NEUROPHYSIOLOGICAL ENTRY CHARACTERISTICS: CORRELATION BETWEEN EEG COHERENCE AND MATH ACHIEVEMENT WITH SUBJECTS PRACTICING THE TM PROGRAM

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EEG coherence was found to be positively correlated with mathematics grades in students practising Transcendental Meditation. EEG coherence has previously been found to increase as a result of Transcendental Meditation and to correlate with clarity of experience of unbounded awareness. Taken together, these findings emphasize the intimate relationship between higher states of consciousness, neurophysiological integration, and intellectual performance.—EDITORS

The purpose of this study was to investigate the strength of EEG coherence in predicting math achievement. Twenty-six male students, who were tested for EEG coherence as part of Maharishi International University's psychophysiological testing program and were enrolled in sophomore year math courses, were randomly selected for the study. Statistical analyses were performed to determine: 1) whether a positive correlation exists between EEG coherence and math grades; and 2) whether EEG coherence is an added predictor of math grades beyond that of prior grades. EEG coherence was found to be positively correlated with math grades (r = .476) and added to the prediction of math achievement significantly beyond the prediction of prior grades. The multiple correlation between EEG coherence and prior grades and the criterion math grades was found to be .934, which accounts for approximately 87% of the variance. The suggestion that EEG coherence is a measure of unbounded awareness, which contributes to math performance, is discussed.

INTRODUCTION

Researchers have focused considerable attention on identifying characteristics that contribute to the prediction of academic success. Bloom (1976) has found that cognitive entry characteristics such as aptitude and prior school performance, correlate with academic achievement between +.50 and +.70, accounting for as much as 50 percent of the variance in achievement. The International Study of Educational Achievement has found correlations between affective entry characteristics and school achievement to be on the average about +.31 (about .10 higher when corrected for unreliability), accounting for 10 to 17 percent of the variance in school achievement (Bloom, 1976). In addition, recent advances in computer technology and electrophysiological (EEG) correlates of brain-wave functioning have enabled the development of procedures that may also contribute to the prediction of academic success (Gresham and Evans, 1979).

According to Beaumont, Mayes, and Rugg (1978), one of the best methods for investigating the
dynamic organizational status within the brain is through the use of EEG coherence data, which measures the correlation of two signals as a function of frequency, together with the associated cross-phase spectrum. Shaw, O'Connor, and Ongley (1977) have lent support for this type of analysis.

Studies using EEG coherence measures have found significant relationships between EEG coherence and creativity (Orme-Johnson and Haynes, in press), moral development (Nidich et al., 1982), concept learning (Dillbeck et al., in press), and the subjective experience of pure consciousness, the state of least excitation of consciousness associated with heightened alertness during the Transcendental Meditation (TM) technique (Orme-Johnson, 1977). In addition, EEG coherence data have been used for clinical diagnosis (e.g., Sklar, Hanley, and Simmons, 1972), to study waking and sleep phases (e.g., Dumermuth, Walz, Scollo-Lavizzari, and Kleiner, 1972), and to investigate hemispheric information processing (e.g., Beaumont, Mayes, and Rugg, 1978).

The purpose of this study was to determine whether a positive correlation exists between the functional organization of the various regions of the brain as monitored by EEG coherence and math grades. In addition, this study was conducted to determine whether EEG coherence is an added predictor of math grades beyond that of prior grades.

METHOD

SUBJECTS—Twenty-six male undergraduate students, who were tested for EEG coherence as part of Maharishi International University's psychophysiological testing program and were enrolled in sophomore year introductory math courses, were randomly selected for the study. All of the students had taken the first year core courses at Maharishi International University and were practicing the TM program. The Transcendental Meditation (TM) technique is defined as turning the attention inwards towards the subtler levels of a thought until the mind transcends the thinking level and arrives at the source of thought, the state of least excitation of consciousness (Maharishi, 1966).

PROCEDURE—The measure of math grades used for this study was the final grade given by the instructors in the sophomore introductory math courses. These courses were taught as one month block courses and were the equivalent of semester-long courses. The EEG coherence measures used for this study were computed within the alpha frequency band for the following pairs of leads: F3, F4 (bilateral frontal); F3, C3 (left intrahemispheric); and F4, C4 (right intrahemispheric). Test-retest reliability coefficients for the frontal, left, and right alpha coherence measures are reported by Orme-Johnson, Wallace, and Dillbeck (1981) to be .857, .848, and .740 respectively, over a three to four month period (N = 45). All measures were monitored simultaneously with the mean coherence scores being derived from ten .53-minute periods during which all students practiced the TM program. All recordings were monopolar referenced to linked ears. The EEG data was amplified by a Grass model 78D 17 channel EEG and Polygraph. The data was digitized on-line in a Megatek Laboratory Interface connected to a Data General 32K word Nova 3 minicomputer.

