AN EXPERIMENTAL ANALYSIS OF THE EFFECTS OF THE TRANSCENDENTAL MEDITATION TECHNIQUE ON REACTION TIME

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People practicing the Transcendental Meditation technique had faster reactions after a period of the technique than after a period of rest. —EDITORS

The study was designed to investigate the influence of the Transcendental Meditation technique on simple reaction time and to compare the relative influence of Transcendental Meditation and ordinary rest. Two groups of 25 college-age subjects were individually tested four times on four days within a two-week period. Group I (meditators) were tested with 100 trials both before and after a 20-minute session of Transcendental Meditation (days 1 and 3) and also before and after 20 minutes of supine rest with eyes closed (days 2 and 4). Group II (nonmeditators) were tested before and after a 20-minute period of sitting rest with eyes closed on days 1 and 3 and before and after an equal period of supine rest on days 2 and 4. Additionally, 53 teachers of the Transcendental Meditation technique (Group III) were simply measured before and after one meditation. Results show an improvement in reaction time performance after meditation in Groups I and III (p < .001) and a lowered performance after supine rest (p < .001) in the Group I meditators. Nonmeditators showed no significant change in reaction time after either condition of ordinary rest. A comparison on pretest mean reaction time for Group I (meditators) and Group II (nonmeditators) indicated that meditators as a group have faster reactions than nonmeditators (p < .01). These findings were discussed in light of a current theory of arousal, activation, and performance.

INTRODUCTION

Physiological research has well established that the state produced by the Transcendental Meditation (TM) technique is a form of deep rest qualitatively and quantitatively different from sleep (8, 9, 10, 11). An exploratory study by Shaw and Kolb (7) suggested that this state of "restful alertness," through its unique psychophysiological structure, may contribute to an improvement in behavioral efficiency.

During the TM technique subjects typically show a large and rapid decline in metabolic activity, lowered heart and breath rate, and lowered arterial blood lactate, as well as sizable increases in the skin resistance response. According to Gellhorn and Kiely (3), these physiological indices indicate that the activity of the central nervous system shifts from the sympathetic dominance, characteristic of the active waking state, towards a parasympathetic dominance, characteristic of rest. Importantly, this increasing quiescence of skeletal muscle activity and emotional responsiveness does not lead to drowsiness or sleep, as would be expected with such low metabolic activity. Electroencephalographic recordings show that during this state of restful alertness subjects produce increased alpha and occasional theta activity, which occurs in the frontal areas. As an explanation for this phenomenon Gellhorn and Kiely suggest that during meditation there are not only increased trophotropic (parasympathetic) discharges, but also concomitant ergotropic (sympathetic) discharges that prevent the subject from passing from a state of alpha dominance into a state of sleep. They propose that a relatively subtle excitation during the meditative state induces partial activation of the ergotropic system. This would explain the EEG activity and persistent awareness during deep meditation.

This physiological evidence and the subjective reports of meditators suggest that through the TM technique one may derive the benefits of deep rest without experiencing the drowsiness and lowered responsiveness commonly associated with brief periods of sleep. In the following research we have undertaken to experimentally evaluate the differential behavioral effects of ordinary supine rest, sitting rest, and the practice of the TM technique by utilizing simple reaction time as the index of behavioral efficiency.
METHOD

In three groups of subjects, including both meditators and nonmeditators, reaction time measurements were taken both before and after periods of rest, as described below.

Group I was composed of 25 students and staff members at Maharishi International University at Santa Barbara, California, who had been practicing the TM technique from nine to 64 months, with a mean time of 28.9 months. The mean age of the 17 males and eight females in Group I was 23.1 years.

Group II was composed of 25 nonmeditating student volunteers from the University of California at Santa Barbara. The 14 males and 11 females (mean age 21.8 years) were comparable in educational level to the members of Group I.

Each subject in Group I (meditators) was first tested for simple reaction time in 100 trials before and after a 20-minute meditation period. The subject was given five minutes to come out of meditation and was retested immediately thereafter.

Each subject in Group II (nonmeditators) was similarly tested before and after a 20-minute session, during which he sat and rested with eyes closed in the same room and chair utilized by the meditators.

Subjects of both groups (I and II) were asked to come back two days later to be retested before and after a 20-minute period of supine rest.

For test-retest validation there were two further sessions for all subjects. These third and fourth sessions were identical to the first and second, respectively, and were conducted on two different days within a two-week period. Testing occurred at the same time of day for each subject.

