditation group at the first session had a slightly greater increase than the control group but thereafter showed a decrease in alpha length to a point slightly below their resting alpha length in the fifth session.

Differences between the resting and test session alpha lengths were calculated as for the percent alpha differences, and are shown in Appendix IX. An analysis of variance of the alpha length difference scores showed no significance in main effects but an interaction effect probability

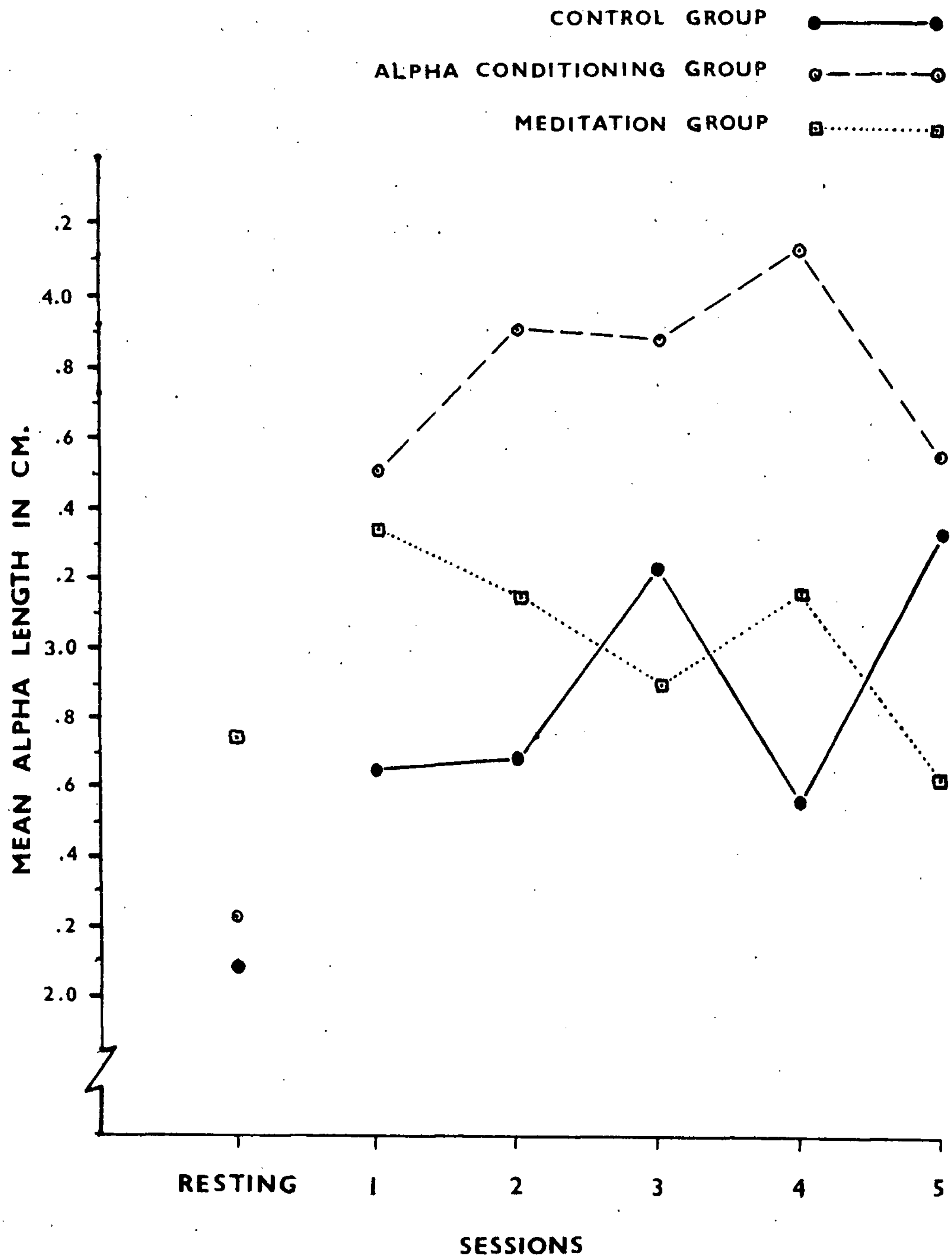

Fig. 3. Mean alpha length over sessions.

between .10 and .05. The summary of this analysis is shown in Appendix X. A comparison graph of the two measures (percent alpha and alpha length differences) is illustrated in Figure 4.

