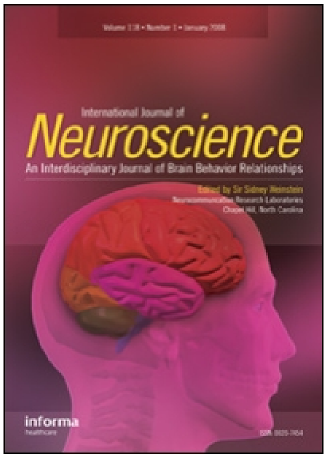

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S. P. Sarang [a]; Shirley Telles [a]
[a] Swami Vivekananda Yoga Research Foundation, Bangalore, India

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CHANGES IN P300 FOLLOWING TWO YOGA-BASED RELAXATION TECHNIQUES

S. P. SARANG
SHIRLEY TELLES

Swami Vivekananda Yoga Research Foundation
Bangalore, India

Cyclic meditation (CM) is a technique that combines "stimulating" and "calming" practices, based on a statement in ancient yoga texts suggesting that such a combination may be especially helpful to reach a state of mental equilibrium. The changes in the peak latency and peak amplitude of P300 auditory event–related potentials were studied before and after the practice of cyclic meditation compared to an equal duration of supine rest in 42 volunteers (group mean age ± SD, 27 ± 6.3 years), from Fz, Cz, and Pz electrode sites referenced to linked earlobes. The sessions were one day apart and the order was alternated. There was reduction in the peak latencies of P300 after cyclic meditation at Fz, Cz, and Pz compared to the "pre" values. A similar trend of reduction in P300 peak latencies at Fz, Cz, and Pz was also observed after supine rest, compared to the respective "pre" values, although the magnitude of change in each case was less after supine rest compared to after cyclic meditation. The P300 peak amplitudes after CM were higher at Fz, Cz, and Pz sites compared to the "pre" values. In contrast, no significant changes were observed in the P300 peak amplitudes at Fz, Cz, and Pz after supine rest compared to the respective "pre" state. The present results support the idea that "cyclic" meditation enhances cognitive processes underlying the generation of the P300.

Keywords cognitive processes, cyclic meditation, P300, supine rest

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Address correspondence to Shirley Telles, Ph.D., Swami Vivekananda Yoga Research Foundation, #19, Eknath Bhavan, Gavipuram Circle, K. G. Nagar, Bangalore 560 019, India. E-mail: anvesana@vsnl.com

INTRODUCTION

Meditation has been described as a training in awareness that, over long periods, produces definite changes in perception, attention, and cognition (Brown, 1977). Most of the early reports on the effects of meditation have dealt with Transcendental Meditation (TM). TM was adapted from ancient Indian texts by Maharishi Mahesh Yogi. While practicing TM, subjects sit in a comfortable posture and mentally repeat a given *mantra*, returning their attention to it whenever attention wanders (Woolfolk, 1975).

The practice of TM was reported to cause reductions in heart rate, respiratory rate, and oxygen consumption, and to increase the level or stability of the electrodermal response as well as the alpha in the EEG (Wallace, 1970; Wallace et al., 1971). These changes were the basis for describing the physiological state induced by TM as "wakeful and hypometabolic." It was also considered interesting to investigate whether TM would improve meditators' overall performance while producing a state of reduced physiological arousal (Bloomfield et al., 1975).

A study was conducted to compare three different measures of attention in 20 people who had been practicing TM for 3 months and a matched control group who were not practicing TM. The rationale for the study was that all types of meditations are supposed to increase the ability to concentrate on external tasks and objects (Pelletier, 1972). Meditators performed better on a test for: (i) auto-kinetic effect suggesting a better ability to concentrate, (ii) in a rod and frame test that suggested that they were more in tune with internal cues, and (iii) in an embedded figure test that suggested a better ability to concentrate without being distracted by surrounding factors.

More recently the effects of transcendent experiences, described to occur during the practice of TM, were studied on the contingent negative variation (CNV) amplitude, rebound, and distraction effects in 41 healthy volunteers (Travis et al., 2002). CNV is an event-related potential occurring between a warning stimulus and an imperative stimulus requiring a response (Walter et al., 1964). Late CNV amplitudes were largest in meditators who had transcendent experiences daily. Because late CNV reflects proactive preparatory processes including mobilization of motor, perceptual, cognitive, and attentional resources, the data were taken to suggest that transcendent experiences enhance cortical responses and executive functioning.

