Transcendental Meditation as a Technique to Increase Neural, Cognitive, and Behavioral Plasticity

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The traditional purpose of meditation is to prepare a person for dynamic activity. The Bhagavad Gita, for example, says, “Established in yoga, perform action” (Maharishi Mahesh Yogi, 1969, pp. 135-138). According to Maharishi, the deeper meaning of the word “yoga” is union of the individual self with the universal Self, of the individual mind with the unified field of nature’s intelligence, the total potential of natural law (pp. 339-340). This can be accomplished through Maharishi’s Transcendental Meditation technique (TM), which allows the thinking mind to settle from its active state to the silent state of transcendental consciousness.

"The Transcendental Meditation technique is an effortless procedure for allowing the excitations of the mind to settle down until the least excited state of mind is reached. This is a state of inner wakefulness with no object of thought or perception, just pure consciousness aware of its own unbounded nature. It is wholeness, aware of itself, devoid of differences, beyond the division of subject and object—transcendental consciousness. It is a field of all possibilities, where all creative potentialities exist together, infinitely correlated yet unexpressed. It is a state of perfect order, the matrix from where all the laws of nature emerge." (Maharishi Mahesh Yogi, 1977, p.123).

The Transcendental Meditation technique, which is neither a religion nor philosophy, is practiced 15-20 minutes twice a day, followed by the regular activity of the day. This alternation of meditation with activity swings the nervous system between deep rest and activity, which increases neural, cognitive, and behavioral plasticity. We will first describe the physiological state produced by the Transcendental Meditation technique and then review the evidence that it increases plasticity.

Transcendental Consciousness (Restful Alertness)

For thousands of years, the Vedic tradition of India, which Maharishi has revived, has described transcendental consciousness as a fourth state of consciousness (e.g., Manduka Upanisad 7 and 12. Radhakrishnan, 1953). In his pioneering research on meditation, Wallace et al. (1970, 1971, 1972) concluded that the physiological state produced by the Transcendental Meditation technique is a fourth major state of consciousness that is different from waking, dreaming, and sleeping on a number of physiological parameters.
Wallace found that the state produced during TM is characterized by somatic arousal reduction (e.g., decreased respiration, oxygen consumption, and plasma lactate) and also by mental “alertness” as indicated by increased alpha and theta EEG power (see review paper by Jevning et al. 1992). Alpha and theta power and coherence, particularly in the frontal cortex, have also been found by others to increase during TM compared to relaxation controls (e.g., Banquet, 1973; Banquet & Sailhan, 1974a, 1974b; Hebert & Lehmann, 1977; Levine, 1976). Furthermore, increased alertness is suggested by increased cerebral blood flow (Jevning & Wilson, 1978; Jevning, et al., 1982; Jevning, et al., 1978a) and increased arginine vasopressin production during TM (O’Halloran, et al., 1985).

A quantitative meta-analysis conducted on the physiological effects of TM compared with simple rest while sitting quietly used all 31 studies that employed either TM or an eyes-closed resting condition in non-meditators (Dillbeck & Orme-Johnson, 1987). This meta-analysis found that TM produced significantly greater reduction in somatic arousal than simply resting quietly, as measured by basal skin resistance, respiration rate, and plasma lactate. Heart rate did not discriminate between TM and rest, decreasing slightly in both conditions (2-3 bpm). Research on other indices of somatic arousal reduction using non-meditating controls in an eyes-closed relaxation condition has also provided evidence that TM differs from ordinary relaxation: e.g., TM produces greater reductions in plasma cortisol, a major stress hormone (e.g. Jevning, et al., 1978b; Jevning, et al., 1978c; Bevan, 1980; Subrahmanyan & Porkodi, 1980).

Cycles within the Meditation Period

Some researchers have noted that averaging the physiological changes during the entire meditation period obscures the dynamics of meditation, which is a cyclical process of inward and outward strokes: “in” towards mental and physical quietude, and “out” towards activation. Studies of the deepest (inward) periods of meditation, which are moments of transcendental consciousness, have provided the clearest evidence of the distinctiveness of the state, showing that it is correlated with virtual respiratory suspension and global increases in EEG coherence across all frequencies (Farrow & Hebert, 1982; Badawi, et al., 1984). An extensive literature of published research on biochemical changes during TM further distinguishes it from ordinary waking, dreaming, or sleep states (see Orme-Johnson & Farrow, 1977; Chalmers, et al., 1989; Wallace, et al., in press). In addition, a recent review article summarizes over 20 psychophysiological dimensions on which experience of transcendental consciousness during TM practice can be distinguished from ordinary waking, dreaming, and sleep (Alexander, et al., 1987).
EEG Correlates as Indicating Increased Neural Plasticity

