HEMISPHERIC SYMMETRY OF THE EEG DURING THE TRANSCENDENTAL MEDITATION TECHNIQUE

MARK WESTCOTT, B.A.
Department of Psychology, University of Durham, Durham, England


Increased orderliness of brain functioning, indicated by a higher level of interhemispheric correlation of the EEG, was found in persons practicing the Transcendental Meditation technique. — EDITORS

Interhemispheric symmetry of the EEG was studied in three groups, each with six subjects, using a Neurodata S.A. 2100 symmetry analyzer with frontal or parietal electrode placements. After eyes-open and eyes-closed precontrol periods, the experimental group practiced Transcendental Meditation while the one control group was instructed to relax as deeply as possible and the other to concentrate as intently as possible.

In the in-phase interhemispheric correlation test, within-group differences among the meditators were considerably lower than those of the controls, possibly indicating a normalizing effect due to TM. Between-group differences (tested for significance by the Mann-Whitney U test for independent samples) showed that the EEG was more correlated from hemisphere to hemisphere in meditators than in the controls, particularly at alpha frequencies (p < .05). Meditators also showed a greater power balance between right and left hemispheres during TM compared with the controls, with p < .05 when power ratios were computed for the alpha band.

INTRODUCTION

This exploratory study was designed to investigate by means of electroencephalography a hypothesized increase in hemispheric symmetry during the Transcendental Meditation (TM) technique.

In recent years there has been increasing interest in the psychophysiology of Transcendental Meditation, including changes in the EEG that occur during meditation. Wallace (4) showed that the physiology during TM is different from that of other states of consciousness, with predominant alpha activity coexisting with a greater drop in oxygen consumption than is produced during sleep, indicating a state of "restful inner alertness." Banquet (1) extended these results by showing that the EEG of TM is characterized by a prominence of alpha activity with occasional periods of high-amplitude beta spindles of similar wave form that are in phase from all leads.

In other research Galin and Ornstein (2) have shown that interhemispheric power ratios are related to cognitive mode. They found that subjects who carried out verbal tasks had greater left hemisphere dominance than those who carried out spatial tasks. Ornstein suggests that the left hemisphere may be used more for mathematical, analytic tasks, while the right may be used more for synthetic, creative tasks.

Many people report that Transcendental Meditation produces a subjective experience similar to that produced by profoundly creative pursuits. Furthermore, it has been reported by several investigators that TM has a normalizing effect on the physiology and psychology of the individual (3, 4, 5). In view of these reports and the research on the EEG of TM, as well as the research on hemispheric symmetry, it was hypothesized that meditators would exhibit greater hemispheric symmetry during TM than nonmeditators would when relaxing or concentrating. To test this hypothesis, measures were taken of the alpha-band in-phase interhemispheric correlation and the power ratio of the right hemisphere over the left, both determined by a Neurodata S.A. 2100 symmetry analyzer. A group of meditators was compared with two control groups, one relaxing and one concentrating, in an attempt to quantify EEG differences between TM on the one hand and relaxation and concentration on the other.

METHOD

SUBJECTS—Each of the three groups was composed of six subjects. Members of the experimental group were experienced in the Transcendental Meditation technique, as taught by Maharishi Mahesh Yogi. The control groups consisted of nonmeditators instructed either to relax (re-
The subjects (four males and two females in each group) were between 18 and 25 years of age. The meditators were three students, two teachers, and one businessman, and the controls were all students.

**APPARATUS**—Silver chloride electrodes were secured with collodion to points P3 and P4 of the 10–20 system in three subjects in each group, and to points F3 and F4 in the others. The common reference point for all subjects was CZ. Grounding was obtained through an electrode on the forehead.