Adjective Checklist Data

From the adjective checklist completed at the end of the five test sessions by all subjects, nine "positive" adjectives and their approximate negatives were selected for a post hoc analysis of the general subjective reaction to the test sessions. Other adjectives originally included on the checklist could not be matched in this way. On this measure subjects were instructed to check the words which described the feelings, thoughts, or sensations experienced at any time during the test sessions. The adjectives for this exploratory analysis are shown in Table 3; these were selected for post hoc analysis because positive and negative adjectives appeared to differentiate better between groups than other types of descriptors. The frequencies for the selected adjectives checked by each group are shown in Table 3 on page 36. A chi square analysis of this data showed a difference significant at the .01 level. Inspection of the cells in Table 3 indicates that there was a tendency for the control subjects to give more positive and fewer negative responses than either of the other groups.

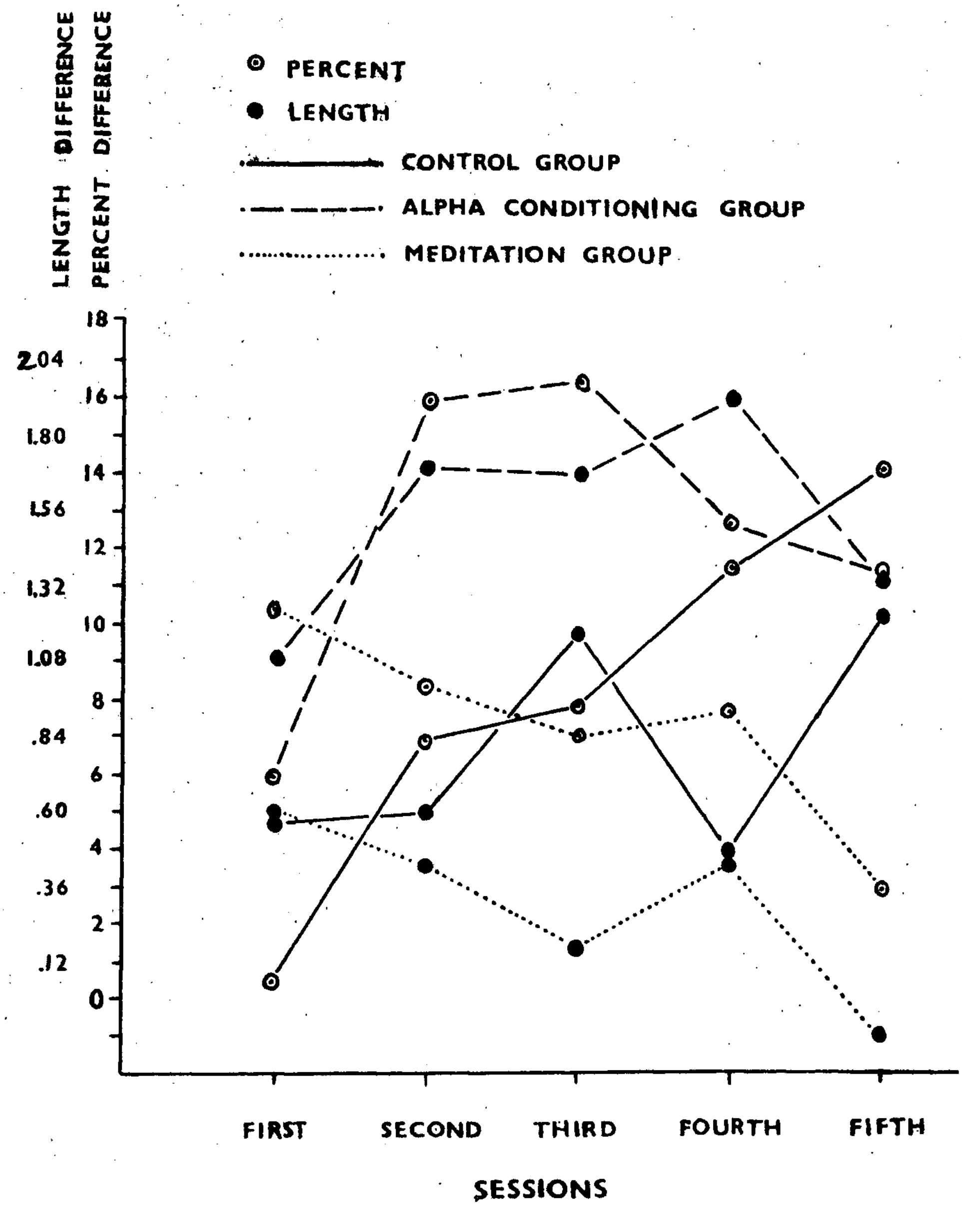

Fig. 4. Comparison of groups on mean percent alpha differences and mean alpha length differences in cm.

Table 3

Frequency of Positive and Negative Adjectives Checked

Group	Positive[1] Adjectives	Negative[2] Adjectives	Totals
Meditation	24	13	37
Control	30	1	31
Alpha Conditioning	22	7	29
Total	76	21	97

[1] comfortable, imaginative, tranquil, peaceful, detached, pleasant, calm, relaxed, self-possessed

[2] uncomfortable, bored, fidgety, impatient, critical, irritated, disturbed, restless, anxious

Discussion

A direct comparison of the alpha changes produced by alpha conditioning techniques and by meditation has never been made previously. Hence, the present findings cannot be compared directly with those of other studies. Further, physiological measurements of initial meditation states have not been reported. Consequently, the results can be only partially compared with previously reported data, although theoretical and methodological aspects can be discussed more extensively.

EEG Analysis

Although the main results were not significant, the alpha conditioning findings from this study tend to agree with Kamiya's (1969b) report that subjects who have learned to discriminate their own alpha and non-alpha states can to some extent produce alpha when requested. Throughout the first four test trials alpha conditioned subjects produced a higher mean percent of alpha than the controls. Hart's (1968) question about continued alpha production without feedback is thus partially answered.

