ORIGINAL RESEARCH

The Effects of Meditation on Twin Hearts on P300 Values: A Repeated Measures Comparison of Nonmeditators and the Experienced

Jeffrey M. Tarrant, PhD; Neus Raines, PhD; Wayne R. Blinne, MA

Abstract

The Meditation on Twin Hearts (MTH) is a core meditation in both Pranic Healing and modern Arhatic Yoga practices. This guided meditation includes components of lovingkindness, open awareness, and self-healing imagery. The changes in peak latency and peak amplitude of P300 auditory event-related potentials were studied before and after listening to the MTH. Subjects were 12 nonmeditators compared with 12 meditators with at least 1000 h of experience with MTH. Between- and within-group comparisons were examined from electrode sites FZ, CZ, and PZ. When compared with nonmeditators at baseline, experienced meditators demonstrated a significantly shorter latency at sites FZ and CZ. Immediately following the MTH, inexperienced meditators showed significant increases in amplitude at sites FZ, CZ, and PZ, whereas experienced meditators showed no significant changes. All variables for both groups showed changes in the direction of more efficient cognitive processing immediately following the MTH. The present study supports the idea that a lovingkindness/compassion meditation results in immediate cognitive improvements in meditation naïve subjects. It also suggests that long-term meditation results in more pronounced and stable improvements.

Jeffrey M. Tarrant, PhD, is at NeuroMeditation Institute in Corvallis, Oregon. Neus Raines, PhD, is in the business department at the European University Business School in Encinitas, California. Wayne R. Blinne, MA, is at Blinne Research Consulting in Columbia, Missouri.

Corresponding author: Jeffrey M. Tarrant, PhD
E-mail address: Dr.Tarrant@hotmail.com

Introduction

Meditation can be defined as "a systematic mental training designed to challenge habits of attending, thinking, perceiving, and feeling."[1] As such, this process, in time, is believed to result in significant neurophysiological changes.[2] This has been demonstrated by numerous studies examining both immediate and long-term changes in the structure and function of the brain.[3-6] Although many of these studies have focused on changes in gray matter, brainwave patterns, or changes in neural connectivity,[7-10] a few have also focused on the effects that meditation may have on the efficiency of neural processing by examining the P300 wave of the event-related potential event-related potential (ERP).[2,4]

The P300 wave is an electrical response of the brain to a unique stimuli. It is measured through electroencephalography (EEG) and is described in terms of amplitude (the strength of the wave) and latency (the speed of the wave). The P300 wave response is a measure of cognitive efficiency that tells us about the brain's ability to distinguish a novel stimuli (amplitude) as well as how quickly or easily this process happens (latency).[11] The average latency to make a discrimination between a standard and unique stimulus is 300 ms. In persons with decreased cognitive ability, the P300 tends to be smaller, with longer latency, whereas shorter P300 peak latencies have been associated with better cognitive performance on tests of attention and immediate memory.[11,12] Consequently, the P300 response is considered a good measure of cognition.[13] Because the P300 wave is only present when the subject is actively engaged in an attention task designed to notice target stimuli, this response is commonly measured using an "oddball" paradigm, where the subject

Table 1. Subject Demographic Variables by Experienced, Nonmeditators, and Total

	Nonmeditators	Experienced Meditators	Total (%)
Age (y)			
Mean	38.72	45.42	42.22
SD	13.5	13.87	13.82
Gender			
Female	7	8	15 (62.5)
Male	5	4	9 (37.5)
Ethnicity			
African	1	1	2 (8.3)
Colombian	1	0	1(4.2)
Guatemalan	2	0	2 (8.3)
Indian	0	2	2 (8.3)
Korean	0	1	1 (4.2)
Mexican	2	0	2 (8.3)
Pilipino	4	4	8 (33.3)
North American	1	3	4 (16.7)
Venezuelan	1	0	1 (4.2)
Meditation Experience (y)			
Mean	N/A	12.90	
SD	N/A	6.74	
Avg min/d			
Mean	N/A	52.08	
SD	N/A	19.82	

Abbreviations: SD, standard deviation.

is exposed to a series of identical stimuli (ie, auditory tones), which are intermittently interrupted by a novel stimuli.

