REAL TIME EEG COHERENCE ANALYSIS OF THE TRANSCENDENTAL MEDITATION AND TM-SIDHI PROGRAMME

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Increases in EEG coherence were found from an eyes-closed pre-control period to the practice of the Transcendental Meditation technique, and from the practice of Transcendental Meditation to the practice of the TM-Sidhi techniques, while a decrease was found from the practice of the TM-Sidhi techniques to a post-control period with eyes closed, indicating that the Transcendental Meditation and TM-Sidhi programme increases the orderliness of neurological functioning.—EDITORS

EEG coherence in the alpha, theta, beta, and delta bands was studied in 80 participants in the Transcendental Meditation and TM-Sidhi programme. Levels of coherence were measured during a 5-minute pre-control period with eyes closed, during 15 minutes practice of the Transcendental Meditation technique, during 5 minutes practice of the TM-Sidhi techniques, and during a 5-minute postcontrol period with eyes closed.

A significant increase in alpha coherence between all four pairs of channels measured was found from the eyes-closed precontrol period to the TM technique, a further significant increase from the TM technique to the practice of the TM-Sidhi techniques, and a significant decrease from the TM-Sidhi techniques to the eyes-closed postcontrol period. The same pattern of significant increases between first and second, and second and third periods was observed for left and right intrahemispheric coherence in the theta band, and for right intrahemispheric and central interhemispheric coherence in the beta frequency. Frontal delta coherence showed opposite changes to the above.

Since EEG coherence can be seen as a measure of orderliness of neurological functioning, these results support the hypothesis that the Transcendental Meditation and TM-Sidhi programme improves the functional organization of the brain.

INTRODUCTION

A number of studies have investigated the effects of the Transcendental Meditation technique and the TM-Sidhi programme on electroencephalographic variables (e.g. Banquet, 1973; Banquet and Sailhan, 1974). More recently attention has focused on EEG coherence, a measure of the similarity between EEG signals from different parts of the brain, which seems to be particularly sensitive to changes arising from Transcendental Meditation (e.g. Levine et al., 1977; Dillbeck and Bronson, 1981; Dillbeck et al., 1981; Orme-Johnson and Haynes, 1981). This paper presents initial findings from a continuing study on levels of coherence before, during, and after the practice of the Transcendental Meditation technique and TM-Sidhi programme and the relationship between EEG coherence and physiological and psychological variables.
METHOD

SUBJECTS—Of 84 subjects initially studied, four subjects were eliminated from the analysis due to persistent and excessive muscle artifacts, leaving a total of 80 subjects. The final group consisted of 40 males and 40 females, with a mean age of 37 years 6 months, a mean length of practice of the Transcendental Meditation technique of 8 years 3 months, and of the TM-Sidhi programme 3 years 9 months.

INSTRUMENTS—Grass gold cup electrodes were applied to F3, F4, C3, C4, and A1 (International 10-20 system). A monopolar derivation was used with the reference at the left ear. The four EEG channels were amplified using an OTE Biomedica Neurograph 18 EEG machine, with the following settings: a 25 Hz frequency filter, 0.3 second time constant, 50 Hz notch filter, and 50 microvolts/cm channel sensitivity.

Each of the four channels was simultaneously sampled to 12 bits at 50 Hz using the MERU Real Time EEG Epoch Analysis System (Beresford and Bowerman, 1982). Magnitude Squared Coherence (MSC) was calculated and displayed as compressed spectral arrays (COSPARs) in real time between channels F3 and C3, F4 and C4, F3 and F4, and C3 and C4 using the following parameters:

1) Bandwidth: 25 Hz
2) Epoch length: 30 seconds
3) Epoch length/subset length ratio: 25.00
4) Number of subsets per Epoch: 25

This resulted in a 32-point Fourier Transform with contiguous subsets.

Two digital muscle artifact filters were applied to eliminate (a) excessive amplitude signals (> 200 µV peak to peak), and (b) excessive amplitude beta components (> 40% of maximum amplitude component in other frequency bands).

A digital low frequency filter set to 1.0 Hz was also applied to reduce the effect of eye movement artifacts on delta frequency coherence.

The ‘Total Coherence Function’ was calculated for each of the four frequency bands: Delta (1-4 Hz), Theta (4-8 Hz), Alpha (8-13 Hz), and Beta (13-25 Hz) for each individual epoch and displayed numerically as an average over all the epochs for each experimental step.