The alpha production test results of the alpha conditioning subjects showed great variability. It is noted that three of the five subjects showed a general increase over test sessions, with subject JM's increase being the most marked and consistently maintained. This subject increased from 59% alpha in her resting session to over 90% alpha on three test sessions, increasing her mean alpha length from 2.43 cm. to 6.62 cm. in her best (fourth) test session. This finding agrees with Kamiya's (1969a, 1969b) report of meditators being rapid learners of alpha control techniques; subject JM had previously had some meditation practice. Although this meditation practice was not recent, the techniques appeared to be easily recalled.

To deal with the findings in the meditation group, it must be remembered that previous EEG studies have used experienced meditators as subjects. In most of these experiments, described in the Introduction, an increase in amount of alpha was found, and in Kasamatsu and Hirai's (1963) studies at least, alpha production became almost continuous in some subjects. In the present experiment, the alpha mean increased markedly in the meditation group for the first test session only. All meditation subjects increased their percent alpha from resting levels. However, a general decrease in subsequent sessions was found. This finding may be related to Kamiya's (1969a) report that "trying" tended to produce non-alpha. This observation was also reported by some of the alpha conditioning subjects from this study. A few of the meditation subjects in the present study noted that they had achieved what they thought was a successful application of the meditation instructions on the first session. Although they were warned not to expect the same results each session, some felt that they definitely kept in mind the achievement of the first session, preventing them from following meditation instructions. The first meditation session may have introduced a challenging and meaningful task encouraging the subjects to involve themselves deeply in the exercise, subsequently found to be difficult. This aspect of the meditation practice will be discussed further with the subjective findings. It seems that meditators do need practice to overcome this "interference", at least with this type of meditation instruction.

Control subjects tended to increase alpha production over sessions. This finding will be dealt with in the following section.