Each subject in Group III (teachers of the TM technique, N = 53) was tested for mean reaction time in 100 trials both before and after a 20-minute session of practicing the TM technique. Their ages were comparable to Groups I and II, but their meditating experience (mean of 39 months) was more extensive than that of Group I subjects.

None of the subjects in the three groups had slept or meditated within four hours of the testing, and none had eaten within one hour of the testing. No experimental hypothesis was expressed or implied by the experimenter, and subjects were not able to anticipate the form of rest that would be assigned between tests until actual instructions were given.

PROCEDURE

Reaction time to a light stimulus placed directly in front of the subject was measured to the nearest thousandth of a second with an electronic timer. Each subject was seated comfortably in front of the reaction-time device with the forefinger of his dominant hand resting on a spot eight inches from a telegraph key "off" button, which took 500 grams of pressure to depress. Each subject was asked to read the following instructions:

1. Sit facing the white board with the red light in its center.
2. If you are right-handed, place your right index finger on the blue dot reference point on the right. If you are left-handed, put the left index finger on the green dot reference point on the left.
3. When the red light goes on, press or tap lightly the telegraph key as fast as possible. Then immediately return your finger to the reference point (dot).
4. There will be 100 trials. Be ready for each trial and perform the task as fast as possible.
5. It is important that you return to the reference point each time in order for the reaction time to be accurate.
6. After the last trial I will return. You will then go to a quiet room and rest in the instructed manner for twenty minutes.
7. At the end of the rest period you will be asked to perform the 100 reaction-time trials again.
8. We keep all information on our subjects confidential and will publish no names.
9. If at any time during testing, you wish to discontinue testing, you may do so.

The subject was then asked if he was ready, and upon the reply of "yes" the experimenter left the room and testing began. For each block of 100 trials a randomly varied intertrial interval of three to seven seconds was maintained, with a mean interval of 6.5 seconds. The sequence of intervals was randomized for each block. Reaction-time sequences were automated with the use of magnetic tape.

RESULTS

GROUP I—Mean reaction times for post-meditation trials were significantly shorter than for pre-meditation trials on both test days 1 and 3 (p < .001). (See fig. 1a and table 1.) Of the total of 50 post-TM test sessions, the mean reaction times for 46 sessions were improved. One subject fell asleep during the practice of the TM technique, and afterwards her reactions were found to be slower than those following a meditation in which she did not fall asleep.
### Table 1

Mean Reaction Time of Meditators (Group I) Before and After the TM Technique and Supine Rest

<table>
<thead>
<tr>
<th></th>
<th>TM I (day 1) Before</th>
<th>TM I (day 1) After</th>
<th>Supine Rest I (day 2) Before</th>
<th>Supine Rest I (day 2) After</th>
<th>TM II (day 3) Before</th>
<th>TM II (day 3) After</th>
<th>Supine Rest II (day 4) Before</th>
<th>Supine Rest II (day 4) After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.444</td>
<td>0.413*</td>
<td>0.436</td>
<td>0.478*</td>
<td>0.452</td>
<td>0.419*</td>
<td>0.448</td>
<td>0.471*</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.053</td>
<td>0.050</td>
<td>0.064</td>
<td>0.077</td>
<td>0.057</td>
<td>0.058</td>
<td>0.067</td>
<td>0.065</td>
</tr>
</tbody>
</table>

*p < .001; two-tailed t-test comparing before and after mean reaction times.

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**Fig. 1a.** Mean reaction time for Group I (meditators) before and after the TM technique and Group II (nonmeditators) before and after sitting rest on days 1 and 3. On both test days meditators' performance improved significantly after the TM technique (reaction time decreased), whereas the reaction time of nonmeditators remained unchanged following rest periods.

**Fig. 1b.** Mean reaction time before and after supine rest for Group I (meditators) and Group II (nonmeditators) on days 2 and 4. In both testing sessions the meditators showed a decline in reaction time performance following supine rest; nonmeditators did not change significantly.
TABLE 2
MEAN REACTION TIME OF NONMEDITATORS BEFORE AND AFTER SITTING REST WITH EYES CLOSED AND SUPINE REST

<table>
<thead>
<tr>
<th>REACTION TIME (sec)</th>
<th>SITTING REST I (day 1)</th>
<th>SUPINE REST I (day 2)</th>
<th>SITTING REST II (day 3)</th>
<th>SUPINE REST II (day 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Mean</td>
<td>0.490</td>
<td>0.482</td>
<td>0.485</td>
<td>0.495</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.057</td>
<td>0.069</td>
<td>0.078</td>
<td>0.098</td>
</tr>
</tbody>
</table>

*NS = not significant; two-tailed t-test comparing before and after mean reaction times.

