ELECTROPHYSIOLOGICAL CHARACTERISTICS DURING THE TRANSCENDENTAL MEDITATION PROGRAM AND NAPPING: A PILOT STUDY

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EEG characteristics were found to distinguish the Transcendental Meditation technique from napping or ordinary rest, and to indicate that Transcendental Meditation gives rise to a unique state of restful alertness.—EDITORS

Electroencephalograms and electrooculograms were taken during the Transcendental Meditation (TM) technique and an equal period of supine rest in five subjects. EEG records were subsequently blind-scored. Significantly more restful wakefulness was seen during the TM technique as compared to napping (p < .001) and significantly more sleep during napping than during TM (p < .001). Furthermore, significantly more high amplitude alpha activity was recorded during TM (p < .05). The findings clearly distinguish Transcendental Meditation from ordinary napping or rest and indicate that the TM technique gives rise to a unique physiological state characterized by restful alertness.
INTRODUCTION

Wallace et al. (11-15) suggested that the Transcendental Meditation (TM) technique produced a "wakeful, hypometabolic state" distinct from sleep, and Banquet (1-3) observed that the theta rhythms occurring during the TM technique were morphologically distinct from those accompanying drowsiness and were steadily responsive to click stimuli, indicating wakefulness.

It has been emphasized that although it is not uncommon to fall asleep during the period of the TM technique if one is fatigued prior to the practice, the TM technique in the main, and "transcendental consciousness" (4, 6, 13)* in particular, are not characteristically associated with sleep. Banquet and Sailhan (4) found a coefficient of wakefulness (alpha power divided by delta power) to be highest toward the end of the TM technique period and to be higher than "sleep" during the TM technique period or night's sleep, or resting, eyes closed sitting in controls.

Levine et al. (7) indicated that the period of the TM technique is typically characterized by an increase in EEG coherence†, particularly in the alpha and theta frequency bands in frontal and central locations, and that drowsiness or sleep during the period of the TM technique resulted in a reduction in coherence.

In a detailed statistical study of one advanced participant in the TM program, Farrow (6) pointed out the cyclical nature of physiological processes during the meditator's practice of the technique. In this subject, about once every minute there occurred periods of approximately 20 seconds of low sleep index (delta power divided by alpha plus theta power), near respiratory suspension, reduced heart rate, stable phasic skin resistance activity, and high levels of EEG coherence in the alpha and theta bands. These periods were correlated with the subjective report of transcendental consciousness and alternated with periods of less EEG coherence and greater autonomic activity which were correlated with thoughts during meditation.

The present study attempted to clarify the relation between the TM technique and sleep by quantitative comparison of blind-scored EEG records taken during the TM technique and a control period nap session for each subject.

METHODS

SUBJECTS—The five subjects observed had practiced the TM technique an average of 3.8 years (range 1.3-8), meditated 27 minutes per session (range 20-45). They slept an average of 7.9 hours a night (range 7-9). Three subjects were women, two were men; their ages ranged from 19-28 years. One female subject was an instructor of the Transcendental Meditation program.

APPARATUS—Electrophysiological recordings were made by a Beckman R411 polygraph. Frontal, parietal, and occipital midline EEG, horizontal DC EOG and submental EMGs were recorded. Time constants for the EEG, EMG, and EOG were .03, .3, and .03 respectively. Voltages for the EEG, EMG, and EOG were 50, 50, and 10μV/cm respectively. Separate polygraph channels indicated onset time of click stimulus presentations by an SP-5 stimulator at maximum voltage, and button pressing by subjects. The experimental room was lit during the TM technique sessions by a 6-volt DC lamp.

Subjects filled out a presession biographical information sheet, a pre- and postsession semantic differential and a postsession questionnaire (data from the latter two instruments were not reported in this study).

