

## THE PSYCHOPHYSIOLOGY OF ADVANCED PARTICIPANTS IN THE TRANSCENDENTAL MEDITATION PROGRAM: CORRELATIONS OF EEG COHERENCE, CREATIVITY, H-REFLEX RECOVERY, AND EXPERIENCE OF TRANSCENDENTAL CONSCIOUSNESS

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High EEG coherence, high creativity, rapid neuromuscular recovery, and experience of transcendental consciousness are all correlated in individuals participating in an advanced Transcendental Meditation program. — EDITORS

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*A multivariate study was conducted on 23 subjects practicing the Transcendental Meditation technique and participating in a six-month Age of Enlightenment advanced training program. The electroencephalogram of each subject was recorded before and during the Transcendental Meditation technique, and compressed spectral arrays of coherence above a threshold of 0.95 were subsequently generated by computer. Each subject was asked to rate the clarity of his experience of transcendental consciousness during sessions of the Transcendental Meditation technique and at a later time took the Torrance Test of Creative Thinking. In 15 of these subjects the Hoffmann (H) reflex was also studied, with identical conditioning and test stimuli delivered in pairs with varying delays between the two stimuli, to provide a measure of the recovery rate of spinal alpha motor neurons.*

*Significant correlations were found between a number of variables derived from the data, including the following: (a) alpha band EEG coherence between left and right frontal derivations during the Transcendental Meditation technique; (b) subjective evaluation of the experience of "transcending" on a scale of increasing clarity; (c) score on the Fluency scale of the "unusual uses" creativity subtest; and (d) percentage of H-reflex recovery in 200 msec. Correlations between all pairs of these four measures were positive and significant ( $p < .05$ ). Of particular interest and significance was the correlation between coherence and creativity ( $r = .71$ ,  $p < .001$ ). These findings may provide a basis for a future understanding of the relation and growth of physiological and psychological performance among individuals participating in the Transcendental Meditation program.*

### INTRODUCTION

An understanding of the evolution of consciousness must include knowledge of the correlation of objective parameters involved in this growth. To this end, in subjects with a wide range of experience with the Transcendental Meditation (TM) technique, we examined several neurophysiological and psychological variables that were selected for their sensitivity to the influence of the TM technique.

One feature of particular interest was the coherence of the electroencephalogram (EEG) between left and right hemispheres of the brain. Increases in contralateral alpha coherence have been shown to be frequently specific to the

TM technique (8, 9) and to the experience of transcendental consciousness (5). Also, a preliminary survey indicated that the rate of Hoffmann (H) reflex recovery was significantly more rapid in some participants in the TM program than in norms, which prompted us to include the H-reflex in this study as a neurological performance measure.

A standard creativity test was administered, since previous studies had indicated positive changes in creativity associated with the Transcendental Meditation program (10, 13). Additionally, an indication of the clarity of the experience of transcendental consciousness during the TM technique was provided by means of a self-rating scale.

This brief report is concerned with the correlations among four variables derived from the above data collected in conjunction with this experiment.

## METHODS

**SUBJECTS**—23 male volunteers (18 to 35 years) practicing the Transcendental Meditation technique were selected from participants in a six-month Age of Enlightenment program in residence at Maharishi European Research University (MERU). This course was designed by Maharishi Mahesh Yogi, the founder of the Transcendental Meditation program, to accelerate the growth of experience and understanding of higher states of consciousness. On the basis of subjective reports which were routinely submitted as part of their program, the subjects were selected so as to provide a wide range of scores on a scale for rating clarity of the experience of transcendental consciousness during the TM technique.

**PROCEDURES**—The EEG of each subject was generally recorded for five minutes with eyes closed before, for 30 minutes during, and again for five minutes after the practice of the TM technique. The instrumentation and experimental procedure for EEG data collection were essentially those of Levine (8) and Levine et al. (9).

Within two weeks of the EEG recording session, the Torrance Test of Creative Thinking (TTCT), Verbal Form A, was administered to each subject in a group setting according to the instructions manual provided by the author (14).

Each subject was asked to evaluate his own experience of "transcending" (transcendental consciousness) during the TM technique on a scale of increasing clarity.

