Default mode network activation and Transcendental Meditation practice: Focused Attention or Automatic Self-transcending?

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**Abstract**

This study used subjective reports and eLORETA analysis to assess to what extent Transcendental Meditation (TM) might involve focused attention—voluntary control of mental content. Eighty-seven TM subjects with one month to five years TM experience participated in this study. Regression analysis of years TM practice and self-reported transcendental experiences (lack of time, space and body sense) during meditation practice was flat ($r = .07$). Those practicing Transcendental Meditation for 1 month reported as much transcending as those with 5 years of practice.

The eLORETA comparison of eyes-closed rest/task and TM practice/task identified similar areas of activation: theta and alpha activation during rest and TM in the posterior cingulate and precuneus, part of the default mode network, and beta2 and beta3 activation during the task in anterior cingulate, ventral lateral and dorsolateral prefrontal cortices, part of the central executive network. In addition, eLORETA comparison of rest and TM identified higher beta temporal activation during rest and higher theta orbitofrontal activation during TM.

Thus, it does not seem accurate to include TM practice with meditations in the category of Focused Attention, which are characterized by gamma EEG and DMN deactivation. Mixing meditations with different procedures into a single study confounds exploration of meditation effects and confounds application of meditation practices to different subject populations.

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**1. Introduction**

The brain exhibits a large-scale intrinsic network, which is more active during periods of rest and is deactivated during cognitively demanding tasks (Golland et al., 2007). This network, called a default mode network (DMN), includes ventral medial prefrontal cortices, the medial temporal lobe, the precuneus, and the posterior cingulate gyrus (Greicius, Krasnow, Reiss, & Menon, 2003; Raichle et al., 2001).

DMN activation is lower during goal-directed behaviors requiring executive control (Gusnard, Raichle, & Raichle, 2001; Raichle & Snyder, 2007), and higher during self-referential mental activity (Gusnard et al., 2001; Kelley et al., 2002; Vogele et al., 2001), higher during tasks involving self-projection (Buckner & Carroll, 2007), and higher when attending to stories containing 1st person pronouns (Decety, Chaminade, Grezes, & Meltzoff, 2002; Kjaer, Nowak, & Lou, 2002). DMN activation systematically varies with level of cognitive load—systematically decreasing from eyes-closed rest, to simple eyes-open, and to eyes-open simple fixation (Raichle et al., 2001; Yan et al., 2009).

The default mode network comprises sub-systems that interact and contribute to cognitive functioning. Medial temporal areas add details from past experiences. Ventral-medial prefrontal areas use past details to construct the ongoing self-relevant narrative. Output from both of these areas are integrated in the precuneus and posterior cingulate cortex (Buckner, Andrews-Hanna, & Schacter, 2008).

DMN activation patterns could give insight into the mental procedures during different meditation practices. To date, research reports that most meditation practices—Mindfulness meditation, focused attention, Loving-Kindness, and Choiceless Awareness—lead to deactivation of the anterior (medial prefrontal) and posterior (posterior cingulate cortices) subsystems of the DMN in experienced meditators (Brewer et al., 2011; Simon & Engstrom, 2015). Deactivation of the DMN is consistent with the understanding that these meditation procedures involve goal-oriented attentional control.

In contrast, DMN activity is reported to remain high during practice of the Transcendental Meditation® (TM®) technique, compared to eyes-closed rest (Travis et al., 2010). Also, unique to...
Transcendental Meditation practice are the findings that frontal alpha coherence and power are reported to be higher, and beta and gamma power are reported to be lower during TM compared to rest (Travis & Wallace, 1999; Travis et al., 2010). Based on analysis of the EEG research literature, Transcendental Meditation has been placed by some authors in the category of Automatic Self-Transcending (Travis & Shear, 2010). Other authors have placed this technique into the category of Focused Attention (Raffone & Srinivasan, 2010). This paper was designed to clarify this issue.

Superficially, Transcendental Meditation can be described as “thinking” a mantra—a meaningless sound—and going back to it when the mantra is forgotten. This process could be understood as focused attention. However, Transcendental Meditation practice is not a technique of keeping the mantra clearly in awareness. Rather, one learns how to use the mantra as a vehicle for transcending. The sound of the mantra is such that the attention easily entertains it, and one learns during TM how to appreciate the mantra at “finer” levels in which the mantra becomes secondary in experience and ultimately disappears, while self-awareness becomes more primary (Maharishi Mahesh Yogi, 1969; Travis & Pearson, 2000). Thoughts other than the mantra can arise during TM practice. They are part of the process of exploring deep inner silence. During TM practice, thoughts are not actively suppressed, and losing track of the mantra is not seen as a failure. TM does not involve contemplation, focused attention, or monitoring ongoing experience. Rather, TM practice is the process of transcending, coming out onto thought, and transcending again using the “natural tendency of the mind” (Maharishi Mahesh Yogi, 1969; Travis & Pearson, 2000). (The concept of the natural tendency of the mind is discussed in detail in the discussion, Section 4.1.)