PROCEDURE—Subjects meditated in a dimly lighted room. Since Banquet (5) has reported that the experimental delay of habitual meditation starting time of long-term meditators may result in increased drowsiness in subjects prior to meditation and is associated with an increase of sleep during the experimental TM technique session, care was taken in the present study to control against experimental delay. Normal sample mean and range starting times were determined (mean, 5 P.M.; range, 4-6.30 P.M.) and experimental sessions were slotted for a somewhat earlier time in the afternoon to allow leeway.

*Transcendental consciousness is said to be characterized initially by a deeply restful yet wakeful, alert condition maintained along with the subjective experience of "pure awareness"—i.e., a state of awareness devoid of objects of thought or mental fluctuations (8).

†EEG coherence is a measure of the constancy of relation between EEG phases for specified frequencies at spatially separated scalp locations. Levine adopted a new signal-processing method—the coherence spectral array—to analyze and display the degree of EEG coherence.
for delays. The experimental range of TM technique starting time was 3–5 P.M. All subjects began at or before their normal TM technique starting time. After 40 to 60 minutes of informal habituation during electrode placement and polygraph adjustment, the subjects underwent a five-minute formal habituation, followed by a meditation period of usual duration in accustomed sitting position, or by a control period matched for duration. The subjects served as their own controls and participated in one meditation and control session, scheduled on different days and in random order for each subject. During the control period subjects were instructed to relax in a supine position with eyes closed in a darkened room and nap if they wished. During the meditation and control periods, click stimuli were presented at irregular intervals during EEG theta activity to determine the EEG arousal response. The subjects were instructed to signal (by pressing a button) the clear subjective experience of transcendental consciousness during the meditation or control sessions. The phenomenological criteria of transcendental consciousness were described (see first footnote).

EEG SCORING — Records from meditation and control sessions for each subject were divided into three minute segments and randomly mixed. An experimenter,* expert in the rating of EEG according to standard arousal-sleep criteria (9), scored each 30-second EEG epoch within the given three-minute segment and predicted blindly whether segments came from meditation or control sessions. Three EEG patterns were observed that were qualitatively or quantitatively distinct from those representative of standard arousal-sleep stages. To account for and rate these patterns, the following categories were added: (a) Restful wakefulness—high alpha—characterized by sinusoidal alpha (8–12 Hz) substantially greater in amplitude (100–300μV) (fig. 1.1) than the alpha of the same subject during the baseline habituation or remainder of the meditation session. (b) Transition—qualitatively different from and intervening between restful wakefulness and stage 1, marked by high amplitude (100–300μV) continuous theta trains (4–7 Hz) of 5 to 15 seconds duration alternating with sinusoidal alpha which was typically associated with some degree of slow eye movement, although in one instance eye movements were absent (fig. 1.2).

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FIG. 1. EEG OR EEG/EOG TRACES REPRESENTATIVE OF THE THREE ADDED AROUSAL–SLEEP CATEGORIES. Calibration EEG, 1 sec, 50μV; EOG, 1 sec, 10μV.

FZ – PZ

1.1 Restful Wakefulness—high amplitude, sinusoidal alpha (8–12 Hz).

FZ – PZ

1.2 Transition—high amplitude, continuous theta train (4–7 Hz) accompanied by absence of eye movements.

FZ – PZ

1.3 Transition-Beta—alternation of high amplitude theta train with beta rhythm without intervening alpha in the parietal region.
(c) Transition-beta—distinguished by alternation of theta trains with beta rhythms without intervening alpha in the parietal region (fig. 1.3).

RESULTS

A 2×5 repeated measures analysis of variance was performed on percentage of time spent in each EEG state as a function of meditation versus control session. The five levels of different EEG patterns included were wakefulness and sleep stages 1–4. In the ANOVA the wakefulness category includes arousal as well as dominant alpha. (In subsequent analyses we break down wakefulness into its constituent parts: arousal, high and regular amplitude alpha). The transition categories were excluded from the ANOVA because they accounted for so little of the EEG patterns and could not readily be assimilated to either wakefulness or sleep.