Previous research examining P300 wave values immediately after a meditation have demonstrated decreased latency[14] as well as increased amplitude[15] following both a Transcendental Meditation (TM) and yoga-based meditation, respectively. Attempts to examine the long-term effects of meditation on the P300 wave have demonstrated mixed results. Travis et al[16] reported no change in P300 response after 10 weeks of TM practice, whereas other research has demonstrated increased P300 wave amplitudes after 3 months of Kriya Yoga.[17,18] One study compared nonmeditators, novice, and experienced meditators in the TM tradition and found those with greater experience had shorter latencies and stronger amplitudes.[19]

These studies provide initial support for the idea that meditation can directly influence both state and trait P300 wave values. However, this research has examined only TM or breath-focused meditations. In addition, only 1 study to date has compared nonmeditators with experienced meditators,[19] and no studies have compared the immediate effects of a meditation experience on these 2 groups. The current study seeks to build on the previous research by examining the effects of a lovingkindness-compassion (LK-C) based meditation (Meditation on Twin Hearts [MHT]) in nonmeditators versus meditators. Specifically, we hypothesize that experienced meditators will demonstrate shorter latencies and stronger amplitudes at baseline and that both groups will show improved P300 wave values immediately following a meditation.

Materials and Methods

Subjects

A total of 24 subjects with ages ranging from 21 to 67 years participated in the study. Twelve of the subjects were volunteers with no significant history of meditative or contemplative practice. Twelve subjects were experienced meditators with an average of 12.9 years of meditation experience (SD = 6.74) who reported practicing an average of 52.08 minutes per day (SD = 19.82; see Table 1). A total of 58% of the nonmeditators and 67% of the experienced group were women. The majority of both groups were non-American (nonmeditators = 92%; experienced = 75%). Two of the subjects in the nonmeditation group were Spanish speaking and listened to a Spanish version of the meditation. For these subjects, the instructions and meditation were provided in Spanish. All experienced meditators identified English as their primary language. Subjects were scheduled in 2-hour time slots between 9:00 AM and 5:00 PM (4 per day) for 6 consecutive days. Data for the inexperienced meditators were collected first, followed by the experienced meditators.

Study Design

After subjects completed consent forms, they were fitted with a 19-channel EEG electrocap (Electro-cap International, Eaton, OH, USA). Each electrode was prepped using electrogel conductance paste (Electro-Cap International). Impedances for all sites were assessed and kept below 10 kOhms. Following a baseline EEG recording, P300 data were collected through a WAVi Medical 19-channel EEG research system amplifier (WAVi, Rapid City, SD, USA). Subjects completed the task with eyes closed and wearing ear covering headphones while seated in a comfortable chair in a quiet, dimly lit room. Each subject held a wireless computer mouse on their lap.

Table 2. Comparing Amplitude (μV) and Latency (ms) of Nonmeditators With Experienced Meditators at Pretest

		Nonmeditators		Experienced			
Location	**Measurement**	**Mean**	**SD**	**Mean**	**SD**	**Test Statistic**	***P* Value**
FZ	Amplitude	7.3	5.2	12.1	10.7	$z = 0.729$	.466
	Latency	330.7	33.7	305.2	34.8	$t = 1.740$[a]	.048
CZ	Amplitude	9.7	4.3	16.4	12.1	$z = 1.131$	.258
	Latency	325.4	32.6	285.6	39.9	$t = 2.519$[a]	.010
PZ	Amplitude	10.4	4.7	14.9	9.0	$z = 1.091$	.275
	Latency	328.7	34.9	303.6	52.1	$t = 1.347$	.097

Note: *t* values are from independent sample *t* tests (1-tailed). *z* values are from Wilcoxon rank-sum nonparametric tests.

[a]$P < .05$.

P300 components were elicited through an "oddball" auditory paradigm. Subjects were presented with 200 common and 40 rare stimuli (higher pitched tone) presented at 1 Hz. Rare stimuli presented randomly. Subjects were instructed to press the mouse button when they heard the rare stimuli. All subjects were given opportunities to practice the task before beginning each trial. Following the initial EEG recordings, subjects listened to a 30-minute recorded version of the "Meditation on Twin Hearts for Psychological Health and Well Being" with eyes closed and while wearing headphones. Immediately following the meditation, subjects completed a postmeditation P300 task, following identical procedures as the premeditation assessment. The study was approved by the University of Missouri Institutional Review Board (Columbia, MO, USA).

