This study demonstrates the importance of EEG coherence in relation to the improvements in age-related psychological variables which are known to result from the practice of the Transcendental Meditation and TM-Sidhi programme, thus emphasizing the importance of neurophysiological integration in the reversal of ageing.—EDITORS

A correlational study was performed in order to examine the relationship between EEG coherence, performance on a number of age-related psychological variables, and the Transcendental Meditation and TM-Sidhi programme.

Subjects consisted of 27 men and 29 ladies (mean age 39 years 2 months, mean duration of practice of the Transcendental Meditation technique 8 years 4 months, mean duration of practice of the TM-Sidhi technique 3 years 11 months).

Mean right beta coherence was significantly predictive of fluency \( (p < .05) \), motor speed \( (p < .001) \), and reaction time \( (p < .001) \); mean right alpha coherence was significantly predictive of shape memory \( (p < .01) \), and mean right delta coherence of flexibility \( (p < .05) \). Age was significantly predictive of lower mean right and mean central beta coherence \( (p < .05) \). Duration of practice of the TM-Sidhi programme was significantly predictive of higher mean right alpha coherence \( (p < .01) \).

These results demonstrate the predictive power of different aspects of EEG coherence for age-related psychological variables, and notably the relationship between right beta coherence and perceptual-motor speed. Taken together with previous research showing increases in right alpha and beta coherence as a result of the Transcendental Meditation and TM-Sidhi programme, and a relationship between duration of practice of the TM-Sidhi programme and improved performance on these age-related psychological measures, the results define important electroencephalographic correlates of the reversal of ageing that occurs through the Transcendental Meditation and TM-Sidhi programme.

INTRODUCTION

There is now considerable evidence to suggest that EEG coherence is a useful tool for measuring changes in neurological functioning which are not detectable by simply measuring amplitude or power spectra. For instance, Shaw et al. (1977) showed EEG coherence to be a valid measure of cerebral functional organization, while Beaumont et al. (1978) found that increased right hemispheric coherence was related to spatial tasks independently of power. More recently Banquet (1983) reported a steady decrease
Several studies have found longitudinal increases in EEG coherence as a result of the practice of the Transcendental Meditation and TM-Sidhi programme (e.g. Dillbeck and Bronson, 1981; Orme-Johnson et al., in press). In our own work, coherence variables significantly increased during the practice of the Transcendental Meditation technique relative to a pre-control eyes closed period, increased further during the practice of the TM-Sidhi techniques, and decreased during an eyes-closed post-control period (Beresford and Clements, in press). In addition, Haynes et al. (1977), Orme-Johnson and Haynes (1980), and Dillbeck et al. (1981) reported correlations between indices of coherence and a number of physiological and psychological measures in practitioners of the Transcendental Meditation and TM-Sidhi programme.

In the field of ageing research, there is growing evidence that the Transcendental Meditation and TM-Sidhi programme produces a positive effect on measures normally found to deteriorate with age (Clements and Clements, 1980; Wallace et al., 1982; Toomey et al., a and b, in press). Jedrczak (in press) found that performance on a number of age-related psychological measures was positively correlated with number of months practising the TM-Sidhi programme and negatively correlated with age.

With respect to EEG correlates of ageing, EEG alpha rhythm is usually seen to decrease in amplitude and frequency with old age, but there have been few reports of the effects of ageing on other frequency bands and types of EEG signal analysis (Marsh and Thompson, 1977).

The purpose of the present study was to explore the relationship between EEG coherence, age-related psychological variables, and the TM-Sidhi programme.

METHODS

The data used in this study were collected from the two separate studies1 of Beresford and Clements (in press), and Jedrczak (in press) which report the effect of the Transcendental Meditation and TM-Sidhi programme on EEG coherence, and on age-related psychological variables, respectively. The subjects in the present study are those who completed both these experiments, and comprise 27 men and 29 ladies (mean age 39 years 2 months, mean length of practice of the Transcendental Meditation technique 8 years 4 months, mean length of practice of the TM-Sidhi programme 3 years 11 months).