The hypothesis that the state produced by the Transcendental Meditation technique increases neural and behavioral plasticity is strongly suggested by the correlates of the EEG parameters that index the meditative state. These experiments predicted that a greater degree of EEG coherence measured during meditation would be correlated with better performance on psychological and psychological tests outside of meditation. The underlying assumption of these experiments is that EEG coherence is a good index of the degree of yoga or union with the underlying intelligence of nature, and therefore that the higher the EEG coherence in meditation, the better performance in activity, indicating that the person had become more in accord with natural law. (Although a number of studies show that in general EEG power and coherence in the fast theta and slow alpha frequency band (7-10 Hz) tend to increase during the Transcendental Meditation technique, there are important individual differences between subjects that we are currently investigating in our laboratory.)

Heightened frontal and central alpha and theta EEG coherence during TM has been shown to be significantly correlated with a number of parameters outside the practice: H-reflex recovery rate, concept learning, creativity, fluid intelligence, and moral reasoning, and (inversely) neuroticism (e.g., Dillbeck, et al., 1981; Dillbeck & Araas-Vesely, 1986; Nidich, et al., 1983; Orme-Johnson & Haynes, 1981; Orme-Johnson, et al., 1981).

Another study found that drowsiness produces a reduction in frontal alpha coherence, which is the opposite of the effect of TM, suggesting that the state produced by TM is one of enhanced wakefulness or awareness, i.e., restful alertness (Orme-Johnson et al., 1981).

This interpretation of EEG alpha coherence as an index of enhanced awareness is supported by a study by Dillbeck and Araas-Vesely (1986) who studied the influence of different levels of EEG coherence on concept learning. This experiment was conducted entirely outside of meditation. High coherence preceding a concept-learning trial in TM subjects predicted the successful acquisition of new information during that trial. This suggests that high EEG coherence reflects a state of high receptivity to information processing and mental alertness in meditators. Sheppard (1988) also studied the state of EEG coherence immediately preceding semantic processing and also found that high coherence predicts superior processing, concluding that it indicates a high level of communication or information flow in the brain. The interpretation of the increased EEG coherence produced by TM in the light of this research is that TM produces a unified state in which the brain is not currently engaged in processing information, but is ready for processing—"Established in yoga (restful alertness, a state of unifying capability), perform action."
Increased Autonomic Plasticity

Through alternation of meditation and ordinary activity, one gains a habit of functioning from a state of lower baseline arousal and greater alertness. The lower baseline level of somatic arousal conserves energy so that there is more adaptive reserve. On the basis of having more adaptive physiological reserves, the meditator's physiological response to challenge will actually be stronger, and recovery after the challenge will be more rapid.

The meta-analysis mentioned above (Dillbeck and Orme-Johnson, 1987) found that the meditators also showed significantly lower physiological arousal levels during baseline than non-meditators controls. The baseline, whose mean length for all experiments was 14.6 minutes, was an eyes-closed rest period before meditation or eyes closed-rest for controls. Baseline levels of respiration rate, plasma lactate levels, heart rate, and spontaneous skin resistance responses were all lower for TM subjects. The results of this meta-analysis indicate that the meditators started at a lower initial level of physiological arousal yet decreased even more during meditation compared to non-meditating controls. In addition, the Transcendental Meditation technique has been found to produce longitudinal baseline increases in EEG coherence (Dillbeck & Bronson, 1981).

Even though meditators have lower baseline levels of arousal, they show greater autonomic plasticity. Orme-Johnson (1973) found that Transcendental Meditation subjects had lower baseline levels of spontaneous skin resistance responses than non-meditating controls, yet their initial skin resistance response to a stressor (loud tone) was at least as large as that of non-meditating controls. The meditators' response to stress was also more stable, showing significantly fewer multiple responses to the first stressor presentation. In addition, meditators showed significantly more rapid habituation to repeated presentation of the stressor, indicating more rapid adaptation. Other research in the literature has shown that low baseline levels of spontaneous skin resistance responses and rapid habituation are correlated with each other and with greater ego strength, mental health, field independence, and ability to withstand stressors. This cluster of changes has also been shown in independent research to occur with the practice of TM.