Prior to beginning the meditation, subjects received the following guidelines: (1) sit comfortably in the chair, (2) keep the back as straight as possible, (3) keep the tip of the tongue resting on the upper palate, (4) keep the eyes closed and facial expressions to a minimum, and (5) follow the instructions from the meditation recording.

Meditation on Twin Hearts

The MTH was developed by Choa Kok Sui, the founder of Pranic Healing and Modern Arhatic Yoga. Since its development, it has become the foundational meditation practice used in Pranic Healing and Arhatic Yoga practices. The meditation itself primarily involves activating the crown and heart chakras (subtle energy centers) while blessing the Earth with lovingkindness.[20]

Data Analysis

The amplitude and latency of the P300 responses to rare tones were averaged in 40 trial sweeps for electrode sites FZ, CZ, and PZ. Any run with fewer than 30 artifact free trials was excluded from analysis.

Data were analyzed with Stata version 9.2. Means were compared using independent *t* tests for between-group comparisons and paired *t* tests for within-group comparisons of the pre- and postmeditation measurements. The assumption of normality was tested using the Shapiro-Wilk *W* test for normality in both circumstances (independent and paired), whereas the assumption of equality of variances (paired) was tested using Brown and Forsythe's *F* test. When normality could not be assumed, Wilcoxon's signed-rank test was used instead of the paired *t* test, and the Wilcoxon rank-sum test was used instead of the *t* test for independent samples. When equality of variances could not be assumed, Satterthwaite's method was used to compute the degrees of freedom for the *t* test.

Results

The hypotheses tested were as follows:

1. Prior to the meditation, compared to nonmeditators, experienced meditators would have greater P300 amplitude and shorter latencies at FZ, CZ, and PZ.
2. Nonmeditators and experienced meditators, tested separately, would show increased P300 amplitude and reduced latencies at FZ, CZ, and PZ immediately after the meditation.

Between-group Comparisons

Prior to the meditation, there were no significant differences in amplitude between the two groups at FZ, CZ, or PZ. Experienced meditators did show significantly shorter latencies at FZ and CZ (both $P < .05$), but not at PZ (see Table 2).

Within-group Pre- and Postcomparisons

Nonmeditators showed significant increases in amplitude from pretest to posttest at all 3 sites, FZ ($P < .05$), and CZ and PZ (both $P < .01$). There was no significant reduction in latency from pretest to posttest at any of the three sites for nonmeditators, although all 3 latency measurements did change in the hypothesized direction (see Table 3). Experienced meditators showed

Table 3. Comparing Change in Amplitude (μV) and Latency (ms) of Nonmeditators From Pretest to Posttest

		Pretest		Posttest			
Location	**Measurement**	**Mean**	**SD**	**Mean**	**SD**	**Test Statistic**	***P* Value**
FZ	Amplitude	7.3	5.2	10.7	5.2	$t = 2.522$[a]	.014
	Latency	330.7	33.7	320.7	38.1	$t = 0.984$	.173
CZ	Amplitude	9.7	4.3	13.4	6.2	$z = 2.820$[b]	.005
	Latency	325.4	32.6	310.7	35.0	$z = 0.988$	.323
PZ	Amplitude	10.4	4.7	13.4	6.8	$t = 3.555$[b]	.002
	Latency	328.7	34.9	315.3	32.6	$z = 0.787$	.431

Note. *t* values are from paired *t* tests (1-tailed). *z* values are from Wilcoxon signed-rank nonparametric tests.
[a]$P < .05$.
[b]$P < .01$.