Final grades for the sophomore math courses were correlated separately with each of the mean EEG coherence scores. In addition, final course grades from the students' first year core courses that involved math skills (math and physics of relativity) were averaged together and correlated with sophomore math grades. The Pearson product moment correlation coefficient was used for the above analyses. Following this procedure, multiple regression analysis was used to determine whether EEG coherence added to the prediction of math grades beyond that of prior grades.

RESULTS

Both bilateral frontal alpha coherence and left intrahemispheric alpha coherence measures were positively correlated with sophomore introductory level math grades (r = .476, p < .01; r = .336, p < .05, respectively). The correlation between right alpha coherence and sophomore math grades was not significant (r = .082). The correlation between freshmen grades and sophomore math grades was .613 (p < .005). Frontal alpha coherence accounted for 23 percent of the variance in sophomore math grades while left alpha coherence accounted for 11 percent of the variance and prior freshmen grades accounted for 38 percent of the variance.

When both frontal alpha coherence and prior freshmen grades were used as multiple predictors of
sophomore grades, the multiple R was found to be \(.692 (p<.005)\), thus accounting for 48 percent of the criterion sophomore grades variance. The partial correlation of frontal alpha coherence and sophomore grades controlling for freshmen grades was \(.321 (p<.05)\).

When left alpha coherence was used with prior freshmen grades as a joint predictor of sophomore grades a multiple R of \(.669\) resulted. Left alpha coherence did not significantly add to the prediction of sophomore grades beyond that of prior freshmen grades (partial \(r = .262, p > .05\)). The inclusion of left alpha coherence with frontal alpha coherence in the prediction of sophomore grades yielded a multiple R increment of only \(.018\) which indicated that left alpha coherence did not significantly add to the prediction. Table 1 displays the means and standard deviations for each variable, and the single correlation between the predictors and the criterion sophomore math GPA.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Simple r with 2nd Year Math GPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEG Frontal Alpha Coherence F3,F4</td>
<td>.749</td>
<td>.063</td>
<td>.476**</td>
</tr>
<tr>
<td>EEG Right Alpha Coherence F3,C3</td>
<td>.681</td>
<td>.101</td>
<td>.082</td>
</tr>
<tr>
<td>EEG Left Alpha Coherence F4, C4</td>
<td>.681</td>
<td>.078</td>
<td>.336*</td>
</tr>
<tr>
<td>1st Year Mathematics GPA</td>
<td>2.62</td>
<td>.698</td>
<td>.613***</td>
</tr>
<tr>
<td>2nd Year Mathematics GPA</td>
<td>2.90</td>
<td>.752</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05 (one-tailed) ** p < .01 ***p < .005

**DISCUSSION**

The results of this study indicate that EEG bilateral frontal alpha coherence is positively correlated with grades in math and is an added predictor of math grades beyond that of prior grades involving math skills. This study suggests that in addition to cognitive entry characteristics, EEG alpha coherence can account for a substantial amount of variance in math grades.

This study indicates that the degree of coherence of activity in the frontal lobes of the brain may play an important part in student outcomes. According to Luria (1973) frontal regions of the brain appear to be responsible for reasoning ability and decision making. According to Orme-Johnson et al. (1979), alpha coherence is an index of the level of cortical tone and may be associated with levels of wakefulness. One interpretation of the results is that bilateral frontal alpha coherence may be a measure of psychophysiological readiness that contributes to the faculty of reasoning, a key element in the area of mathematics. While prior school performance gives us a quick and fairly reliable means of predicting school performance by looking at the history of the student, EEG coherence may provide a measure of the current psychophysiological organization of the student which contributes to his/her readiness to process information. Further studies should be undertaken to determine whether EEG coherence is independent of affective entry characteristics.

Bloom (1976) suggests that in addition to correlational studies, research showing causal relationships between entry characteristics and school achievement is needed. In terms of EEG coherence measures, studies by Levine (1976) and Dillbeck and Bronson (in press) indicates that EEG coherence is increased through the practice of the TM program. Orme-Johnson and Haynes (in press) suggest that there is a direct relationship between high EEG coherence and the experience of unbounded awareness during the practice of the TM program. Looked at from this perspective, this study suggests that there may be a direct causal influence between the degree of unrestricted, unbounded awareness of the student and actual school performance. According to Maharishi (1966), unbounded awareness is the prime factor responsible for achievement in any field of life.

Future research should be undertaken to find out whether EEG coherence correlates with grades from other subjects. It may be that some subjects, e.g., mathematics, require that the student have a broad, flexible level of awareness in order to perform well, whereas other subjects may be less demanding in this respect. In addition, studies should be undertaken to assess whether EEG coherence measures help
predict post-school success, and whether there is a correlated effect among the length of practice of the TM program, increased EEG coherence, and improved effectiveness in school and post-school performance.

REFERENCES