<u>Subjective Data Analysis</u>

The alpha conditioning participants' subjective comments tended to vary in reports of alpha-maintaining techniques. One subject, NF, found that visual imagery seemed to enhance alpha production rather than to decrease it, a report contradicting Kamiya's (1969a, 1969b) main findings. The present result is in agreement with the statement of Kreitman and Shaw (1965), however, to the effect that visual imagery is associated with alpha decreases only as a trend with numerous exceptions. Subject WR indicated that she was developing or discovering a way to keep herself in a feeling of "being inside" her own head, with a realization that she could control herself from there. Subject LA said that concentration on the rhythm of the machine (the click of the timer at one-second intervals) or on her breathing brought her back to X when she felt herself going into Y. Subject PH used the analogy of alpha being at the bottom of a steep staircase, mentioned in Results, but did not describe further any technique. She did state, however, that following the longer sessions she "experienced a strange aftereffect", being "unwilling" to produce any non-alpha, "recording data" like people she saw or the lecture she heard, without analysis. This state was described as a "strange but pleasurable, encapsulated feeling, an entirely-inside-oneself sort of feeling". This comment resembles reports by Kamiya's subjects that the alpha state is not critical or analytical, and is similar to the detachment of meditation.

The test trials in both alpha conditioning and control groups produced a higher percent alpha than the resting sessions. The slight increase in the control group percent alpha may be due to the instruction to "let the mind wander", a description of one alpha producing technique according to some of Kamiya's subjects. Another factor in the increased alpha might be habituation to the situation when no other task was imposed. The increase might also reflect drowsiness. A mention of drowsiness was more common in control subjects' descriptions of the course of the test sessions than in those of the meditation and alpha conditioning subjects. All five control subjects checked "drowsy" on the checklist. The increased alpha with alert, non-drowsy subjective reactions in both the alpha conditioning results and the first meditation session may parallel Bradley and Key's (1958) findings that certain parasympathomimetic and parasympatholytic drugs such as atropine produced patterns of electrical activity which did not correlate with the subject's behavioral state.

The subjective findings in the meditation group are similar to Maupin's (1965) reports. Maupin's subjects in their initial meditation practice reported occasional dizziness, calmness and relaxation, feelings that the body was suspended or light, vividness of breathing, and occasional loss of body feelings. All of the meditation subjects in the present study experienced at least some of these feelings. Subject MN reported a floating feeling during meditation, and also experienced distortions of body image, feeling that her hands were coming into her body at strange angles, all twisted together and feeling very heavy and large. A dreamy, floating feeling was noted in almost all her test sessions but not mentioned in association with drowsiness. Subject WS noted that in the fourth test session she felt that "the patch of floor where my feet were and the chair and I were floating". She said she thought she was "imagining" the feeling, and tried to stop it but could not. Later during that session she "really did concentrate" on her breathing, and "it was really great. There was only my breathing and space all around. Then I spoiled it when I realized what I was doing." According to Maupin's meditation response scaling system, this type of finding is classed as a high level of response. One or two alpha conditioning and control subjects also reported some similar occurrences but these were not as emphasized or detailed in their reports. The reporting might be slightly misleading in this respect, because subjects tended to verbalize their reports in terms of their instructions. Also, considering that the meditation subjects checked more negative indicators on the adjective checklist, the greater feeling reported may be related to the greater concentration demanded by the task or personal involvement with it. If it can be determined whether the "meditation state indicators" previously mentioned were more vividly experienced by the meditators even on these initial practice sessions, it might be assumed that the subjective experiences at this stage of meditation are not paralleled by significant or corresponding EEG alpha changes.

That both meditation and alpha conditioning subjects were still learning their techniques in the test sessions is reflected in their assessment of those sessions as more difficult, uncomfortable, and on the whole somewhat less positive compared with the experiences of the control group. On the questionnaires, early indicators of the difficulty of the meditation task were shown by comments such as subject CD's statement, "I was surprised how hard it was to concentrate completely," or subject WS's, "I thought it would be fairly easy to concentrate on my breathing but instead I found it very difficult." At least these comments indicate that an effort was made to comply with the instructions. A similar difficulty was noted on early test sessions by alpha conditioning subjects. Subject NF stated that after the first long session she felt most uncomfortable and her interest wandered, and that she was just beginning to feel confidence in her ability to produce alpha in the longer sessions. Subject WR felt that towards the end of the last session she was "just beginning to find out how to stay in X."