Another meditation technique, called "cyclic meditation" (CM) that also has its origin in ancient Yoga texts was shown to reduce oxygen consumption, breath rate, and increase breath volume more than a comparable period of supine rest (SR) in 40 male volunteers aged between 20 and 47 years. The magnitude of change in these three measures was greater after CM: (i) oxygen consumption decreased by 32.1 % after CM compared with 10.1% after SR; (ii) breath rate decreased by 18.0% after CM and 15.2 % after SR; and (iii) breath volume increased by 28.8% after CM and 15.9% after SR (Telles et al., 2000).

The present study was planned to determine whether cyclic meditation (like TM) would increase the ability to pay attention to a given stimulus in addition to the already described effect of reducing metabolic and respiratory rates (Telles et al., 2000). The P300 component of the event-related brain potentials (ERPs) is considered as a "cognitive" neuro-electric phenomenon because it is generated in psychological tasks when subjects attend to and discriminate stimuli that differ from one another on some dimension. Such discrimination produces a relatively large, positive waveform with a modal latency of about 300 ms when elicited with auditory stimuli (Polish & Kok, 1995). The P300 event-related brain potentials (ERP) reflect fundamental cognitive events requiring attentional and immediate memory–processes (Polich, 1999).

Hence, in the present study the P300 was recorded before and after (i) cyclic meditation and (ii) a comparable period of supine rest.

METHODS

Subjects

Forty-two male volunteers with ages ranging from 18 to 48 years (group mean ± S.D., 27.1 ± 6.3 years) participated in the study. They were residing at a yoga center. Male subjects alone were studied as auditory evoked responses have been shown to vary with the phases of the menstrual cycle (Yadav et al., 2002) and the P300 evoked by stimuli of the visual modality also varied with sex (Polich & Conroy, 2003). All of them were in normal health based on a routine clinical examination and none of the volunteers were taking any medication. The subjects had experience of the practice of cyclic meditation for more than 3 months (mean experience ± *SD*, 15.3 ± 13.3 months). The aims and methods of the study were explained to them and all the subjects gave their informed consent.

Design of the Study

Subjects were assessed in two separate sessions, namely, cyclic meditation (CM) and supine rest (SR). For half the subjects the CM session took place on the one day, with SR the next day. The remaining subjects had the order of the sessions reversed. Subjects were alternately allocated to either schedule to prevent the order of the sessions influencing the outcome. The subjects were unaware about the hypothesis of the study. The assessments were done before and after each session, which lasted for 22 min 30 s.

Recording Conditions

The peak latencies and peak amplitudes of P300 were recorded using Nicolet Bravo System (USA). The P300 component was elicited with a simple discrimination task known as the "oddball" paradigm because two stimuli are presented in a random series so that one of them occurred infrequently that is, the oddball (Polich, 1999). For assessments subjects were seated in a sound attenuated and dimly lit cabin and were monitored on a closed circuit television with instructions being given through an intercom, so that subjects could remain undisturbed during a session.

Electrode Positions

Ag/AgCl disk electrodes were affixed with electrode gel (Ten 20 conductive EEG paste, D.O. Weaver, USA) at the Fz, Cz, and Pz scalp sites, referred to linked earlobes (A1–A2) with the ground electrode on the forehead (FPz); according to the International 10–20 system (Jasper, 1958). The electro-ocular activity (EOG) was recorded with a bipolar derivation from electrodes placed 1 cm above and 1 cm below the outer canthus of the right eye. The electrode impendence was kept below 5 kΩ at all scalp sites.

Amplifier Settings

The electroencephalographic (EEG) activity was amplified with a sensitivity of 100 μV. The low pass filter was kept at 0.01 Hz and the high pass filter was kept at 30 Hz. The P300 ERPs were computer averaged in 300 trial sweeps, in the 75–750 ms range. The pre-stimulus delay was kept at 75 ms and the level of artifact rejection was set at 90%.