Table 4. Comparing Change in Amplitude (μV) and Latency (ms) of Experienced Meditators From Pretest to Posttest

		Pretest		Posttest			
Location	**Measurement**	**Mean**	**SD**	**Mean**	**SD**	**Test Statistic**	***P* Value**
FZ	Amplitude	12.1	10.7	12.3	10.2	$t = 0.154$	.441
	Latency	305.2	34.8	286.8	37.4	$t = 1.027$	.166
CZ	Amplitude	16.4	12.1	17.3	10.1	$t = 0.705$	.250
	Latency	285.6	39.9	282.0	39.7	$t = 0.842$	.211
PZ	Amplitude	14.9	9.0	15.3	8.1	$t = 0.332$	.374
	Latency	303.6	52.1	296.8	45.1	$t = 0.426$	.340

Note: *t* values are from paired *t* tests (1-tailed).

no significant change in amplitude or latency immediately following the MTH, although all changes were in the hypothesized direction (see Table 4)

Discussion

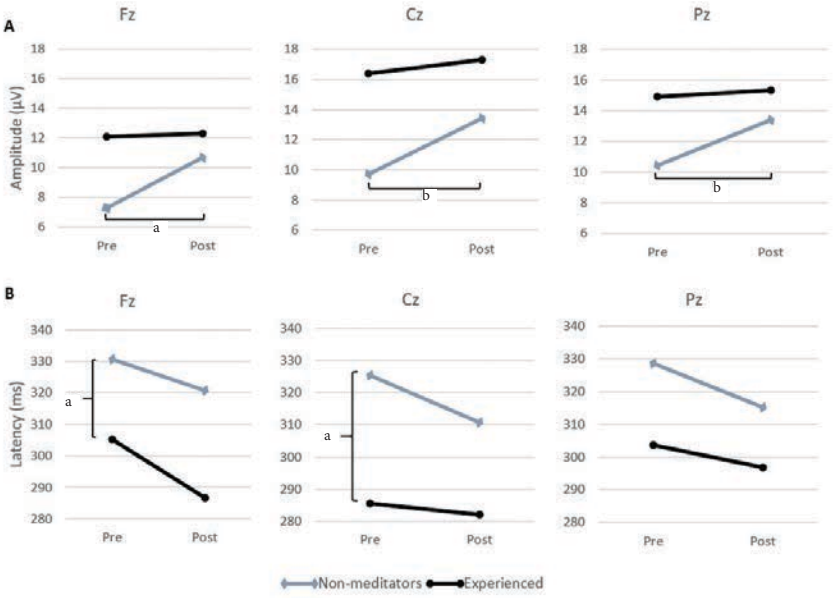
Despite the relatively small sample size, this study found that nonmeditators demonstrated significant changes in all 3 locations (FZ, CZ, PZ) in the amplitude of their P300 response immediately after listening to a guided MTH. Nonmeditators did not show any significant changes in latency, although it was noted that all changes were in the expected direction (see Figure 1). Experienced meditators did not show any significant changes in latency or amplitude immediately postmeditation although, again, all changes were in the expected direction (see Figure 1).

These findings indicate that the immediate impact of practicing MTH on cognitive functioning may be to facilitate a stronger, but not necessarily faster P300 response in meditation naïve subjects. As this is the first study to examine the immediate effect of meditation on P300 values in a meditation naïve sample, these findings are encouraging and suggest that there may be some immediate cognitive benefit to engaging in the MTH. It is unknown how long such changes last before returning to baseline function and if those immediate (state) changes can be connected to any significant improvement in cognitive performance.

The experienced meditators in this study did not show any significant changes in P300 amplitude or latency immediately following the MTH. This suggests that previous meditation experience may be an important variable when examining P300 response to meditative practices. Two previous studies have examined the immediate impact of meditation on P300 values. A study comparing the immediate impact of rest versus TM found that P300 latency decreased at electrode site PZ immediately following TM practice with no significant changes occurring after the resting condition.[14] Unfortunately, the authors did not report the subjects' level of meditation experience.

In a study examining P300 changes across 2 different yoga-based meditative practices, Sarang and Telles[15] found positive changes immediately following 2 different practices. A breath awareness intervention resulted in increased amplitude at CZ, whereas a cyclic meditation practice that involves physical postures, the repetition of a sacred verse, and body awareness resulted in a significant increase in peak amplitudes at FZ, CZ, and PZ, and a significant decrease in peak latency at FZ. The subjects in this study had approximately 3 months of intensive training in the practices evaluated.

Figure 1. Changes in P300 Latency and Amplitude at FZ, CZ, and PZ, Premediation and Postmeditation



Note: Panel A shows changes in P300 amplitude for nonmeditators and experienced meditators premeditation and postmeditation at FZ, CZ, and PZ. Panel B shows changes in P300 latency for nonmeditators and experienced meditators premeditation and postmeditation at FZ, CZ, and PZ.