Most meditators reported that they fell asleep during the 20 minutes of supine rest and felt drowsy afterwards. Reaction times were significantly longer after supine rest than before (p < .001). (See fig. 1b and table 1.) Of the 50 post-supine rest test sessions, 45 were characterized by slower mean responses. The mean differences in reaction time for Group I are substantial in the light of the small individual variability commonly associated with simple reaction time. (Note in tables 1 and 2 the consistency of mean reaction times in all four pre-TM test sessions for meditators and in all eight test sessions for non-meditators.)

GROUP II—The results for the nonmeditators showed no significant improvement or impairment after 20 minutes of either sitting rest or supine rest. (See figs. 1a and 1b and table 2.) Fewer subjects in this group actually fell asleep during the rest periods, possibly because the Group II subjects were less accustomed to the surroundings than Group I subjects, who lived and worked in the building complex where the testing took place.

Analysis of covariance yielded significant differences between the changes in mean reaction time for Group I (from before to after meditating) compared to Group II (from before to after sitting rest) on day 1 (p < .02) and day 3 (p < .001). This demonstrates that the TM technique has a significantly stronger effect on reaction time than sitting rest. Also, a comparison of pre-meditation mean reaction time for Group I and prerest reaction time for Group II yielded a significant difference (p < .01, t-test), suggesting that the improvement in reaction time that occurs immediately after meditation produces a cumulative overall improvement in reaction time.

GROUP III (TEACHERS OF THE TM TECHNIQUE)—As did the Group I meditators, Group III meditators showed a reduction in reaction time following 20 minutes of meditation. The mean reaction time for the 53 teachers of TM before meditation was 0.414 seconds, whereas the mean after meditation was 0.378 seconds. This reduction was significant at the 0.001 level. (See fig. 2.) Further, although no statistical analysis was performed, the mean reaction times, both before and after meditation, were shorter for the Group III meditators (who had had greater experience with the TM technique) than for the Group I meditators.

DISCUSSION

The above results confirm the previous findings of Shaw and Kolb (7). Both studies suggest that the physiological style of functioning of the nervous system during Transcendental Meditation predisposes the organism toward improved behavioral responsiveness immediately following the meditation period and that long-term practice of the technique has a cumulative positive effect on reaction time. In the present study ordinary sitting rest was found to have no clear influence on reaction time, although Shaw and Kolb demonstrated a decrease in performance in subjects who merely sat for 20 minutes between sets of trials. They indicated, however, that many of their subjects fell asleep while sitting, as did the meditators during the supine rest condition in the present research. Thus, the effects of a brief nap prior to testing appear to be detrimental to performance. The non-meditators in Group II, during both sitting and supine rest, were apparently not relaxed to the point of going to sleep;
therefore, because they remained in the same state of consciousness throughout the 20-minute period, performance afterwards did not change significantly.

An explanation for these opposite influences of Transcendental Meditation and "napping" requires a brief consideration of the current theory on activation and performance. In general it can be stated that psychomotor performance and perception are best when arousal is in the medium range. Hebb (5) claims that psychomotor performance is low at both extremes of the arousal continuum, i.e., in situations of boredom or sleepiness and in situations of hyperstimulation or overly strong environmental demands. Bruner (1) concurs that too much, as well as too little, activation can interfere with the reception of sensory impulses. He found that if a subject is overly vigilant, he pays a price in the raising of sensory thresholds, and that a "certain amount of relaxation" yields better perceptual performance. Peak performance is thus expected when the individual is maximally awake and not overly excited.

Electrophysiological studies support the behavioral data concerning the relationship between arousal and performance. Goodman (4) suggests that there is a level of reticular neuron activity that is optimal for reaction time performance. From microelectrode recordings he found that when neurons in the brain stem were firing steadily at a moderate level, performance was maximal. Deviations from this optimal level of neural firing were related to a deterioration in performance. With the use of electrostimulation techniques, Fuster (2) found that shorter reaction times and improved perception resulted from a mild stimulation of the mesencephalon. When the stimulation was of a higher intensity, performance was adversely affected. The brain areas stimulated were the same as those shown by other investigators to produce electroencephalographic and behavioral arousal.

