FLASH VISUAL EVOKED POTENTIALS IN ZEN-BUDDHIST MEDITATION

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Abstract: Observation of the inner-light perception in deep Zen meditation [10] has aroused our attention. Based on the recording of F-VEPs (flash visual evoked potentials), this study was thus designed to investigate the characteristics of visual nervous pathway for the Zen-meditation practitioners (experimental group), in comparison with that for the normal, healthy subjects (control group). Flash stimuli were applied before, during and after meditation / relaxation in experimental / control subjects. We focused on the F-VEPs at the occipital site Oz, central site Cz and frontal site Fz. Our results show that amplitudes of late latency components N3-P3 and P3-N4 at Oz decrease for the experimental subjects during meditation, whereas they increase in the control group. Both Cz and Fz amplitudes increase during meditation, yet decrease during relaxation for the control group. The latencies of some components were increased under relaxation in control group, yet little variation (except P2) is observed in the meditators. According to our findings, Zen meditation induces particular effects on the visual nervous system and cortex that are distinct from the normal relaxation.

Introduction

During the past decades, a number of papers have reported the benefits of meditation to the physiological and mental health, with particular emphasis on transcendental meditation, Yoga meditation, and Japanese-Zen meditation. It is the first attempt to investigate the electrophysiological signals of the orthodox Zen-Buddhist practitioners. The main doctrine of Zen-Buddhist practice is to transcend the physiological, mental, and subconscious states via Zen meditation that enables the practitioners to reach a fully egoless, transcendental state (the Alaya state) [10].

Researchers have been probing into the physiological and psychological parameters during meditation for several decades [6] [15]. Some important results include: Wallace [14] claimed the emergence of theta waves in the frontal area in transcendental meditation, Banquet [2] observed the slowdown of alpha frequency and the increase of alpha amplitude as well as the occurrence of the rhythmic theta trains. Recently, Lutz and et al. [7] found that long-term Buddhist practitioners self-induced sustained high-amplitude, gamma-band EEG and phase-synchrony during meditation. These patterns obviously occurred at the lateral fronto-parietal electrodes. Travis [11], found several physiological markers including the decrease of respiration rate, higher respiratory sinus arrhythmia amplitudes, higher alpha coherence, etc.

In addition, ERPs (evoked response potential) used to explore the underlying neuron activities in meditation were investigated. Zhang [17] claimed the increase of F-VEP amplitudes of Qigong practitioners under meditation. In [16], increase of amplitude and decrease of latency were reported. Furthermore, auditory evoked potential (AEP) under meditation has also been studied to investigate the meditation effects on the brainstem auditory response [8][12].

The paper survey given above shows a particular phenomenon of meditation, that is, its effects on the frontal cortex. The transcendental state of Zen meditation, in fact, reflects that the human life system turns off its physical and mental sensors, leaves off the message transmission from outside world, and keeps subconscious tranquil. When further attaining the deeper meditation state, practitioners often ignite their *inner energy*, accompanied with the experience of perceiving the *inner light* [10]. Base on the observation of frontal EEG and the common experiences of *inner-light* perception, we hypothesized that meditation would affect the visual neuron pathway, and the effect might be modulated by the meditation effects in the frontal area of the cortex.

Accordingly, this study aimed to investigate the meditation effects on visual neuron pathway by quantitatively analyzing the visual evoked potentials (VEPs). Owing to the limitation that meditators must close their eyes during meditation, we employed the flashed light as the visual stimulus and recorded the flash visual evoked potential (F-VEP), with particular emphasis on channels Oz, Cz, and Fz.

Materials and Methods

1. Subjects: This study involves 30 experimental subjects (meditators) and 30 control subjects (normal, healthy people without any experience in meditation). In the experimental group, 15 females and 15 males at the mean age of 28.7±4.6 years participated. Their experiences in Zen-Buddhist practice span 6.6±4.1

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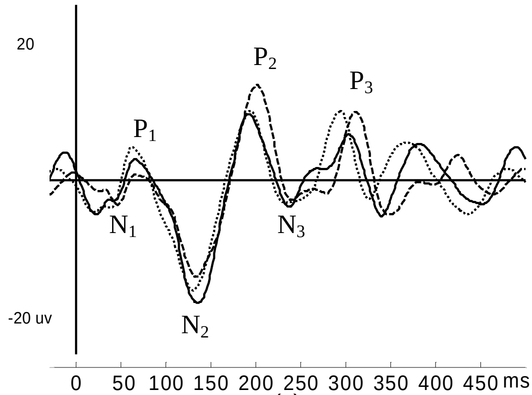
years. The control group consists of 9 females and 21 males at the mean age of 24.1±1.6 years.