**PROCEDURE**—Subjects were seated comfortably in a room dimly lit for observation purposes. Each recording session was divided into eight five-minute periods:

1. resting—eyes open
2. resting—eyes closed
3a–3d. test
4. resting—eyes closed
5. resting—eyes open

During the test period, which lasted 20 minutes, the experimental subjects were asked to meditate, the relaxation group was asked to relax (with eyes closed) as deeply as possible, and the concentration group was asked to concentrate (with eyes closed) as intently as possible on composing a letter or letters. Instructions were given to deeply as possible, and the concentration group was asked the subject before the beginning of each recording session. In addition the experimenter indicated the beginning and end of each rest period and the beginning and end of the test period. At the end of each session, the effect of eye movements on the EEG was measured by asking the subject to blink his eyes at specified times.

Power ratio and correlation readings in the alpha band were taken simultaneously once during every five-minute period. Correlation and the EEG were recorded on paper on the polygraph, and power ratios were manually recorded from dial readings.

**CALIBRATION**—To determine what the apparatus actually measured, three oscillators were attached to the circuit, one representing each hemisphere and one the reference point. The two hemispheric oscillators were kept stable so that a constant correlation and power ratio was registered, the output of the reference oscillator was changed in amplitude and frequency, and the resultant modifications in correlation and power ratio were measured. The wave patterns of the three oscillators were analyzed by the differential computer, and the effect of the reference wave form was measured, with the following results.

**CORRELATION**—When the two hemispheric sources both produced sine waves of 250 μV, one at 16 Hz, and the other at 10 Hz, and there was no reference source, a correlation coefficient of 0 was registered. When the reference was a sine wave of between 2.5 μV and 25 μV, there was no change in the coefficient of correlation. When the reference wave had an amplitude of 50 μV, the correlation was modified very slightly. At 125 μV the correlation varied from between 0.07 to 0.10, and at 250 μV it registered 0.40.

This result was independent of frequency changes except when the frequency of the reference wave was the same as that of one of the sources. In that case the correlation was modified by the harmonics of the wave pattern, there was a phase shift, and the correlation flickered up and down around 0.40. Therefore, the larger the amplitude in the reference channel, the larger was the coefficient of correlation.

**POWER**—When one hemispheric source was 125 μV and the other was 250 μV, and when both were sine waves of a constant frequency and the reference source was zero, the power ratio was 2/1. When the reference amplitude was 125 μV, the ratio was 1.6/1. When it was 250 μV the ratio was 1.3/1, and at 500 μV it was 1.1/1. When the frequency was changed the results were modified, but the overall trend was the same. Therefore, the larger the amplitude of the reference wave, the lower was the power ratio.

**DATA ANALYSIS**—Correlation between hemispheres was computed in the analyzer by calculating the differences in amplitudes of the two hemispheric wave patterns over a 0.3-second period. Power ratios were computed in the analyzer by calculating the differences in the areas under the curve of the two wave patterns over a one-second period.

The mean correlation and power ratio for each subject and group for each period during the recording session were calculated. The data were analyzed using a Mann-Whitney U test for independent samples, and p < .05 was taken as the significance level.

**RESULTS**

**CORRELATION**—Table 1 and fig. 1 show the group means of in-phase correlation as measured by the analyzer during the recording session. Within-group differences can be gauged from table 2, which shows the mean correlation for each subject over test periods 3a–3d inclusive.

As a group the meditators are characterized by significantly higher interhemispheric correlation (p < .05 Mann-Whitney U test for independent samples) than
TABLE 1

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>MEAN IN-PHASE CORRELATION OVER THE ALPHA FREQUENCY (GROUP MEANS)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TM (N = 6)</td>
<td>Relaxation (N = 6)</td>
<td>Concentration (N = 6)</td>
</tr>
<tr>
<td>1. Resting—eyes open</td>
<td>0.57</td>
<td>0.45</td>
<td>0.37</td>
</tr>
<tr>
<td>2. Resting—eyes closed</td>
<td>0.68</td>
<td>0.55</td>
<td>0.52</td>
</tr>
<tr>
<td>3a.</td>
<td>0.70</td>
<td>0.53</td>
<td>0.48</td>
</tr>
<tr>
<td>3b.</td>
<td>0.71</td>
<td>0.42</td>
<td>0.48</td>
</tr>
<tr>
<td>3c.</td>
<td>0.73</td>
<td>0.38</td>
<td>0.52</td>
</tr>
<tr>
<td>3d.</td>
<td>0.70</td>
<td>0.55</td>
<td>0.57</td>
</tr>
<tr>
<td>4. Resting—eyes closed</td>
<td>0.76</td>
<td>0.53</td>
<td>0.50</td>
</tr>
<tr>
<td>5. Resting—eyes open</td>
<td>0.67</td>
<td>0.52</td>
<td>0.40</td>
</tr>
</tbody>
</table>