Stimulus Characteristics

Binaural tone stimuli of alternating polarity delivered at 0.9 ms with a frequency of 1 KHz (50 cycles for the plateau, 10 cycles for the ramp) for the standard stimuli and 2 KHz (10 cycles for the plateau, 20 cycles for the ramp) for the target stimuli were used to trigger online averaging of the EEG. The percentage of standard stimuli was set at 80 and for the target stimuli at 20. The stimulus intensity was kept at 70 dB SPL.

Recording Procedure

Subjects were asked to avoid substances that influence cognitive performance (e.g., coffee for the caffeine content) for the day preceding and the day of the recording. Where this was unavoidable the session was taken on another day. The P300 evoked potentials were recorded in the eyes-closed supine position. The "standard" and "target" auditory stimuli were delivered through close-fitting earphones (TDH-39, Amplivox, UK). Subjects were asked to distinguish between the two tones by mentally counting the "target" stimuli. The P300 responses were recorded before and immediately after the intervention.

Interventions

Cyclic Meditation. Throughout the practice subjects kept their eyes closed, and followed pre-recorded instructions. The instructions emphasized carrying out the practice slowly, with awareness and relaxation. The practice began by repeating a verse (40 s) from the yoga text, the *Mandukya Upanisad* (Chinmayananda, 1984); followed by isometric contraction of the muscles of the body ending with supine rest (1 min); slowly coming up from the left side and standing at ease (called *tadasana*) and 'balancing' the weight on both feet (called centering) (2 min); then the first actual posture, bending to the right (*ardhakaticakrasana,* 1 min 20 s); a gap of 1 min 10 s in *tadasana* with instructions about relaxation and awareness; bending to the left (*ardhakaticakrasana,* 1 min 20 s); a gap as before (1 min 10 s); forward bending (*padahastasana,* 1 min 20 s); another gap (1 min 10s); backward bending *(ardhacakrasana*, 1 min 20 s); and slowly coming down in the supine posture with instructions to relax different parts of the body in sequence (10 min). The postures were practiced slowly, with awareness of all the sensations that are felt. The total duration of the practice was 22 min 30 s (Telles et al., 2000).

Supine rest. During the supine rest session, the subjects lay supine with their legs apart and arms away from the sides of the body in corpse posture (*shavasana*), with their eyes closed. This practice lasted 22 min 30 s, so that the duration was the same as for CM.

Data Extraction

The peak amplitude and peak latency of the P300 was measured at the three electrode sites; that is, Fz, Cz and Pz. The peak amplitude (in μV) was defined as the voltage difference between a pre-stimulus baseline and the largest positive-going peak of the ERP waveform within 250–500 ms latency (Polich, 1999). The peak latency (ms) was defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window. The peak latency and the peak amplitude were selected using the cursors.

Data Analysis

Statistical analysis was done using SPSS (Version 10.0). Data were analyzed using the repeated measures analysis of variance (ANOVA). There were two "Within subjects" factors, that is, Factor 1: Sessions, that is, CM and SR and Factor 2: States, that is, Pre and Post. Paired *t*-test analyses were performed to compare the data of the "post" periods with those of the respective "pre" periods.

RESULTS

Repeated Measures Analysis of Variance

For the peak latency at Fz the repeated measures ANOVA showed a significant difference between the two Sessions ($F = 9.526$, $df = 1{,}41$, $p < .01$, Greenhouse-Geisser epsilon = 1.000), between the six States ($F = 82.990$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), and the interaction between Sessions and States ($F = 20.532$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000).

Also, for the peak amplitude at Fz there was a significant difference between the six States ($F = 9.723$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), and the interaction between Sessions and States ($F = 4.944$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000); however, there was no significant difference between the two Sessions ($F = 0.426$, $df = 1{,}41$, $p > .05$, Greenhouse-Geisser epsilon = 1.000).

For the peak latency at Cz the repeated measures ANOVA showed a significant difference between the two Sessions ($F = 22.167$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), between the six States ($F = 92.290$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), and the interaction between Sessions and States ($F = 16.451$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000).

Also, for the peak amplitude at Cz there was a significant difference between the six States ($F = 8.932$, $df = 1{,}41$, $p < .01$, Greenhouse-Geisser epsilon = 1.000), and the interaction between Sessions and States ($F = 6.793$, $df = 1{,}41$, $p < .01$, Greenhouse-Geisser epsilon = 1.000) however, there was no significant difference between the two Sessions ($F = 1.178$, $df = 1{,}41$, $p > .05$, Greenhouse-Geisser epsilon = 1.000).