The H-reflex was separately studied in many of these subjects (after the technique of Hugon (7)) by weakly stimulating the popliteal nerve at the popliteal fossa, which elicits a monosynaptic reflex contraction of the soleus muscle. This contraction was recorded with an electromyograph, using surface electrodes. Identical conditioning and test stimuli of 1 msec duration and slightly above threshold intensity were delivered in pairs, and the amplitude of the conditioning and test responses were displayed on a Tektronix 564B oscilloscope. The time course of recovery of the alpha motoneuron pool was measured by varying the delay between the conditioning and test stimuli of each pair. This paired stimulation was done repeatedly, allowing at least 15 sec between pairs of stimuli, while the subject was comfortably seated with his leg supported and eyes closed, both before and during the TM technique. The H-reflex data were obtained on 15 of the 23 subjects used in this experiment.

**DATA ANALYSIS**—Analysis of the EEG coherence between left and right frontal derivations (F3–F4, International 10–20 System) was performed for each 5.12-second epoch of the experimental period. Values over a threshold of 0.95 were displayed as a compressed coherence spectral array (COSPAR) with temporal continuity filtering (by means of a computer program previously developed in our laboratory (8, 9)). From visual analysis of these COSPARS it was apparent that the most salient differences across subjects were in the consistency and spectral width of high level alpha band (8 to 12 Hz) coherence during the TM technique. This prompted the reduction of the COSPAR information to a single variable for comparison with other measures. This variable, here referred to as COH, is the product of the percentage of time with superthreshold alpha band coherence peaks during the TM technique and the mean spectral width of this coherence.

The H-reflex data for each individual were displayed on a graph of the delay between conditioning and the test stimuli vs. the amplitude of the test response (H2) expressed as a percentage of the conditioning response (H1). Separate curves were drawn for the precontrol data and the TM technique data. Values for the precontrol points were averages of three trials. There was little difference in most cases between the precontrol and TM technique curves for an individual subject. The most pronounced differences among subjects were at about 200 msec delay. For comparison with other variables reported in this paper, we have used only the TM technique ratio (H2/H1) for each subject, which is here referred to as the PHR (paired Hoffmann reflex) variable.

## RESULTS

The TTCT Fluency scale of the "unusual uses" (activity 5) subtest was initially selected for comparison with other variables and blindly scored according to the instructions provided with the test (14). This subtest scale was selected because of its wide use and applicability as a measure of divergent creative thinking ability according to the concepts of Guilford (4), and it is here referred to as the CR variable. The correlation matrix with significance levels for creativity (CR), coherence (COH), H-reflex (PHR), and subjectively evaluated clarity of the experience of transcendental consciousness (TC) is displayed in table 1. All correlations are positive and significant. The pattern of these correlations is presented graphically in fig. 1.

Of particularly great theoretical interest and statistical significance is the correlation between coherence (COH) and creativity (CR) ( $r = .71, p < .001$ ). The scatter diagram for these variables, with the regression line, is displayed in fig. 2.

TABLE 1  
CORRELATION MATRIX WITH SIGNIFICANCE LEVELS FOR CLARITY OF EXPERIENCE OF TRANSCENDENTAL CONSCIOUSNESS (TC), CREATIVITY (CR), COHERENCE (COH), AND H-REFLEX (PHR) VARIABLES.\*

	PHR (N = 15)	CR (N = 23)	COH (N = 23)
CR	.53 <i>p</i> < .05		
COH	.60 <i>p</i> < .02	.71 <i>p</i> < .001	
TC	.65 <i>p</i> < .01	.50 <i>p</i> < .02	.43 <i>p</i> < .05

\*See text for further description of these variables.

Figure 3 presents the COSPARS from which COH was derived for the three subjects with the highest and the three subjects with the lowest creativity (CR) scores among those tested. These COSPARS correspond to the lettered points of fig. 2. It is important to note that only peaks of very high coherence, in excess of the threshold of 0.95 (on a scale of 0 to 1), are displayed on these COSPARS. Thus, the absence of peaks does not indicate a complete absence of coherence. This somewhat arbitrary threshold is probably responsible for the cluster of COH values at zero, as seen in fig. 2. However, the threshold is necessary to simplify the COSPARS visually so that important features of high coherence are apparent. A nongraphic measure of coherence that is weighted for high levels of coherence, but does not have an arbitrary threshold, is being developed and may prove more sensitive in correlation analysis.

A number of other variables were included in this multivariate study, and the analysis of this body of data has not yet been completed. In this brief report we have included only the most interesting and significant variables from our initial analysis. Further analysis and discussion of these and other variables involved in the study are forthcoming.