The analysis indicated a significant difference among the EEG categories collapsing across session which suggests that some of the EEG patterns occurred more frequently than others (F4,16 = 10.33, p < .0002). Not surprisingly, session effect did not reach significance (F1,4 = 4.65). More important to the present study, there was a significant interaction effect. Our study hypothesized that meditation and napping differ—such that greater wakefulness would be associated with TM and more sleep with napping. This hypothesis is tested by the interaction of session and EEG pattern. The interaction is highly significant (F4,16 = 10.51, p < .0002).

One-tailed t-tests were performed to test specific hypotheses on the relationship of meditation vs. napping to the frequency of occurrence of each particular EEG pattern. As predicted, t-tests clearly revealed that more time was spent awake in TM than during napping (T16 = 7.65, rpb* = .97, p < .001), and more time was spent asleep (1-4) while napping relative to the TM sessions themselves, regular alpha occurred 2.4 times more frequently than high alpha. Arousal EEG manifested infrequently during either TM or control sessions. Transition-beta occurred only in meditation, as did Transition in all but one instance. The longest single periods of Transition and Transition-beta were both followed by signalling of transcendence. These transition patterns may be related to the synchronous beta and theta during transcendence previously reported (2, 6). The remaining signals of transceding in the present study also occurred during meditation—nine during Restful-Wakefulness and one in the context of stage 1. Theta response to click stimulus was variable both during meditation and control. Only one instance, which took place during the control period, appeared to resemble Banquet's theta-blocking response. However, click stimuli were given during

period, stage 1 was followed by deeper stages in four of five subjects, and during meditation in only one subject. During meditation, the subjects tended to maintain stage 1 or momentarily shift into it and return to alpha.

If, in accordance with "conventional designations," only stages 2–4 are considered to be sleep (10), then our subjects slept an average of 4% of the meditation time—four subjects not sleeping at all and one exhibiting stage 2 in one-fifth of his meditation. No instances of stages 3–4 were observed. With respect to percentage breakdown of time spent clearly asleep (stages 2–4), subjects slept 9.25 times as much during napping relative to the TM sessions. Our subjects spent four-fifths of their meditation sessions in a clearly wakeful condition. The new category of Restful-Wakefulness—high alpha—proved highly discriminating and accounted for most of the waking activity observed during TM. High alpha occurred 5.6 times more frequently during TM than napping; baseline or regular alpha took place only 1.7 times more often during TM. Within the napping sessions themselves, regular alpha occurred 2.4 times more frequently than high alpha. Arousal EEG manifested infrequently during either TM or control sessions. Transition-beta occurred only in meditation, as did Transition in all but one instance. The longest single periods of Transition and Transition-beta were both followed by signalling of transcendence. These transition patterns may be related to the synchronous beta and theta during transcendence previously reported (2, 6). The remaining signals of transceding in the present study also occurred during meditation—nine during Restful-Wakefulness and one in the context of stage 1. Theta response to click stimulus was variable both during meditation and control. Only one instance, which took place during the control period, appeared to resemble Banquet’s theta-blocking response. However, click stimuli were given during

* rpb signifies a point biserial correlation which indicates "effect size" independent of sample size. Rpb = √(T1/T1+T0). The square of the rpb provides a measure of the proportion of variance accounted for. T-tests are dependent on sample size for their determination. Because our sample size was quite small, T values were necessarily reduced in magnitude. An effect size of .40 is considered large in the behavioral sciences and an effect greater than .50 is rarely observed. (Cohen, J. Statistical Power Analysis for the Behavioral Sciences. New York: Academic Press, 1969. Welkowitz, J.; Ewen, R. B.; and Cohen, J. Introductory Statistics for the Behavioral Sciences. New York: Academic Press, 1976, p. 187.)
TABLE 1