For the peak latency at Pz the repeated measures ANOVA showed a significant difference between the two Sessions ($F = 16.622$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), between the six States ($F = 130.831$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000), and the interaction between Sessions and States ($F = 18.163$, $df = 1{,}41$, $p < .001$, Greenhouse-Geisser epsilon = 1.000).

Also, the for peak amplitude at Pz there was a significant difference in the interaction between Sessions and States ($F = 4.577$, $df = 1{,}41$, $p < .05$, Greenhouse-Geisser epsilon = 1.000); however, there was no significant difference between the two Sessions ($F = 1.789$, $df = 1{,}41$, $p > .05$, Greenhouse-Geisser epsilon = 1.000) and between the six States ($F = 3.310$, $df = 1{,}41$, $p > .05$, Greenhouse-Geisser epsilon = 1.000).

Paired *t*-test

There was a significant decrease in the P300 peak latencies at Fz, Cz, and Pz sites after the practice of cyclic meditation compared to the "pre" state ($p < .001$). There was a significant increase in the peak amplitude at Fz, Cz, and Pz sites after the practice of cyclic meditation compared to the "pre" state ($p < .001$).

There was a significant decrease in the P300 peak latencies at Fz, Cz, and Pz sites after the practice of supine rest compared to the "pre" state ($p < .001$). However, there was no significant change in the peak amplitude at Fz, Cz, and Pz sites after the practice of supine rest compared to the "pre" state.

The peak latencies at Fz, Cz, and Pz sites before cyclic meditation and before supine rest were not significantly different [$p > .05$, paired *t*-test (2)]. However, the peak latencies at Fz, Cz, and Pz sites after cyclic meditation and after supine rest were significantly different [$p < .001$, paired *t*-test (2)].

The group mean $\pm$ S.D., of the peak latencies and the peak amplitudes at Fz, Cz, and Pz sites are given in Table 1.

Table 1. Peak latency (ms) and peak amplitude (μV) of the P300 component in "pre" and "post" cyclic meditation and supine rest sessions.

		Cyclic meditation (CM)		Supine rest (SR)	
Electrode Site[†]	Variables	Pre	Post	Pre	Post
Fz	Latency (ms)	363.92 ± 23.63	328.07*** ± 19.95	359.85 ± 25.52	347.28*** ± 19.41
	Amplitude (μV)	5.92 ± 3.60	7.96*** ± 3.51	7.06 ± 4.01	7.36 ± 3.97
Cz	Latency (ms)	362.92 ± 24.46	326.21*** ± 21.79	364.64 ± 27.44	346.85*** ± 19.59
	Amplitude (μV)	7.24 ± 3.62	9.14*** ± 3.43	8.65 ± 3.72	8.64 ± 3.66
Pz	Latency (ms)	368.42 ± 27.34	328.28*** ± 22.06	369.57 ± 29.81	352.54*** ± 23.32
	Amplitude (μV)	8.71 ± 3.62	9.88** ± 3.84	9.79 ± 3.67	9.90 ± 3.86

Values are group mean ± S.D. ***$p < .001$, **$p < .01$, *$p < .05$. Paired t-test (2-tailed), "Post" compared with respective "Pre" values.
[†]Reference: linked earlobes.

DISCUSSION

The changes in the peak latency and peak amplitude of P300 auditory event-related potentials were studied before and after the practice of cyclic meditation compared to a comparable period of supine rest in 42 volunteers, from Fz, Cz and Pz electrode sites referenced to linked earlobes.

Cyclic meditation consists of alternating cycles of practicing yoga postures interspersed with periods of supine rest (Nagendra & Nagarathna, 1997). The basis for this practice is an idea drawn from the ancient texts (Chinmayananda, 1984). The underlying idea is that for most persons the mental state is routinely somewhere between the extremes of being “inactive” or of being “agitated” and hence to reach a balanced, relaxed state the most suitable technique would be one that combines “awakening” and “calming” practices. In cyclic meditation, the period of practicing yoga postures constitutes the “awakening” practices, whereas periods of supine rest comprise the “calming practices.” An essential part of the practice of cyclic meditation is being aware of sensations arising in the body (Nagendra & Nagarathna, 1997).