[a]Denotes $P < .01$.
[b]Denotes $P < .05$.

By way of comparison, the experienced meditators in the current study had an average of nearly 13 years of experience and practiced an average of 52 minutes each day. Although much more research is needed to clarify this issue, it is possible that extended and consistent meditation practice results in a higher level of baseline cognitive efficiency which is less influenced by a single meditation. A baseline comparison of nonmeditators and experienced meditators revealed that the experienced meditators demonstrated significantly shorter latencies at 2 of the 3 electrode sites (FZ, CZ). Although not statistically significant, it seems noteworthy that compared with nonmeditators, the experienced meditators also demonstrated greater P300 amplitude and shorter latencies at all sites both before and after the meditation (see Figure 1). This finding is consistent with other research that examined P300 data during a passive auditory listening study comparing nonmeditators and novice and experienced TM meditators. The results showed that the passive P300 latency was shorter for both meditation groups compared with controls. The experienced meditators demonstrating the shortest latencies.[19] The baseline differences in latency between groups suggest that consistent and long-term practice of MTH meditation may result in faster or more efficient cognitive processing..

These findings examined in connection with previous research suggests that there may be some differential effects of meditation on the P300 response based on the meditation experience of the subjects. Specifically, it appears that amplitude and latency are immediately impacted (to greater or lesser degrees) following most forms of meditation, but these changes do not become permanent or stable until there is a consistent and longer-term practice. Although there may be an immediate measurable effect, these do not "stick" without repeated training. If this interpretation is accurate, an examination of previous research in this area would suggest that 10 weeks may not be long enough to see the changes,21 whereas 3 months may be sufficient.[17,18]

It also seems that the type of meditation may be important. Based on the studies available, it appears that Kriya Yoga, cyclic meditation, and now MTH, have a stronger influence on P300 values than TM or breath awareness meditations. It may be that the more complex meditations (those that involve various mudras, chanting, breathing exercises, prayers, or physical postures) have a more dynamic impact on P300 values than meditations that emphasize a quiet mind and/or experiences of transcendence. Additional research is required to test these hypotheses.

Limitations and Future Directions

The positive findings in the current study should be viewed as preliminary and in the context of study limitations. In addition to the small sample size, the

current study did not include other measures of cognitive performance. Despite evidence that P300 latency and amplitude are directly related to a range of cognitive performance measures,[13] without assessing these directly, we do not know the exact relationship between the findings in this study and "real-life" improvements in cognitive functioning. It will be important for future studies to evaluate cognitive performance using other objective measures of attentional resource management, stimulus processing speed, and cognitive efficiency.

In addition, the current study did not examine or control for other factors that may have influenced the results. For example, research has previously demonstrated that P300 values can be influenced by subject motivation,[22] and mental fatigue,[23] both of which may have been factors that favored the meditation group over the nonmeditator group. In addition, it is widely recognized that experienced meditators often have other lifestyle differences that may be important including use of caffeine and alcohol, diet, and sleep patterns.2 Although the results of the current study are consistent with other research in this area, without examining the effects of these potentially confounding variables, we cannot definitively determine how much of the effect was from the meditation versus other factors. For these reasons, future studies should include a larger sample size, significantly expanded demographics, and assessments of motivation, fatigue, and interest. Future research in this area should also directly compare the influence of different meditation styles as well as track changes in P300 values in the course of time as a meditator moves from inexperienced to experienced.

Conclusion

The present study extends the previous research on the effects of meditation on P300 values by demonstrating that a lovingkindness-based meditation results in immediate improvements in meditation naïve subjects. In addition, this study provides additional evidence that long-term practice results in increased brain efficiency. Because P300 latency and amplitude are independent of behavioral responses and indicate the brain's speed and strength in classifying information,4 these findings suggest that the practice of MTH may result in improved cognitive performance.

Acknowledgements

Special thanks to Glenn Mendoza, MD, for supporting this project. Thank you to David Joffe, PhD, for his expertise and consultation regarding P300 recording and analysis. We also thank the 24 volunteers for their time and energy.

Author Disclosure Statement

Neus Raines, PhD, is a certified Pranic Healer and teaches introductory courses on Pranic Healing. Funding for this project was provided by the Center for Pranic Healing.