Goleman replicated the essential features of the Orme-Johnson (1973) study in his doctoral dissertation at Harvard (Goleman & Schwartz, 1976). Compared to non-meditating controls, he found that TM practitioners showed significantly more rapid mobilization of heart rate and skin resistance responses to the stressor (a movie of shop accidents) and then more rapid recovery to baseline after the stressful incident had passed. This research shows that rather than developing a style of lower responsiveness to
stressors. TM actually develops a more dynamic style of functioning. Adaptive reserves are conserved in order to support more rapid mobilization of physiological resources to meet the demands of stress when needed. In addition, there is greater adaptive flexibility to recover quickly once the challenge has passed, so that adaptive reserves are not wasted.

The research on hypertension, medical care utilization, and aging reviewed by Wallace (1993) in his article in the proceedings of this conference also indicated increase adaptive flexibility through the Transcendental Meditation technique.

**Increased Central Nervous System Plasticity**

Research on event-related potentials has suggested shorter latencies and increased amplitude on many important potentials in meditators. Kobal et al. (1975) and Wandhofer et al. (1976) found shorter latencies of auditory evoked potentials at N100 (both during and outside the practice of Transcendental Meditation), as well as increased EEG alpha power.

McEvoy et al. (1980) found changes in brainstem auditory evoked potentials following the Transcendental Meditation and TM-Sidhi Program, which suggest improved processing of auditory information.

Banquet and Lesovre (1980) found shorter latency and larger amplitude of visual evoked potentials, together with faster reactions with fewer mistakes on a visual choice reaction time task. These results suggest increased vigilance and improved capacity for selective attention.

Goddard (1989) found reduced age-related declines of P300 latency in elderly people practicing Transcendental Meditation on a more demanding cognitive task. Similarly, Miskov (1992) found shorter latencies of P3A and P3B in elderly meditators compared with controls. These results indicate a possible immediate positive influence of the meditative process upon processing efficiency of information during cognition.

**Increased Cognitive and Behavioral Plasticity**

Schwartz (1979) studied the strength and sensitivity of the nervous system by looking at changes in reaction time to auditory stimuli that ranged from very low levels near the detection threshold to very loud levels near the pain threshold. Meditators were found to have faster reactions than controls to both very quiet and very loud levels of sound, indicating increased sensitivity, strength and flexibility of the nervous system.

Cranson et al. (1991) found that 45 college students who practiced TM over a two-year period improved significantly on Cattell's Culture Fair Intelligence Test compared with 55 non-meditating control students, statistically controlling for subjects' age,
education level, level of interest in meditation, fathers’ education level, and fathers’ annual income. Also, the TM subjects improved significantly compared to controls on IQ-related measures of choice reaction time and standard deviation of choice reaction time. Choice reaction time is a measure of speed in processing complex information. Decreased variability of choice reaction time has been interpreted in the literature as indicating a reduction of “noise” in the functioning of the central nervous system (Jensen, 1987, pp. 134–136; Eysenck, 1987, p. 38). These results replicate previous studies reporting that TM increases IQ (Aron et al., 1981; Dillbeck et al., 1986; Tjoa, 1975) and decreases reaction time (Holt et al., 1978; Warshal, 1980).

Other longitudinal changes that indicate psychological and behavioral plasticity include enhanced flexibility of perception and verbal problem solving (Dillbeck, 1982); increased creativity (Travis, 1979); improvements in overall academic achievement (Nidich et al., 1986); increased field independence (Pelletier, 1974); better marital relations (Aron & Aron, 1982) and improved relations with co-workers (Frew, 1974; see Orme-Johnson & Farrow, 1977; Chalmers et al., 1989; Wallace, Orme-Johnson, & Dillbeck, in press.)

There have been 24 studies showing that TM is highly effective for treating drug abuse (Gelderloos et al., 1991), and eight studies showing its effectiveness for prison rehabilitation (Bleich, 1987; Dillbeck & Abrams, 1987).

A major meta-analysis by Eppley et al. (1989) considered all the research on the effects of meditation and relaxation on anxiety (146 independent outcomes), and found that the Transcendental Meditation technique produces significantly greater reduction in trait anxiety (i.e., chronic stress) than is provided by any other meditation or relaxation technique. Studies with the strongest experimental design (random assignment to groups and low attrition) showed the largest effects for TM.

Another recent exhaustive statistical meta-analysis of 42 independent outcomes found that the effect produced by TM on overall self-actualization as indicated primarily by the Personality Orientation Inventory (POI) was significantly larger than that produced by other forms of meditation and relaxation, controlling for duration of intervention and strength of experimental design (Alexander et al., 1991).

Conclusion

A wide range of experiments support the hypothesis that the Transcendental Meditation technique produces a unique state of restful alertness and that alternation of this state with ordinary daily activity increases the flexibility of nervous system and improves general adaptive ability.
References


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