Both Kamiya and Hart discussed some possible therapeutic applications of autonomic and CNS autocontrol techniques. In this study one subject reported that a headache had disappeared during an alpha conditioning test session. The therapeutic possibilities of this type of training are shown in one of the alpha conditioning subjects' comments that she could now fall asleep faster, by putting herself into an "X state". This report, together with subject JM's use of a meditation technique to maintain an alpha state, tends to support Kasamatsu and Hirai's (1966) note that meditation is a prolonged continuation of the pre-sleep pattern but lacking any of the characteristics of a deeper sleep pattern, because the alpha state in a non-test situation apparently rapidly developed into a sleep state.

Considerations for Future Research

In further studies, subjects should be tested so that such peripheral response mechanisms as eye movements and changes in myogenic potential could be excluded as factors influencing alpha production, as mentioned by Begleiter and Platz (1969). These measurements could be recorded to determine whether changes are significantly associated with increased alpha production. None of the subjects involved in the alpha conditioning or meditation groups in the present experiment indicated awareness of using such peripheral response mechanisms as cues during their training or test sessions, suggesting instead subjective means as previously mentioned. Nevertheless, in future experimentation controls should be included to eliminate the possibility of their use as cues.

The problem of comparison of test trials with an initial resting level involves potential changes in the baseline over time, such as Kamiya (1969b) found. The resting session percent alpha for this study was determined over three recordings in only one session. To deal with this problem in a more effective manner, an experiment should be run with baseline or resting trials interspersed among test trials so that the amount of change in the baseline can be calculated and a more valid comparison between resting and test sessions can be obtained. This type of experiment could attempt to replicate Kamiya's study in which he found that subjects who had been trained to increase alpha production tended to have an increasing percent alpha baseline, while those who had been trained to suppress alpha had a generally decreasing baseline.

The lack of statistically significant differences between groups on the main conditions of the study is due for the most part to the large intra-individual variability. To more effectively compare the alpha autocontrol produced by meditators and by alpha conditioned subjects, a study should be designed so that alpha and non-alpha discrimination is overlearned because several subjects in this study felt that they had inadequate control even though the training criterion had been met. Alpha conditioned subjects in this study took a shorter time to reach a discrimination criterion than was indicated in other experiments (Kamiya, 1969a; Kamiya, 1969b). However, Kamiya (1969b) reported that subjects typically responded correctly about 75-80% of the time during the third hour of training, roughly equivalent to the performance of some of the slower subjects in this experiment. The number of actual discrimination trials to criterion was not indicated in Kamiya's work. Further, the meditation and control subjects should be exposed to the same number of recording sessions as the alpha conditioning subjects to control for habituation to the situation, a factor which was impossible to control adequately in this study.

Also, meditators should have an opportunity to "learn" a meditation technique to be practiced in the test sessions so that the novelty of the technique will not be a possible alpha-suppressing factor. That is, experienced meditators should be compared with overtrained alpha-conditioned subjects. Relevant here is Wallace's (1970) finding that transcendental meditators with a relatively short training period showed similar physiological changes to more experienced practitioners of other disciplines of meditation. A replication of Wallace's findings would have to be attempted. Future control subjects should not be given the specific instructions administered in this study, which may have permitted some form of non-focused meditation. To determine whether the present instructions could allow such a process to occur, instructions for a future control group should involve simply the basic posture outline and a warning to remain awake.

Use of Kamiya's (1969b) description of "good alpha subjects" could be made to minimize the variability within each group. For example, persons interested or participating in sensitivity training or similar groups could be used as subjects in the same type of meditation-alpha conditioning experiment.