2. Recording setup: EEG and F-VEP were recorded within the frequency range from 0.15Hz to 50Hz. The sampling rate is 1000Hz. We applied the 30-channel recording montage with the ground at the forehead and the reference as the linked mastoids.

   F-VEPs were recorded before, during and after the main session (meditation or relaxation), that is called the pre-, mid-, or post-session. Continuous, 100 flash stimuli were applied to the subject in each session. The flash light was 10 μs in duration and 1 Hz in frequency produced by a xenon lamp that was placed 60 cm in front of the subjects' eyes. These parameters were referred to the standard procedures [1][3][9].

3. Experimental protocol: Subjects sat in a isolated space during the recording. Each recording lasted for about one hour. The course included 10min pre-session, 40min mid-session, and 10min post-session recording.

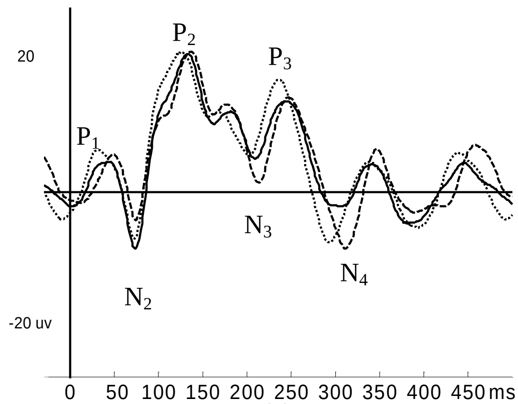
   In the mid-session period, experimental subjects practiced the Zen meditation, while control subjects sat in normal relaxed position with eyes closed. During the meditation, the subject sat, with eyes closed, in the full-lotus or half-lotus position.



(c)

Figure 1: The F-VEP on (a)Oz (b)Cz (c)Fz of a meditator.

4. Zen meditation: In the begining of meditation, the subjects focused on the Navel Chakra and regulated their respiration. Navel Chakra is regarded as an important *switch* that activates the other Chakras. After igniting the Navel Chakra, meditators focused on the Zen Chakra or Dharma Chakra to empty the thought.



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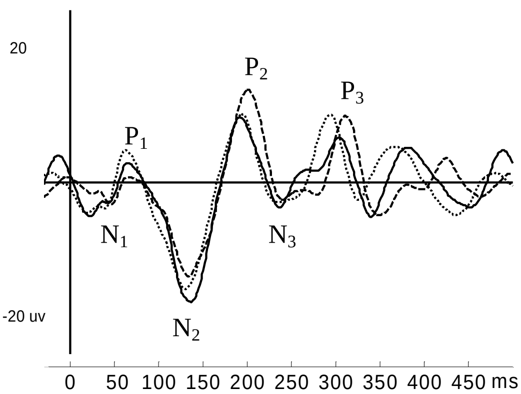

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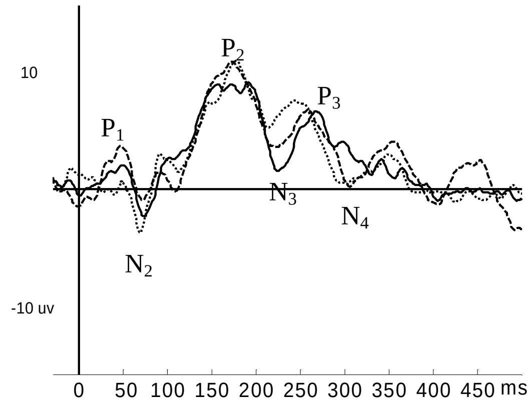