**DISCUSSION**

The EEG coherence measure indicates the degree of phase stability of the brain waves from two spatially separated electrodes and thus provides a measure of long-range spatial ordering of the EEG (8, 9). Previous research indicates that coherence, by measuring the degree of linear coupling of the EEG from separated regions of the brain, may be strongly related to the transfer of information between cerebral systems. Coherence would thus reflect—and provide a basis for understanding—an important property of functional brain organization. This belief has been supported by animal studies that have shown high levels of coherence to be correlated with

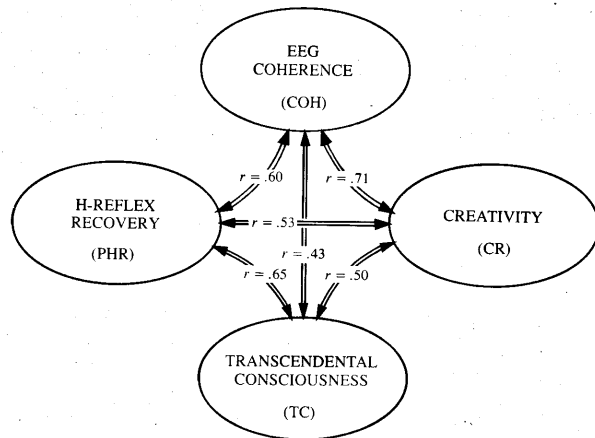


FIG. 1. CORRELATIONS AMONG VARIABLES OF THIS STUDY.

marked effects upon the visual evoked response (6) and with improved task performance (1, 2).

It has been suggested that functional organization of the left and right hemispheres in man is important for creativity (3). Further, it is well known that the left and right frontal lobes of the brain, from which the EEG for our coherence measure (COH) was taken, play an important part in the most highly developed human abilities, which include functions associated with creativity. Also, activity in the alpha frequency band, from which COH was derived, is associated with low arousal states, which, in turn, have been related to divergent thinking ability during a creative task (11).

Thus, the strong correlation found in this study between creativity (CR) and coherence (COH) appears to be a significant aid in establishing a basis for understanding the functional brain organization that underlies creativity. The overall results of this study also support the concept that the growth of creativity is part of a holistic development of the physiology and psychology, for high creativity scores were significantly correlated with fast motor neuron recovery (PHR) and clear experiences of transcendental consciousness (TC), as well as high coherence (COH). Thus, it seems quite unlikely that the relation of coherence and creativity is isolated from other psychophysiological factors, and therefore it is felt that any theory explaining creativity, or any technique for developing it, must be holistic in nature.

In considering the relation of the Transcendental Meditation technique to all four variables studied here, it is important to collectively consider the following features of this study:

1. The H-reflex variable was selected for its apparent ability to reflect the influence of the TM technique, as suggested by a preliminary investigation.

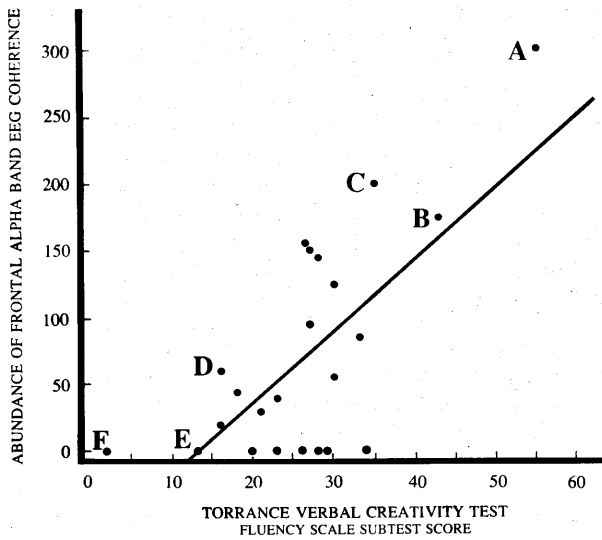
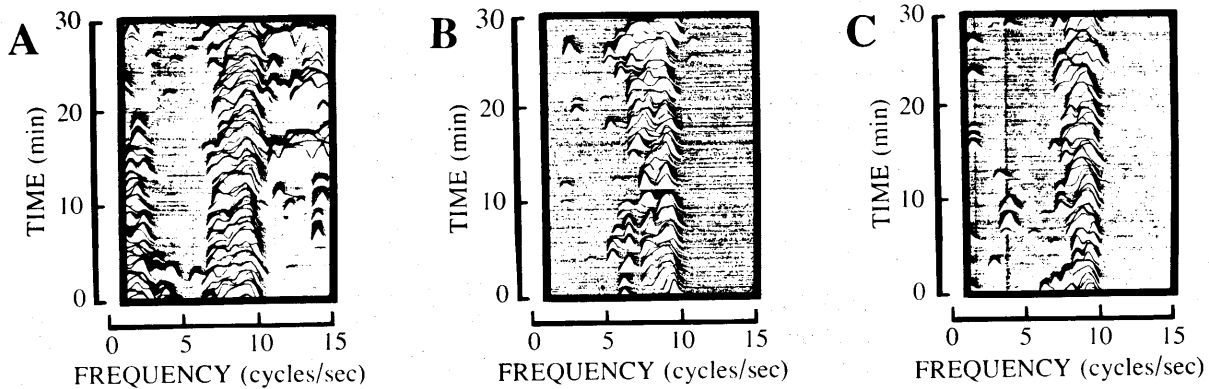