References

1. Tarrant J. *Meditation Interventions to Rewire the Brain: Integrating Neuroscience Strategies for ADHD Anxiety Depression and PTSD*. Eau Claire, WI: PESI Publishing Media; 2017.
2. Sing N, Telles S. Neurophysiological effects of meditation based on evoked and event related potential recordings. *BioMed Res Internat.* 2015;1(1):1-11.
3. Lutz A, Greischar LL, Rawlings NB, Ricard M, Davidson RJ. Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proc Natl Acad Sci USA*. 2004;101(46):16369-16373.
4. Cahn BR, Polich J. Meditation states and traits: EEG ERP and neuroimaging studies. *Psychol Bull.* 2006;132(2):180-211.
5. Engstrom M, Soderfeldt B. Brain activation compassion meditation: A case study. *J Alternat Complement Med,* 2010;5:597-599.
6. Fox K, Dixon M, Nijeboer M, et al. Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neurosci Biobehav Rev.* 2016;1(1):208-228.
7. Davidson RJ, Kabat-Zinn J, Schumacher J, et al. Alterations in brain and immune function produced by mindfulness meditation. *Psychosom Med.* 2003;65(4):564-570.
8. Barnhofer T, Chittka T, Nightingale H, Visser C, Crane C. State effects of two forms of meditation on prefrontal EEG asymmetry in previously depressed individuals. *Mindfulness.* 2010;1(1):21-27.
9. Zeidan F, Martucci KT, Kraft RA, Gordon NS, McHaffie JG, Coghill RC. Brain mechanisms supporting the modulation of pain by mindfulness meditation. *J Neuroscience.* 2011;31(14):5540-5548.
10. Luders E, Kurth F, Mayer EA, Toga AW, Narr KL, Gaser C. The unique brain anatomy of meditation practitioners: Alterations in cortical gyrification. *Front Hum Neurosci.* 2012;6(34):1.
11. Picton T. The P300 wave of the human event related potential. *J Clin Neurophysiol.* 1992;9(4):456-479.
12. Polich J, Kok A Cognitive and biological determinants of P300: An integrative review. *Biologic Psychol.* 1995;41:103-146.
13. Kraus N, Nicol T. Auditory evoked potentials. In Binder MD, Hirokawa N, Windhorst U (Eds.). *Encyclopedia of neuroscience.* Berlin, Germany: Springers; 2009:214-218.
14. Travis F, Miskov S. P300 latency and amplitude during eyes-closed rest and Transcendental Meditation practice. *Psychophysiology.* 1994;31:S67.
15. Sarang SP, Telles S. Changes in P300 following two yoga-based relaxation techniques. *Internatl J Neurosci.* 2006;116:1419-1430.
16. Travis F, Haaga D, Hagelin J, et al. Effects of Transcendental Meditation practice on brain functioning and stress reactivity in college students. *Internat J Psychophysiol.* 2009;71:170-176.
17. Murthy PJ, Gangadhar BN, Janakiramaiah N, Subbakrishna DK. Normalization of P300 amplitude following treatment in dysthymia. *Biologic Psychiatr.* 1997;42:740-743.
18. Murthy PJ, Gangadhar BN, Janakiramaiah N, Subbakrishna D. KP300 amplitude and antidepressant response to Sudarshan Kriya yoga (SKY). *J Affect Dis.* 1998;50:45-48.
19. Cranson R, Goddard PH, Orme-Johnson D. P300 under conditions of temporal uncertainty and filter attenuation: Reduced latency in long-term practitioners of TM. *Psychophysiology.* 1990;27:S23.
20. Sui CK. *Pranic Healing.* Newburyport, MA: Red Wheel Weiser; 2005.
21. Travis F, Shear J. Focused attention open monitoring and automatic self-transcending: Categories to organize meditations from Vedic Buddhist and Chinese traditions. *Consciousness Cognit.* 2010;19(4):1110-1118.
22. Carillo-de-la-Pena MT, Cadaveira F. The effect of motivational instructions on P300 amplitude. *Clin Neurophysiol.* 2000;30(4):232-239.
23. Malihe S, Reza B, Karim R. How mental fatigue affects the neural sources of P300 component? *J Integrat Neurosci.* 2018;17(1):93-111.