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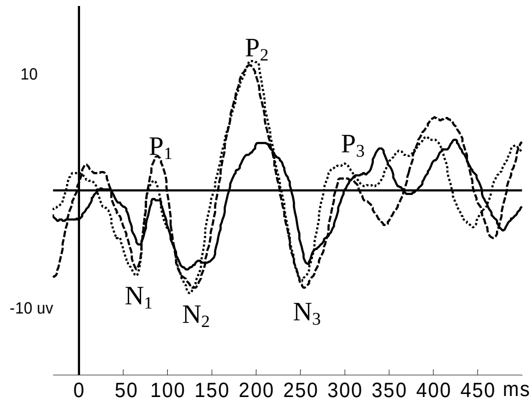

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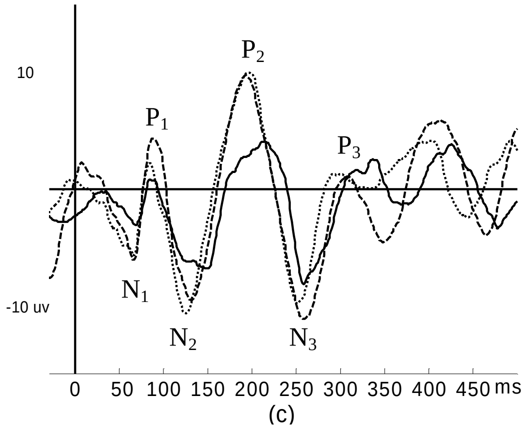

Figure 2: The F-VEPs on (a)Oz (b)Cz (c)Fz of a control subject.

Results

Figures 1 and 2 are the averaged F-VEPs on Oz, Cz and Fz of one experimental and one control subject, respectively. The dotted, solid and dashed lines represent respectively the pre-, mid-, and post-session F-VEPs. Tables 1 and 2 list the average ratios of mid- to pre- and post- to mid-session latencies and amplitudes for both group. The p values are calculated by *paired t-test* and *t-test*.

The peak numbers are named according to the visual evoked potential standard [9]. From Table 1, we can examine the variations in latencies between sessions or between groups. We summarize some important findings as follows (exp: experimental group, cnt: control group).

(1) Significant variations in latency are: (exp) P2 at Oz; (cnt) N1 at Cz, P1 and N3 at Fz. Note that all the latencies of these components increase during meditation/relaxation and decrease in the post-session.

(2) Two groups show different trends in the latency ratios: (mid/pre) N1 and P1 at Cz; P1 and N3 at Fz. The latencies of these components in the control group show considerable increasing, whereas the changes of experimental group are not apparent. (post/mid) N1 at Fz: the latency of the experimental group increased, but it decreased in the control group.

From Table 2, we can examine the variations in amplitudes between sessions or between groups. We summarize some important findings as follows.

(1) Significant variations in amplitude are: (exp) N3-P3 and P3-N4 at Oz; (cnt) P1-N2 at Cz and Fz. The amplitudes of these components decrease during meditation/relaxation and increase afterwards.

(2) Two groups show different trends in the magnitude ratios: (mid/pre) N3-P3 and P3-N4 at Oz; P1-N2 at Cz and Fz; (post/mid) P1-N2 at Cz. In experimental group, the amplitudes of N3-P3 and P3-N4 at Oz are decreased under meditation, but the trends are opposite under relaxation in the control group. The amplitudes of P1-N2 on Cz and Fz are increased in experimental group but decreased in the control group during meditation/relaxation. Furthermore, after meditation/relaxation, P1-N2 at Cz is decreased in the experimental group and is increased in the control group.

Table 1: Average ratios of peak latencies (NS: not significant).