Subjects quickly master Transcendental Meditation practice. While significant differences are reported in brain patterns during meditation practice in novice and expert Buddhist meditators (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007), no significant differences are reported between novice and expert TM subjects during the meditation session, as suggested by data from an one-year longitudinal study (Travis & Arenander, 2006), and from two cross-sectional studies: one comparing individuals with 4-months’ versus 8-years’ Transcendental Meditation practice (Travis & Pearson, 2000), and the other comparing individuals with 7 years’ versus 32 years’ Transcendental Meditation practice (Travis, Tecce, Arenander, & Wallace, 2002). While no differences are reported during the practice, novice/expert differences are reported during tasks after Transcendental Meditation practice. Namely, the high levels of EEG alpha coherence seen during the session begins to be integrated and displayed with waking EEG after the meditation session (Travis & Arenander, 2006; Travis et al., 2002).

The current study explores whether and to what extent focused attention may be part of Transcendental Meditation practice as evidenced by subjective experience and brain patterns. This study explores subjective ratings of the frequency of transcendence in subjects with a range of Transcendental Meditation experience. In this research, transcendence is described as a perfectly peaceful state in which the mind is very awake, but still—a state in which awareness seems expanded beyond the boundaries of thought, beyond the limits of time and space, without the sense of body or environment. Also, this study explores brain patterns during Transcendental Meditation practice and two comparison conditions, namely an eyes-open choice reaction-time task, which is reported to lead to default mode network deactivation, and eyes-closed rest, which is reported to lead to default mode network activation. These data were analyzed with eLORETA to compare 3-D cortical activation during these three conditions with special attention to frontal and posterior areas included in the default mode network. If Transcendental Meditation practice involves focused attention, then we hypothesize that (1) the subjective ratings of transcendence during TM practice should increase as the person masters the practice over time—with practice controlled cognitive processes can be transformed to an automatic process, (2) greater cortical deactivation of the default mode network during Transcendental Meditation, as compared to eyes-closed rest, and (3) little or no differences in cortical activation in the task/TM comparison.

2. Materials and method

2.1. Subjects

At Maharishi University of Management, students have been encouraged to have their EEG recorded as freshman and as seniors. This research initiative was started in 2010. Presentations are made during orientation meetings to invite students to have their EEG recorded. Data from 87 individuals who participated in this research and so were part of the database in the Center for Brain, Consciousness and Cognition in Fairfield, Iowa were used for this study. This included all subjects, who had both freshman and senior recordings and had been practicing TM from one month to five years. Their mean age was 30.3 ± 9.4 years, and their mean years Transcendental Meditation practice was 1.3 ± 0.9 years. There were 42 females and 45 males. The research was compliant with the Code of Ethics of the World Medical Association and the study was approved by the University’s Institutional Review Board. All subjects signed consent forms before beginning the study.

2.2. Procedure

A standard protocol is used to record EEG at the Brain Center. Participants come in the late afternoon after their classes. After completing consent and demographic forms, 32 active-sensors are applied in the 10–10 system with a forehead ground, and left and right earlobe sensors for re-referencing offline. Resistance was <10 kΩ at each sensor. Subjects complete the Survey of Peak Experiences to measure frequency of transcending while sensors were applied.

EEG was recorded with the BIOSEMI ActiveTwo System (www.BIOSEMI.COM) during (1) five minutes eyes-closed rest when they were told to “Close the eyes and sit easily, and not begin their TM practice,” (2) a 4-min choice reaction-time task, and (3) a five-minute Transcendental Meditation session. All signals were digitized on line at 256 points/s, with no high or low frequency filters, and stored for later analyses using eLORETA.

There were natural breaks between each condition. The instructions and practice trials for the choice reaction-time task gave a natural 4–5 min break between eyes-closed rest and the reaction-time task. Between the reaction-time task and TM practice, the subject discussed their experiences during the task and any strategies they used to perform at their best (3–4 min).

2.2.1. Choice reaction-time tasks

The choice reaction-time task included 24 trials. Each trial included a one or two-digit number (150 ms duration, 1 cm in height), a 1.5-s blank screen, and another one- or two-digit number (150 ms duration, 1 cm in height). Subjects were asked to press a left- or right-hand button to indicate which number was larger in value, i.e. a 10 is larger than a 5.

2.2.2. Survey of peak experiences

This survey consists of four items that assess frequency of experiences of transcendence during eyes-closed rest, during waking activity when engaged in tasks, during sleep, and a question on luck. Subjects were asked to circle the frequency of each...
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