FIG. 2. SCATTER DIAGRAM WITH REGRESSION LINE OF INDIVIDUAL CREATIVITY (CR) AND COHERENCE (COH) SCORES. Lettered points correspond with COSPARs of fig. 3.

2. Previous studies (one also using the TTCT) have shown positive changes in creativity associated with the TM program (10, 13).
3. COH was derived from EEG recorded during the TM technique.
4. COH was designed to be most sensitive to the features of coherence that have been found in this and another study (9), to be most specific to the TM technique: namely the consistency and spectral broadening of highly coherent alpha.
5. The subjects in this study were selected from a group that was particularly advanced in the practice of the TM technique.
6. The subject selection was such as to maximize the difference between subjects in their clarity of experience of transcendental consciousness during the TM technique.

COHERENCE OF THE THREE SUBJECTS  
 WITH HIGHEST CREATIVITY SCORES AMONG THOSE TESTED



COHERENCE OF THE THREE SUBJECTS  
 WITH LOWEST CREATIVITY SCORES AMONG THOSE TESTED

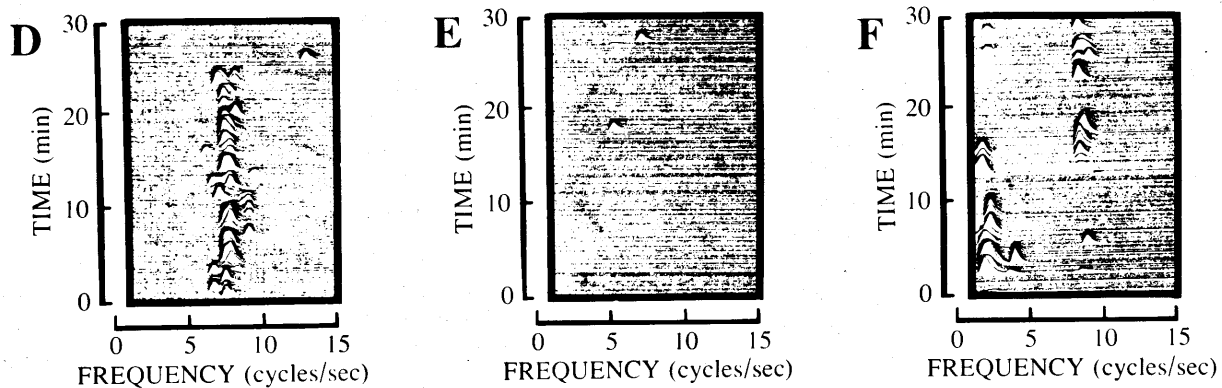


FIG. 3. PORTIONS OF COHERENCE SPECTRAL ARRAYS (COSPARs) FROM WHICH COH WAS DERIVED FOR THE THREE SUBJECTS WITH THE HIGHEST AND THE THREE SUBJECTS WITH THE LOWEST CREATIVITY SCORES AMONG THOSE TESTED. Identifying letters correspond to the lettered points of fig. 2.

7. The clarity of experience of transcendental consciousness during the TM technique correlated significantly with all three of the other variables discussed here.

Though it is not possible to draw conclusions of causality from correlations alone, considering all of the above points, we may infer that the TM technique has a positive influence on each of the variables in this study and is thus in part responsible for the high correlations reported here.

The results of this study are consistent with central concepts of the Science of Creative Intelligence, as taught by Maharishi Mahesh Yogi (12, p. 34), which state that creative ability is intimately related to functional brain organization, and that the coherent ordering of brain functioning during the Transcendental Meditation technique provides a basis for creative ability and holistic growth.

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