Item		Exp group			Ctrl group			t-test	
		mid/pre (%)	post/mid (%)	**P value (paired t-test)**	mid/pre (%)	post/mid (%)	**P value (paired t-test)**	mid/pre	post/mid
Oz	P1	106.45	98.79	NS	110.79	96.36	NS	NS	NS
	N2	100.65	100.16	NS	103.40	99.94	NS	NS	NS
	P2	103.52	99.13	**0.001****	104.60	100.72	NS	NS	NS
	N3	101.91	99.99	NS	100.00	101.59	NS	NS	NS
	P3	101.34	99.85	NS	100.24	101.47	NS	NS	NS
	N4	100.57	99.81	NS	100.62	99.51	NS	NS	NS
Cz	N1	103.47	101.77	NS	129.77	98.57	**0.009****	**0.008****	NS
	P1	100.72	102.66	NS	109.84	106.50	NS	**0.009****	NS
	N2	101.15	99.61	NS	102.68	98.82	NS	NS	NS
	P2	101.03	99.93	NS	102.51	100.00	NS	NS	NS
	N3	103.41	100.09	NS	105.02	100.40	NS	NS	NS
Fz	N1	105.77	104.65	NS	111.05	92.74	**0.040***	NS	**0.042***
	P1	102.32	100.75	NS	109.13	97.42	**0.024***	**0.024***	NS
	N2	100.98	100.38	NS	102.19	99.59	NS	NS	NS
	P2	100.50	99.30	NS	103.65	99.47	NS	NS	NS
	N3	99.81	100.29	NS	105.68	98.30	**0.021***	**0.042***	NS

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Table 2: Average ratios of peak amplitudes (NS: not significant).

Item		Exp group			Ctrl group			t-test	
		mid/pre (%)	post/mid (%)	**P value (paired t-test)**	mid/pre (%)	post/mid (%)	**P value (paired t-test)**	mid/pre	post/mid
Oz	P1-N2	112.89	102.20	NS	121.64	100.98	NS	NS	NS
	N2-P2	104.98	104.86	NS	110.82	115.67	NS	NS	NS
	P2-N3	109.57	100.72	NS	121.50	116.99	NS	NS	NS
	N3-P3	82.93	128.93	**0.016***	124.61	111.83	NS	**0.006****	NS
	P3-N4	89.10	126.96	**0.037***	132.79	116.69	NS	**0.002****	NS
Cz	N1-P1	95.91	114.92	NS	108.88	103.98	NS	NS	NS
	P1-N2	112.49	90.94	NS	84.88	117.91	**0.038***	**0.019***	**0.031***
	N2-P2	102.87	107.42	NS	98.14	115.47	NS	NS	NS
	P2-N3	125.30	119.52	NS	113.01	130.20	NS	NS	NS
Fz	N1-P1	112.13	113.35	NS	106.25	109.02	NS	NS	NS
	P1-N2	100.18	101.09	NS	84.82	113.64	**0.047***	**0.045***	NS
	N2-P2	99.62	110.85	NS	105.07	103.83	NS	NS	NS
	P2-N3	105.58	122.10	NS	121.35	114.16	NS	NS	NS

Discussion

In this paper, we have reported the differences of F-VEPs between the Zen-meditation practitioners and the normal healthy subjects. Latencies of the experimental group show no significant difference between sessions except P2 at site Oz. In Tsutsui's study [13], early latency components occurred before 70 msec, including P1-N2 at Oz and N1- P1 at Cz and Fz, whereas late latency components occurred after them. At Oz, it was claimed that late latency components (P2~N4 at Oz in our data) originated from the cortex, and P2 was thought the inhibitory effect of lamina [4][5]. Accordingly, our results apparently reflect the substantial effects of Zen meditation on the cortex correlating with higher level brain function.

Two groups show the opposite variations in the amplitudes of late components, N3-P3 and P3-N4 at Oz, that indicates the suppression (enhancement) of the late-component responses via meditation (relaxation). The reason may be the influences of the background EEG. This observation further supports an alternative viewpoint of meditation that exhibits distinct effects on the brain nervous system in comparison with the normal relaxation.

Another significant distinction between two groups is the amplitude of P1-N2 at the fronto-central region (Cz and Fz). Note that P1 is the early component (generated from the visual pathway and the primary visual cortex) and N2 is a late one. From the results of P1-N2, we may infer that meditation affects the visual pathway, primary visual cortex and the cortex, that the effects are different from those of relaxation.

In sum, meditation affects the late-latency components of the occipital F-VEP, yet, the earlier components of the fronto-central F-VEPs. One possible hypothesis states that the meditators concentrate their attention and inner energy on the Zen Chakra or Dharma Chakra, therefore neorons at the fronto-central regions become more active to enhance the visual evoked potentials from primary visual cortex and the association area. Further study is underway to provide firm evidence.

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