The corresponding results of psychophysiological and neurophysiological experimentation strongly suggest that, as a general rule, either overstimulation or low activation of central arousal mechanisms causes a decline in performance. In the present study the longer reaction time following sleep can be easily explained by the above theoretical model—as drowsiness dominates, two components of arousal change: physiological activation declines and alertness diminishes. Under the low-stress conditions of the present experiment the theory predicts a decline in performance following a period of supine rest. The poorer performance may be attributed to reduced alertness, or lowered physiological activation, or both.

As in sleep, the physiological responses elicited by the TM technique would, by current definition, be classified as a state of lowered arousal. As described earlier, the decreases in heart rate and respiration, and the increases in skin resistance, are characteristics of trophotropic dominance and waning activation. Thus, under the conditions of moderate anxiety in a reaction-time test situation, the theory would predict a decline in performance following a session of the Transcendental Meditation technique. An evaluation of the two separate elements of arousal—activation and alertness—becomes important. Here activation is defined as the release of energy into various internal physiological systems, and alertness is defined as awareness, wakefulness, or inner liveliness. As has been suggested, the Transcendental Meditation technique causes these two components of arousal to be differentially affected—activation declines and alertness increases.

To date researchers have implied that alertness and activation covary; that is, if arousal increases, alertness increases, and if arousal decreases, alertness decreases. For example, it has been suggested that increases in alertness are accompanied by increases in muscle tone, body temperature, and other such indices of physical activation. Such a parallel is certainly validated by the common experience that stimulation and activity increase subjective alertness.

The experience of meditators suggests, however, that alertness can also be gained through a systematic procedure for reducing rather than increasing physiological activation. For mental and motor tasks not requiring great exertion of physical energy, this quiet alertness appears to effectively produce the psychophysiological readiness so vital for behavioral efficiency. Clarity of mind and alertness coupled with moderate activation appear to represent the most favorable balance of arousal components.

Recent research suggests that this desirable combination of lower physiological activation and heightened awareness may continue outside of meditation. OrmeJohnson (6) has provided evidence that meditators adjust more quickly to environmental stresses and have an overall lower resting arousal level. The long-term effect of the TM technique may be to lower internal "noise" and agitation levels and thereby enhance cue utilization. This would in part account for the excellent overall performance of the two groups of meditators in the present study.

Alertness appears to be the common denominator of success on any behavioral measure. Very common in society today, however, is the all too heavy reliance upon environmental or chemical stimulants as means to gain alertness and maintain performance levels. These stimulants, through their influence on biochemical and neurological activation centers, maintain a level of arousal compatible with the requirements of routine daily activity. (It is improbable, for example, that an employee will fall asleep on the job with excitement levels artificially elevated by means of chemical stimulants.) A review of the evi-
dence suggests, however, that the alertness gained through such mechanisms of activation has implicit disadvantages—the hazard of overstimulation, the largely unnecessary release and expenditure of energy accompanying generalized physiological arousal, and the impaired capability for relaxation at will.

The TM technique promises to provide a means to maintain a high degree of alertness along with lower states of activation. Thus, individuals may find it possible to maintain moderate arousal with a high degree of alertness and responsiveness without relying upon external sources of activation. Such a physiological structure would provide an ideal platform for greater accomplishment with minimum waste of energy.

In summary, the two detriments to performance, dullness and overstimulation, both appear to be eliminated by the TM technique. TM appears to provide that ideal balance of rest and alertness which most beneficially influences perceptual-motor performance on vigilance tasks and which, by lowering activation levels, prepares the individual to interact more successfully in complex and stressful life situations.

The above considerations suggest many directions for future research. Of particular value will be empirical EEG evaluations of the subjective states of alertness experienced during and after the practice of the TM technique. The present study and the findings of Shaw and Kolb (7) also demonstrate the crucial role of precise electroencephalographic determination of drowsiness and sleep during the course of the experiment. We recommend further study to evaluate the relative changes in vigilance task performance after physical or emotional arousal as compared with performance following the TM technique. Most valuable would be controlled longitudinal studies investigating the development of behavioral efficiency in meditators.

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REFERENCES

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