Beresford and Clements measured frontal and central interhemispheric, and right and left intrahemispheric EEG coherence in the delta, theta, alpha, and beta2 frequency ranges using the MERU Real Time EEG Epoch Analysis System (Beresford and Bowerman, 1982). The experimental period, of 30 minutes total duration, consisted of 5 minutes sitting quietly with eyes closed, 15 minutes practice of Transcendental Meditation, 5 minutes practice of the TM-Sidhi programme, and finally 5 minutes sitting quietly with eyes closed.

Jedrczak administered a number of psychological tests, including shape memory, fluency (creativity), flexibility (opposites test), reaction time, and motor speed; correlations of these parameters with EEG coherence are reported here.

Full details of the subjects, instruments, and procedures used in collecting the EEG and psychological data are contained in the papers mentioned above.

ANALYSIS—The coherence variables used were the mean values in each of the four frequency bands for each area of the brain analysed over the whole 30-minute experimental period. The values in each of the 4 steps of the experiment were highly intercorrelated and the mean values were used both to reduce the number of variables used (to 16) and to create more representative variables (the mean values representing sixty 30-second epochs).

Statistical analysis of the coherence and psychological data was carried out as follows:

1. Stepwise multiple regression was performed with each of the psychological variables in turn as the dependent variables, and the coherence values as the independent variables. In common with the study of Jedrczak (in press), age

1. Reprinted in this volume of Collected papers.
2. It should be noted that the MERU system uses two digital filters to eliminate muscle artifacts (Beresford and Clements, in press). It is therefore highly unlikely that levels of beta coherence are related to such artifacts.
and number of months of practice of the TM-Sidhi programme were also studied as dependent variables in the same manner. It should be noted, however, that this measure also includes the effects of previous and continuing practice of Transcendental Meditation. The stepwise regression procedure was terminated at the point before which the t-values for the last two regression coefficients added were not significant.

2. In this study the main concern was the significant relationships of individual coherence measures with the dependent variables, rather than maximising prediction of the dependent variables. Therefore those variables acting as net and classical suppressors in each multiple regression equation were identified and ignored. Their contribution to the variance of the dependent variables is minimal, even though they may exhibit significant t-values (Cohen and Cohen, 1975).

3. Finally the multiple regression equations were recalculated using only those independent variables remaining after 2 above.

RESULTS

Table 1 lists:

\[ a \] Dependent variables from 3 above that have coherence predictors clearly related to them, both directly and in the multiple regression equations; and

\[ b \] The standardised beta coefficients and t-values for those coherence predictors.

The multiple correlation coefficients for each of the equations calculated in 3 above were all significant.

DISCUSSION

These results clearly demonstrate the predictive power of different aspects of EEG coherence for age-related psychological variables—creative fluency, motor speed, reaction time, shape memory, and flexibility—and support the hypothesis that the reversal of ageing with respect to these variables that occurs with the Transcendental Meditation and TM-Sidhi programme is related to increases in cortical integration as measured by EEG coherence.

The clearest pattern to emerge concerns the relationships between age, right beta coherence, and tasks related to speed. (In this context a further analysis indicated that the correlation of the fluency variable with beta coherence was mainly due to the speed component inherent in this task.)

The results show that higher levels of right beta coherence are related to faster performance and younger age (the latter is also associated with higher levels of central beta coherence, independently of right beta coherence).

It is also well established that old age is associated with slower performance (Welford, 1977), and specifically in relationship to the measures of speed used in the present study, Jedrczak (in press) found reaction time and line crossing performance to be negatively related to age.

These results can be related to existing research on the effects of the Transcendental Meditation and TM-Sidhi programme, in that practice of this programme has been found to: (a) increase right beta coherence (Beresford and Clements, in press); (b) improve performance on speed tasks (e.g. Holt et al., 1978; Jedrczak, in press; Orme-Johnson et al., 1977); (c) generally produce changes in the opposite direction to those normally occurring as a result of ageing (Clements and Clements, 1980; Toomey et al., in press, a and b; Wallace et al., 1982).