In the present study, there was reduction in the peak latencies of P300 after cyclic meditation at Fz, Cz and Pz compared to the “pre” values. A similar trend of reduction in P300 peak latencies at Fz, Cz and Pz was also observed after supine rest, compared to the respective “pre” values, although the magnitude of change in each case was less after supine rest compared to after cyclic meditation.

The P300 peak amplitudes after CM were higher at Fz, Cz and Pz sites compared to the “pre” values. In contrast, no significant changes were observed in the P300 peak amplitudes at Fz, Cz, and Pz after supine rest compared to the respective “pre” state.

Previous studies have shown definite changes in the P300 evoked responses following Transcendental meditation (TM). The effect of TM practice on the P300 was studied using a passive auditory listening trial paradigm with variable interstimulus intervals (1–4 s) between identical tone stimuli (Cranson et al., 1990). The subjects were experienced TM meditators, novices, and nonmeditator controls with mean ages of 41, 28 and 20 years, respectively. The P300 latency was shorter for the two meditation groups, with the long-term meditators showing the shortest P300 latency regardless of their age. In another study an auditory oddball task was used with eyes-closed to assess experienced TM meditators at pretest baseline, after 10 min of rest, or after 10 min of TM practice with conditions counterbalanced across subjects (Travis & Miskov, 1994). The P300 latency decreased at Pz after TM practice relative to no change after the rest condition.

Sudarshan Kriya Yoga (SKY) is a meditation system that emphasizes breathing techniques. This technique was used as an intervention for persons with dysthymia compared with an unaffected control group. At three months, the P300 amplitude increased to the levels of the control group in the patient group (Naga Venkatesh Murthy et al., 1998).

The P300 amplitude is thought to indicate the amount of brain activity related to incoming information processing and it is more sensitive to the amount of attentive resources engaged during the task (Polich, 2004). The P300 latency reflects the stimulus classification (cognitive) speed, is generally unrelated to the overt response, and is independent of behavioral reaction time. Because P300 latency is an index of stimulus processing rather than response generation, it is used as a motor-free measure of cognitive function. The P300 peak latency has been found to be negatively correlated with mental function in normal subjects: shorter latencies are associated with superior cognitive performance from neuropsychologic tests of attention and immediate memory.

In the present study, both the peak amplitude and the peak latency of the P300 potentials were changed following cyclic meditation. The reduction in latency was also seen following supine rest, however the magnitude of change was smaller than that after cyclic meditation. These results suggest increased attentional resources, stimulus processing speed and efficiency after cyclic meditation compared to an equal duration of supine rest.

Yoga practice has been understood to help in reducing anxiety based on a reduction in levels of psychophysiological arousal (Telles & Srinivas, 1998). In a previous study both cyclic meditation (CM) and supine rest (SR) practiced for the same duration as in the present study, resulted in decreased oxygen consumption, breath rate, and increased breath volume immediately after the practice (Telles et al., 2000). These changes suggested that both practices reduce physiological arousal. However, for all three variables the magnitude of change was greater following CM compared with following SR. This supported the idea that a combination of “stimulating” and “calming” techniques practiced with a background of relaxation and awareness (during CM) may reduce psychophysiological arousal more than SR. Hence, CM may be supposed to be able to reduce anxiety more than SR, which may explain the greater magnitude of change in the performance observed in the present study following CM.

The neuroelectric events that underlie the P300 generation stem from the interaction between the frontal lobe and hippocampal and temporoparietal function (Halgren et al., 1998). The primary neural generators for the P300 components are in the anterior cingulate when new stimuli are processed into working memory with subsequent activation of the hippocampal formation when frontal lobe mechanisms communicate with the temporal or parietal lobe connections (Polich, 1999).

In the present study the P300 peak amplitude increased at Fz, Cz and Pz but the increase was maximum at Fz, which indicates greater involvement of frontal areas, which are required for sustained attention. Various neuroimaging studies on meditators have shown increased regional cerebral blood flow in the frontal and prefrontal areas during meditation (Herzog et al., 1990). Hence, the present findings may also support the idea of activation of frontal cortical areas during meditation.

In summary, the present study supports the idea that meditation (in this case, "cyclic" meditation) enhances cognitive processes underlying the generation of the P300, though further research is required to understand mechanisms underlying the change.

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