In this study, the adjective checklist data can only be considered as suggestive of further lines of research, as the adjectives analyzed were selected following administration of the questionnaire. Before concluding that subjective data as inferred from the checklist are not reflected in parallel physiological findings, it would have to be determined by a continuation and amplification of this type of study whether the subjective reactions following each session were correlated with its physiological findings. Also, because the EEG produces a gross type of psychological measurement, refinement of techniques and additional recording sites would undoubtedly yield more informative data. Post-session information was not consistently obtained in this experiment. Rather, the checklist referred to global feelings and experiences in the study. The rest of the questionnaire was often not answered specifically enough to satisfy the preceding criterion. Clearer results would likely have been obtained with administration of the questionnaire following each session, like the interviews in Deikman's (1963) and Maupin's (1965) studies.

As shown by Kasamatsu and Hirai (1963), alpha duration and percent alpha tended to increase with meditation practice. One line of future research could investigate the nature of the relationship between percent alpha and alpha length to determine whether this relationship might be closer in meditation and alpha conditioning than in the control condition, a possibility suggested by observation of Figure 4.

Conclusion

As a technique for increasing alpha production on a very short term basis, alpha conditioning procedures (discrimination training or continuous feedback systems) appear to be more effective than the type and stage of meditation used in this study. However, no long term studies (other than Kamiya's marathon runs) have investigated alpha conditioning, whereas there are numerous reports that with practice meditation tends to increase alpha production to a high degree. That previous meditation experience enables faster learning of alpha discrimination is supported by subject JM's performance.

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Appendix I

Instructions for Alpha Discrimination Training

Your task is to try to discriminate between two brain states as measured by the EEG. Each time you hear a click, tell me right away whether you think you were in state X or state Y at the time of the click. I will tell you whether you were right or wrong, and in that way you will get to know how to tell the difference between the two states. Make sure you remain as motionless as possible, with your eyes closed. We will have several short training periods today. Are there any questions?

Instructions for Alpha Test Sessions

Now that you feel you are able to produce X or Y more or less at will, I want you to try to produce as much X as possible in these "test sessions", using any method you find that you feel works. There will be two 10-minute sessions today and three 15-minute sessions later when you are able to come. Remember to sit as motionless as possible with your eyes closed, feet flat on the floor, and hands in your lap. Questions? Ready?

Instructions for Meditation Sessions

Your task in this experiment is to practice a simple meditation exercise in the Zen tradition. Your ultimate aim is to suspend your ordinary flow of thoughts without falling into a stupor. Your aim is not any specific experience; whatever happens will come with the achievement of various steps in the process of quieting your mind's activity. What I want you to do now is sit up straight but comfortably in the chair with your feet flat on the floor and your hands together in your lap. You must make sure this position is reasonably comfortable and do not slouch or move around once you have started the exercise. Keep your eyes closed at all times during your practice. Let your breathing become relaxed and natural. Let it set its own pace and depth if you can. Then focus your attention on your breathing: the movements of your belly, not your nose or throat. Do not allow extraneous thoughts or stimuli to pull your attention away from the breathing. This may be hard to do, but keep directing your attention back to it. Turn everything else aside if it comes up. You may find yourself becoming anxious or uncomfortable. This is because sitting still and concentrating like this restricts the ordinary ways of avoiding discomfort. If you have to feel uncomfortable, feel uncomfortable. If you feel pleasant, accept that with the same indifference. Do not analyze your experience but let your awareness of your breathing fill your entire mind. There will be two 10-minute practice sessions today and three 15-minute sessions later when you can come. I will tell you when the time is up. Questions? Ready?

Instructions for Control Sessions

For this experiment I need to know the cumulative effect of sitting as motionless as possible, but relaxed, with the eyes closed--the basis of meditation. Your task in this experiment is to sit up straight with your feet flat on the floor and your hands in your lap, eyes closed, and let your mind do what it wants to. Just let things happen but observe what's going on in your mind. I want you to do this for five sessions, two 10 minutes long today and three 15 minutes long later when you have time to come. I will tell you when the time is up. Questions? Ready?

Instructions to all Subjects after the First Session

I would like you to complete a short questionnaire recording your feelings during these sessions. So you can do this better, it might be a good idea to jot down your feelings and reactions following each session so you don't have to try and remember them at the end of all the sessions.

