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Changes in EEG and autonomic nervous activity during meditation and their association with personality traits

Tetsuya Takahashi[a], Tetsuhito Murata[a,*], Toshihiko Hamada[b], Masao Omori[a], Hirotaka Kosaka[a], Mitsuru Kikuchi[c], Haruyoshi Yoshida[b], Yuji Wada[a]

[a]Department of Neuropsychiatry, Faculty of Medical Sciences, University of Fukui, Matsuoka-cho, Fukui 910-1193, Japan
[b]Department of Clinical and Laboratory Science, Faculty of Medical Sciences, University of Fukui, Fukui, Japan
[c]Department of Psychiatry and Neurobiology, Graduate School of Medical Science, Kanazawa University, Kanazawa, Japan

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Abstract

Meditation is the attainment of a restful yet fully alert physical and mental state practiced by many as a self-regulatory approach to emotion management, but the psychophysiological properties and personality traits that characterize this meditative state have not been adequately studied. We quantitatively analyzed changes in psychophysiological parameters during Zen meditation in 20 normal adults, and evaluated the results in association with personality traits assessed by Cloninger's Temperament and Character Inventory (TCI). During meditation, increases were observed in fast theta power and slow alpha power on EEG predominantly in the frontal area, whereas an increase in the normalized unit of high-frequency (nuHF) power (as a parasympathetic index) and decreases in the normalized unit of low-frequency (nuLF) power and LF/HF (as sympathetic indices) were observed through analyses of heart rate variability. We analyzed the possible correlations among these changes in terms of the percent change during meditation using the control condition as the baseline. The percent change in slow alpha EEG power in the frontal area, reflecting enhanced internalized attention, was negatively correlated with that in nuLF as well as in LF/HF and was positively correlated with the novelty seeking score (which has been suggested to be associated with dopaminergic activity). The percent change in fast theta power in the frontal area, reflecting enhanced mindfulness, was positively correlated with that in nuHF and also with the harm avoidance score (which has been suggested to be associated with serotonergic activity). These results suggest that internalized attention and mindfulness as two major core factors of behaviors of mind during meditation are characterized by different combinations of psychophysiological properties and personality traits.
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1. Introduction

Meditation is the mental activity associated with attaining a deeply restful yet fully alert state (Mason et

* Corresponding author. Tel.: +81 776 61 8363; fax: +81 776 61 8136.
E-mail address: tmurata@fmsrsa.fukui-med.ac.jp (T. Murata).

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al., 1997). Meditation is practiced by many to facilitate their health and adaptation to medical illness, as a form of systematic training in a self-regulatory approach to stress reduction and emotion management (Bishop, 2002; Kabat-Zinn et al., 1992; Reibel et al., 2001). In recent years, there have been various studies on the behaviors of the mind during meditation using psychophysiological parameters such as EEG and autonomic nervous activity. During meditation, experienced meditators were reported to demonstrate increased alpha and theta EEG power, and reduced or enhanced autonomic response to external stimuli (Corby et al., 1978; Delmonte, 1984; Travis, 2001; Woolfolk, 1975).

Mikulas (1990) proposed the usefulness of dividing meditation into four components (form, object, attitude and behaviors of mind). Of these components, form and object vary among meditation techniques. The expressions used for the behaviors of mind induced during meditation also vary, but there are two core components (or some weighted combination of both), i.e., manipulation of one's attentional focus (internalized attention) and maximization of the breadth and clarity of self-awareness (mindfulness) (Mikulas, 1990). In addition, attitude (the mental set in which one approaches meditation) is considered to be an important factor affecting behaviors of mind during meditation (Dunn et al., 1999; Mikulas, 1990), and its close association with personality traits has been also reported (Bulik et al., 2000; Helmreich, 1984). Although it is fairly well known that proficient meditation involves the cultivation of internalized attention and/or mindfulness (Mikulas, 1990; Shapiro, 1982), the psychophysiological properties and personality traits that characterize these two behaviors of mind have not been adequately studied.

In the present study, we used a meditation task called 'Su-soku', which is a Zen meditation practice that does not require any special training, as only sustained attention and breath control are needed (Kubota et al., 2001). Normal adults performed the Su-soku task, and we then quantitatively analyzed the changes in psychophysiological parameters (EEG and autonomic nervous activity using heart rate variability (HRV) as an index) during meditation. The obtained results were evaluated in association with induced behaviors of the mind and personality traits.

2. Methods

2.1. Subjects

A total of 20 undergraduate students were recruited to participate in this study, all males, with an average age of 24.6 years (S.D.=1.89 years, range=21–26 years). They were all free from cardiac, pulmonary, metabolic and other diseases that would cause autonomic nervous system dysfunction. All subjects were nonsmokers and medication-free and none of them was a habitual drinker. No subject had previously practiced any form of meditation technique. Informed written consent was obtained from each subject after the experimental procedures had been explained.

2.2. Physiological measurements

EEG, electrocardiogram (ECG) and breath rate were measured simultaneously under the control condition and during meditation in this study. EEG activity was recorded using six electrodes (i.e., F3, F4, C3, C4, O1 and O2) according to the International 10–20 System, referenced to linked ear lobe electrodes. Three other electrodes were used to measure respiration, eye movements and blinks. Impedance was less than 10 kΩ for each electrode. EEG signals (sampling frequency: 500 Hz) were recorded with a time constant of 0.3 s, a high cut-off frequency of 120 Hz and a sensitivity of 50 μV/7 mm using an EEG-4518 (Nihon-Koden, Tokyo, Japan). The data were simultaneously stored on a magnetic optical disk for offline analysis.

ECG signals (lead II) were recorded with FM300 Holter monitoring (Fukuda-Denshi, Tokyo, Japan). The ECG signals were digitized, stored on an integrated circuit card and sampled at the rate of 125 Hz for offline analysis. The R–R intervals (i.e., the length of time between the R peaks of consecutive QRS complexes) were measured by a peak detection algorithm and checked for artifacts with an accuracy of 8 ms, and the occasional ectopic beats were identified and replaced with the interpolative R–R interval data using an SCM 6000 (Fukuda-Denshi).

2.3. Personality assessment

Personality traits were assessed with the Japanese version of Cloninger's Temperament and Character

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