either of the nonmeditating control groups (table 2 and fig. 2). Furthermore, the within-group differences are significantly less for the meditators than for either group of nonmeditators (TM vs. relaxation, $F = 10.26, p < .05$; TM vs. concentration, $F = 6.13, p < .05$; relaxation concentration, $F = 1.68$, not significant; $F$-test for ference of population variances).

Longitudinally, all groups showed the expected increased alpha correlation upon closing the eyes. Thereafter the meditators' correlation increased, reaching its peak in the resting eyes closed postcontrol period. The relaxation group experienced a decrease in correlation during the test, possibly reflecting loss of alertness. A more immediate decrease in correlation was observed in the concentration group, with recovery towards the end of the test period.

In comparing the eyes-open resting periods at the beginning and end of the experimental period, it will be noted that the TM group began with a noticeably higher correlation than the relaxation or concentration groups and, over the course of the experiment, the TM group had the largest increase in correlation, ending with a substantially higher eyes-open correlation than the control groups. Thus, the high level of correlation found during the TM technique is maintained to a large extent with eyes

![Figure 1](image-url)

FIG. 1. IN-PHASE CORRELATION OF LEFT AND RIGHT HEMISPHERES OVER THE ALPHA FREQUENCY. The figure shows overall group means for periods 3 and 4. The significance value is for the comparison of the TM group with the relaxation and concentration groups during the test period (Mann-Whitney U test).
open, providing a basis for activity after meditation.

R/L POWER RATIO—Table 3 and fig. 3 show the group means of the right-to-left power ratios for the various periods during the session. Most noteworthy are the between-group differences in the power ratio change with the onset of the test period. In the meditators the ratio came closer to unity, while for the concentration group the ratio increased and for the relaxation group remained unchanged (as one might expect).

It is also significant to note that the increased left-to-right balance for the TM group carried over into the eyes-open postcontrol period, while the other groups showed less balance at this time than in the eyes-open precontrol period.

DISCUSSION

These results clearly indicate that the meditators as a group displayed significantly higher in-phase interhemispheric correlation in the alpha band than did the control groups. This was true both for pre- and posttest values, suggesting an increased waking-state harmony of the brain rhythms from the left and right hemispheres in meditators. Furthermore, the increase in correlation with the onset of Transcendental Meditation was clearly distinguishable from the changes observed in the relaxation and concentration groups. This may be indicative of the qualitatively different style of mental functioning during Transcendental Meditation compared with mere relaxation or concentration.

The data on right-to-left power ratios are particularly interesting. Since increased power in a given hemisphere is indicative of the increased intrahemispheric synchronization that accompanies reduced specialized activity, the lower R/L ratios in meditators suggest that there was a trend for meditators to use relatively more of their right hemisphere than the controls. Conversely, during the test the concentration group tended to use relatively more of their left hemisphere than the other two groups. Thus, meditators appear to display greater balance in the activity
of their two hemispheres, which, taken together with the increased correlation noted earlier, may imply a greater functional integration.

In the in-phase interhemispheric correlation test, within-group differences among the meditators were considerably lower than those of the controls. This could indicate that the Transcendental Meditation program causes a cumulative normalizing effect on the functioning of the brain.

**CONCLUSION**

However, it is somewhat unclear how the results of an analog symmetry analyzer compare to more conventional digital analysis of the EEG. It is hoped that the present study will provide a direction for future research on the longitudinal effects of the Transcendental Meditation program on interhemispheric correlation and its functional significance.

**REFERENCES**