PERCENTAGE TIME SPENT IN EACH EEG STAGE

<table>
<thead>
<tr>
<th>STAGE</th>
<th>CONDITION</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>MEAN (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wakefulness (arousal and</td>
<td>Meditation</td>
<td>77</td>
<td>100</td>
<td>38</td>
<td>97</td>
<td>86</td>
<td>80 (12)**</td>
</tr>
<tr>
<td>alpha)</td>
<td>Nap</td>
<td>4</td>
<td>62</td>
<td>12</td>
<td>52</td>
<td>15</td>
<td>29 (13)</td>
</tr>
<tr>
<td>Arousal</td>
<td>Meditation</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>3 (6)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Restful Wakefulness—High</td>
<td>Meditation</td>
<td>32</td>
<td>96</td>
<td>0</td>
<td>70</td>
<td>25</td>
<td>45 (38)*</td>
</tr>
<tr>
<td>Alpha</td>
<td>Nap</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>29</td>
<td>0</td>
<td>8 (12)</td>
</tr>
<tr>
<td>Restful Wakefulness—</td>
<td>Meditation</td>
<td>45</td>
<td>4</td>
<td>25</td>
<td>27</td>
<td>61</td>
<td>32 (22)</td>
</tr>
<tr>
<td>Regular Alpha</td>
<td>Nap</td>
<td>2</td>
<td>51</td>
<td>4</td>
<td>23</td>
<td>14</td>
<td>19 (20)</td>
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<tr>
<td>Transition</td>
<td>Meditation</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1 (2)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Transition-Beta</td>
<td>Meditation</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1 (2)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total Sleep (Stages 1–4)</td>
<td>Meditation</td>
<td>23</td>
<td>0</td>
<td>57</td>
<td>3</td>
<td>9</td>
<td>18 (23)**</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>96</td>
<td>40</td>
<td>88</td>
<td>48</td>
<td>83</td>
<td>71 (25)</td>
</tr>
<tr>
<td>Stage 1</td>
<td>Meditation</td>
<td>23</td>
<td>0</td>
<td>36</td>
<td>3</td>
<td>9</td>
<td>14 (11)**</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>8</td>
<td>32</td>
<td>49</td>
<td>48</td>
<td>31</td>
<td>34 (17)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Meditation</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>4 (9)**</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>62</td>
<td>8</td>
<td>39</td>
<td>0</td>
<td>52</td>
<td>32 (27)</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Meditation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4 (9)</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Meditation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 (0)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

* p<.05, one-tailed t for related measures  ** p<.005  *** p<.001

** FIG. 2. EEG CHARACTERISTICS OF TM VS. NAPPING. Inner wakefulness during deep rest: a unique physiological state.**
less than one-fourth of the theta instances (12 times during meditation sessions and 21 times during control sessions) and, due to the irregular pattern of stimulation, never during theta in transition stages, when theta most closely approximated the meditative theta of Banquet. The scorer discriminated between randomly mixed meditation and control segments for each subject quite accurately, with 90% correct predictions, scoring correctly on 106 out of 118 trials (two tailed, chi square, \( x^2 = 74.77, df = 1, \) phi coefficient = .80, \( p < .0001 \)).

**CONCLUSION**

The findings presented above support the hypothesis that greater wakefulness would be associated with TM and more sleep with napping (\( p < .0002 \)). It was seen that significantly more time was spent awake during TM than during napping (\( p < .001 \)) and more time was spent asleep during napping than during TM (\( p < .001 \)). The wakefulness seen during TM was characterized by alpha activity (96%) and particularly by high amplitude alpha (56%). Significantly more high alpha was recorded during TM (\( p < .05 \)). Furthermore, significantly more sleep stages 1 (\( p < .005 \)) and 2 (\( p < .001 \)) were noted during napping than during the TM technique.

In this study, where for the purpose of statistical analysis stage 1 was conservatively treated as sleep, subjects slept during 18% of the TM technique session. If only stages 2–4 are evaluated as sleep, in accordance with "conventional designation" (10) then the TM subjects spent an average of only 4% of the TM session in sleep. In this later case subjects indicated stages 2–4 sleep 9.25 times as much during TM than during napping less than one-fourth of the theta instances.

**ACKNOWLEDGMENTS**

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**REFERENCES**