PROCEDURE—Subjects were allowed to settle down during the period when the electrodes were being applied (approximately 20 minutes).

The 30-minute experimental period consisted of the following steps:

1) 5 minutes precontrol in which subjects sat quietly with eyes closed. A standard passage of poetry was read by the experimenter during this period to inhibit subjects from spontaneously starting to meditate
2) 15 minutes practice of the Transcendental Meditation technique
3) 5 minutes practice of the TM-Sidhi techniques (the first 5 minutes of the subjects’ normal programme)
4) 5 minutes postcontrol, sitting quietly with eyes closed

ANALYSIS—Paired t-tests were used to calculate the significance of the difference in mean values of coherence between consecutive programme steps in each frequency band.

RESULTS AND DISCUSSION

The results are presented in figure 1 and table 1. Representative COSPARs are shown in figure 2.

The main features of the results are as follows:

1) There was a significant increase in alpha coherence between all four pairs of channels from the precontrol eyes-closed period to the Transcendental Meditation technique, a further significant increase from practice of the Transcendental Meditation technique to practice of the TM-Sidhi techniques, and a significant decrease from practice of the TM-Sidhi techniques to the eyes-closed postcontrol period. There was also a significantly higher level of left and right intrahemispheric and central interhemispheric alpha coherence in the postcontrol period relative to the precontrol period.

2) The same pattern of significant increases between the first and second, and second and third programme steps, and a significant decrease between the third and fourth programme steps was observed for right intrahemispheric coherence in the theta band (left intrahemispheric theta coherence also showed the same pattern but there was no significant increase between the second and third steps), and for right intrahemispheric and central interhemispheric coherence in the beta frequency. (A trend to significance was also noted between steps 1 and 2 and...
steps 3 and 4 in central coherence for theta and left hemisphere coherence for beta.)

3) Frontal delta coherence showed opposite changes to the above, with a significant decrease from eyes closed to Transcendental Meditation, a slight nonsignificant decrease from Transcendental Meditation to the TM-Sidhi techniques, and a significant increase from the TM-Sidhi techniques to eyes-closed postcontrol. Although coherence is independent of amplitude, this finding may be related to the fact that the delta frequency is associated with the sleeping state, while Transcendental Meditation can be seen as producing a state of increased 'wakefulness' (Orme-Johnson et al., 1979).

4) Of the four pairs of channels measured, right intrahemispheric coherence showed the clearest changes, with significant changes for the theta, alpha, and beta frequencies between all programme steps.

We are currently testing control subjects on all these measures, and hope to be able to clarify the meaning of the increases in coherence in different frequency bands and different parts of the brain in future work. However, the present results clearly support previous work showing that the practice of Transcendental Meditation increases EEG coherence (Dillbeck and Bronson, 1981), and that the TM-Sidhi programme produces changes over and above the effects of the Transcendental Meditation technique (Orme-Johnson et al., 1979). They also confirm the suggestion in several of these studies that alpha coherence is particularly sensitive to changes in consciousness.

Coherence can be seen as a measure of orderliness in neurological functioning. Orme-Johnson et al. (1982) found that this was expressed in a pattern of significant correlations between indices of coherence and parameters of performance for a group of meditators. Our results are consistent with the hypothesis that the Transcendental Meditation and TM-Sidhi programme improves the functional organization of the brain, and that EEG coherence is a useful tool for studying the development of consciousness.

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**FIG. 1. HISTOGRAMS SHOWING MEAN COHERENCE IN EACH FREQUENCY BAND FOR EACH PROGRAMME STEP AND BRAIN AREA (SEE TABLE 1 FOR SIGNIFICANCE LEVELS).**
FIG. 2. EXAMPLE OF COSPARS PRODUCED BY THE MERU REAL TIME EEG EPOCH ANALYSIS SYSTEM SHOWING ABUNDANCE OF ALPHA COHERENCE IN ALL DERIVATIONS, AND EXTENSION OF COHERENCE INTO THE THETA AND BETA FREQUENCIES IN THE LEFT AND RIGHT HEMISPHERES DURING THE PRACTICE OF THE TRANSCENDENTAL MEDITATION AND TM-SIDHI PROGRAMME.
**TABLE 1**

**MEANS AND STANDARD DEVIATIONS OF COHERENCE (%) IN EACH FREQUENCY BAND AND PROGRAMME STEP**

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Note: The significance levels refer to the difference between the mean values of coherence (%) for the programme step indicated and the previous programme step.

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**REFERENCES**