Appendix II

Adjective Check List

From the following list, check the words which best describe the feelings, thoughts, or sensations you experienced during the "test sessions".

__comfortable	__observant	__critical	__restless
__planning	__uncomfortable	__calm	__dizzy
__floating	__emotional	__relaxed	__pleasant
__alert	__impatient	__anxious	__heavy
__reflective	__energetic	__irritated	__analytical
__vital	__preoccupied	__detached	__insightful
__euphoric	__tranquil	__hyperactive	__calculating
__imaginative	__fidgety	__invulnerable	__self-possessed
__bored	__cheerful	__attentive	__disturbed
__receptive	__drowsy	__understimulated	__peaceful

Name:______________________Age:_____Date of Birth:__________

Major or Area of Interest______________Year and Faculty__________

Reason for taking Rel. St. 200______________________________

Have you ever meditated?________If so, please give details:__________

____

Have you ever had any sort of "peak experience" or "religious experience"?

______If so, details:__________________________________

Have you had any powerful drug experiences which may be called "peak experiences"?______Details:______________________________

In the following space and on the reverse if necessary, please describe the course of your test sessions, your feelings, thoughts, sensations, satisfaction or dissatisfaction with what happened, expectations you may have had, and any other relevant details:

Appendix III

Analysis of Variance for Percent Alpha

Source	SS	df	MS	F
Between Subjects	51,137.86	14		
A (Groups)	369.93	2	184.96	0.0437
Subjects within	50,767.93	12	4,230.66	
Within Subjects	3,993.97	60		
B (Sessions)	258.67	4	64.67	1.0509
AB Interaction	781.74	8	97.72	1.5880*
B x Subjects within	2,953.56	48	61.53	

* significant between .25 and .10

Appendix IV

Analysis of Variance for Percent Alpha

on 15 Min. Sessions Converted to 10 Min.

Source	SS	df	MS	F
Between Subjects	53,211.56	14		
A (Groups)	223.61	2	111.81	0.0253
Subjects within	52,987.95	12	4,415.66	
Within Subjects	4,740.80	60		
B (Sessions)	249.26	4	62.32	0.8615
AB Interaction	1,019.66	8	127.46	1.7621*
B x Subjects within	3,471.88	48	72.33	

* significant between .25 and .10

Appendix V

Kirk Analysis of Simple Main Effects for Percent Alpha Scores

Source	SS	df	MS	F	p
A	369.9	2	185.0	2.7786	.10*
A at b_1	422.5	2	211.3	3.1735	.05*
A at b_2	216.7	2	108.4	1.6277	NS
A at b_3	256.5	2	128.3	1.9266	NS
A at b_4	26.8	2	13.4	0.2013	NS
A at b_5	159.6	2	79.8	1.1988	NS
B	258.7	4	64.7	0.9714	NS
B at a_1	533.8	4	133.5	2.0047	NS
B at a_2	357.0	4	89.3	1.3407	NS
B at a_3	162.6	4	40.7	0.6106	NS
AB	781.7	8	97.7	1.4679	.25*
Within	3994.0	60			

* using Kirk's method for critical values (A + B)

Appendix VI

Percent Alpha Difference Scores

(Test Session Minus Resting Session)

	Subject	First Session	Second Session	Third Session	Fourth Session	Fifth Session
Control	LP	-1.8	+0.2	+7.1	+15.1	-3.5
Group	SB	+8.3	+6.7	+15.1	+13.5	+27.8
	BBr	-16.4	-11.5	-26.2	-4.8	-6.1
	BBa	+3.9	+29.0	+35.1	+30.7	+40.9
	JL	+8.4	+9.6	+7.5	+2.9	+10.5
Alpha	WR	+1.5	+4.9	+12.1	+15.5	+4.7
Conditioning	LA	+22.6	+37.1	+22.0	+16.6	+11.4
Group	NF	-14.9	-3.5	+8.9	-10.2	+3.1
	JM	+12.7	+33.4	+30.2	+33.0	+31.1
	PH	+7.5	+8.0	+7.9	+7.9	+5.5
Meditation	DMc	+11.5	+5.2	+7.5	+1.0	+6.2
Group	WS	+23.3	+18.7	+24.8	+29.4	+30.8
	DV	+11.1	+6.7	+2.4	-12.3	-8.6
	CD	+1.0	+5.9	-2.8	+18.4	-14.5
	MN	+4.7	+4.1	+2.6	+0.4	-0.7