Beresford and Clements (in press) found an increase in right and central beta coherence from an eyes-closed pre-control period to practice of Tran-
scendental Meditation, a further increase from Tran­
scendental Meditation to practice of the TM-Sidhi
techniques, and a decrease from these to the eyes­
closed post-control period. It is interesting to note
that left and frontal beta coherence did not exhibit
these significant changes, i.e. the beta coherence
variables which were found to change significantly
were those which are found to be of importance in the
present study.

It is also interesting that, in studying changes in
coherence ratios, Beresford (in preparation) found
increases in the ratio of right beta coherence to left
beta coherence and central beta coherence to frontal
beta coherence.

It may be hypothesised that:

1. Right beta coherence is an expression of ac­
tivity in the brain related to perceptual-motor
speed, and that the lower levels of right beta
coherence associated with age are an expres­
sion of deterioration of neurological processes
underlying this function.

2. The improvements in perceptual-motor speed
noted to result from the practice of the Tran­
scendental Meditation and TM-Sidhi pro­
gramme are closely related to increases in right
beta coherence, reflecting greater integration
of cortical function, and reversal of age-related
deteriorations in neurological processes.

Although right hemisphere beta coherence was
not a significant predictor of number of months prac­
tice of the TM-Sidhi programme in this study, it is
highly likely that, given the above pattern of results,
the 'state' increases found would also result in a
'trait' increase which the present linear methods of
analysis may not be able to model. This could be
confirmed in a longitudinal study.

These relationships are illustrated in fig. 1.

The present findings also complement previous
neurological studies showing faster normal and Jen­
drassik reflex time (Warshal, 1980), and shorter
latencies of auditory evoked responses (Kobal et al.,
1975), which help to elucidate the improved per­
formance resulting from the practice of the Tran­
sendental Meditation and TM-Sidhi programme.

The second main finding concerns the alpha fre­
quency. Right alpha coherence was significantly
predictive of performance on shape memory and also
of number of months of practice of the TM-Sidhi
programme. These results are consistent with the
findings of Beresford and Clements (in press), who
found right alpha coherence to increase during the

FIG. 1. RELATIONSHIPS BETWEEN PRACTICE OF THE TRANSCENDENTAL MEDITATION AND TM-SIDHI PROGRAMME, AGEING, RIGHT HEMI­SPHERE BETA COHERENCE, AND PERCEPTUAL MOTOR SPEED.
practice of the Transcendental Meditation and TM-Sidhi programme, and of Jedrczak (in press), who found that length of practice of the TM-Sidhi programme predicted better shape memory performance. Jedrczak also found that shape memory was negatively correlated with age. However, in this study, right alpha coherence was not found to be linearly related to age.

This finding can be seen in the broader context of right hemisphere activity. Beresford and Clements (in press) found that the right hemisphere showed the most consistent increases during the Transcendental Meditation and TM-Sidhi programme. This, along with previous research showing improvements in tonal memory as a result of practice of Transcendental Meditation (Pagano and Frumkin, 1977), supports the hypothesis that the programme enhances the functions of the usually non-dominant right hemisphere, which has been associated with a more holistic style of functioning (Bradshaw and Nettleton, 1981).

It should be noted here that the psychological tests were designed to evaluate age differences and were not primarily intended to be sensitive to different types of brain activity such as laterality effects.

In conclusion, the results of this study confirm the findings of previous research that EEG coherence is significantly related to psychological performance, and indicate that the reversal of ageing that results from the Transcendental Meditation and TM-Sidhi programme is correlated with specific increases in EEG coherence. These findings bring out important new avenues for investigating the neurophysiological basis of the benefits of the Transcendental Meditation and TM-Sidhi programme, both in general and in terms of its positive effects on factors which normally deteriorate with age.

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REFERENCES