Appendix VII

Mean Length of Alpha Bursts by Sessions for the Three Groups

	Subject	Resting Session	First Session	Second Session	Third Session	Fourth Session	Fifth Session
Control	LP	1.20	1.27	1.36	1.70	1.79	1.32
Group	SB	1.72	1.97	2.18	2.26	2.29	2.41
	BBr	1.97	1.75	1.75	1.66	2.04	2.21
	BBa	1.91	3.78	3.54	5.63	3.57	4.91
	JL	3.62	4.36	4.52	4.80	3.03	5.64
Alpha	WR	1.33	1.49	1.63	1.78	1.66	1.59
Condition-	LA	1.82	3.23	2.71	2.30	2.45	2.35
ing Group	NF	1.44	1.38	1.75	1.86	1.61	1.77
	JM	2.43	3.39	5.80	4.80	6.62	5.14
	PH	4.05	7.99	7.61	8.66	8.27	6.91
Meditation	DMc	1.24	1.51	1.47	1.55	1.37	1.48
Group	WS	1.64	2.08	2.04	2.12	2.34	2.42
	DV	1.80	2.34	2.18	1.95	1.75	1.75
	CD	2.12	2.01	2.44	2.07	2.27	2.07
	MN	6.87	8.69	7.56	6.71	7.98	5.21

Appendix VIII

Analysis of Variance for Mean Alpha Length

Source	SS	df	MS	F
Between Subjects	310.2795	14		
A (Groups)	12.2471	2	6.1235	0.2465
Subjects within	298.0324	12	24.8360	
Within Subjects	23.6866	60		
B (Sessions)	0.3574	4	0.0893	0.2362
AB Interaction	5.1844	8	0.6480	1.7142*
B x Subjects within	18.1448	48	0.3780	

* significant between .25 and .10

Appendix IX

Mean Alpha Length Difference Scores in cm.

(Test Session Minus Resting Session)

	Subject	First Session	Second Session	Third Session	Fourth Session	Fifth Session
Control	LP	+0.07	+0.16	+0.50	+0.59	+0.12
Group	SB	+0.25	+0.46	+0.54	+0.57	+0.69
	BBr	-0.22	-0.22	-0.31	+0.07	+0.24
	BBa	+1.87	+1.63	+3.72	+1.66	+3.00
	JL	+0.74	+0.90	+1.18	-0.59	+2.02
Alpha	WR	+0.16	+0.30	+0.45	+0.33	+0.26
Conditioning	LA	+1.41	+0.89	+0.48	+0.63	+0.53
Group	NF	-0.06	+0.31	+0.42	+0.17	+0.33
	JM	+0.96	+3.37	+2.37	+4.19	+2.71
	PH	+3.94	+3.56	+4.61	+4.22	+2.86
Meditation	DMc	+0.27	+0.23	+0.31	+0.13	+0.24
Group	WS	+0.44	+0.40	+0.48	+0.70	+0.78
	DV	+0.54	+0.38	+0.15	-0.05	-0.05
	CD	-0.11	+0.32	-0.05	+0.15	-0.05
	MN	+1.82	+0.69	-0.16	+1.11	-1.66

Appendix X

Analysis of Variance for Mean Alpha Length Differences

(Test Session Minus Resting Session in cm.)

Source	SS	df	MS	F
Between Subjects	92.9247	14		
A (Groups)	19.9571	2	9.9785	1.6410
Subjects within	72.9676	12	6.0806	
Within Subjects	23.2426	60		
B (Sessions)	0.5614	4	0.1403	0.3973
AB Interaction	5.7284	8	0.7160	2.0277*
B x Subjects within	16.9528	48	0.3531	

* significant between .10 and .05.