

# Repeatability Value in Heart Rate Associated with Experienced Zen Meditation

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## Abstract

*To understand the repeatability of hemodynamic events elicited by deep Zen meditation during Zazen, we studied heart rate in 5 experienced Zen meditators and beginners. The study took place over 8 sets of Zen meditations in a quiet, Zen practice hall. Each set of Zazen lasted at least for 25 minutes. The first sets were used for habituation, and the data obtained from the following seven sets were used for analysis. Power spectrum analysis showed distinctive change in frequency components. Very low frequency (VLF) components decreased for experienced meditators. Most notably, standard deviations from 7 sets of measurements within each subjects were significantly low for experienced meditators, showing increased repeatability. We attribute the decrease in VLF components to the less easily distracted meditation, and the increase in repeatability to the effective regulation of mind and body movement during experienced Zen meditation.*

## 1. Introduction

Zen is a traditional meditation method which utilizes unification of body, respiration and mind [1]. Though Zen has been sophisticated highly in Japan, it is spreading widely into western world today, realizing deeper meditation with minimum body movement and distraction.

While heart rate variability (HRV) during controlled breathing by the subject has been studied in the past where the variability of HRV between repeat measurements in the same subject was still very high [2-5], there remains a lack of consensus whether heart rate during Zen practice elicit consistent repeatability measures of HRV especially for experienced and practicing Zen meditator. Research done in our laboratory aims at using the information contained in the fluctuation response of ECG heart rate to meditational state. To achieve this goal, it is necessary to understand better the mechanisms underlying the control of hemodynamic events through reciprocal autonomic activation elicited by

meditational manipulation of body, respiration and mind. Specifically, we are interested in quantifying the degree of difference between repeatabilities of ECG interbeat interval fluctuation responses seen during experienced Zen meditators and beginners.

## 2. Methods

We studied heart rate in 5 experienced Zen meditators who had been practicing several years of regular sitting Zen meditation (Zazen) and 5 beginners. The study took place over 8 sets of Zen meditations in a quiet, Zen practice hall in Kamakura or Tokyo. Each set of Zazen lasted at least for 25 minutes.

Zazen prescribes a certain bodily posture. We sit on a cushion 5 to 15 centimeters thick that is placed on our blanket. We cross our legs so that one foot rests on the opposite thigh with the sole of our foot turned up and with our knees touching the blanket (lotus or half-lotus position). The torso should be kept straight, but it should not be strained. Except in the belly, there should be no strain anywhere. The head should be kept high with our eyes opened slightly and focused on a point about a meter away on the floor (Fig 1).

We should breath calmly and deeply through nose, but take 2 or 3 times as long to exhale as to inhale. We should also use lower abdominal muscles to accomplish Tanden breathing.

We should keep mind free from specific state of consciousness or distractions where 3 methods have been used for over a thousand years: concentration on breathing, so called *shikantaza* which means only to sit, and the *koan*. For beginners we use the first one by counting breaths mentally from 1 to 10 beginning with 1 again (*susokukan*), or by following the breaths, being aware only of inhalation when inhaling, and only of exhalation when exhaling (*zuisokukan*). For experienced meditator we use the latter two. In *shikantaza* we directly ignore any thoughts which might arise by simply letting any thoughts in and out without sticking to them. The *koan* is logically insoluble riddle, because it contains a contradiction. Logical solutions are rejected, and

experienced meditators become ‘one with *koan*’.



Figure 1. Bodily posture of Zazen. Left: Statue of Buddha, Right: Schematic representation of lotus position. See text.

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Figure 2. Sequence of events. 8 Zazen sessions were allocated with intermission after each sessions. The inter-beat intervals from ECG during last 7 Zazen meditations were used for analyses.

The first sets of Zazen were used for habituation, and the beginning 25 minutes data obtained from the following seven sets were used for analysis (Fig 2). The HR was obtained from ECG recordings.

### 3. Results

ECG data were analyzed for 10 subjects to test for autonomic states during each set of Zen meditation. Population averaged results for heart rate were not

significantly different between experienced and beginners. Power spectrum analysis using Lomb method showed distinctive change in frequency components. Low frequency component (LF; 0.04Hz to 0.15Hz) and high frequency component (HF; 0.15Hz to 0.40Hz) increased for experienced meditators ( $p=0.05$ ). Very low frequency component (VLF; 0.003Hz to 0.04Hz,  $p=0.02$ ) and total frequency power (TF;  $p=0.05$ ) increased relatively for beginners (Fig. 3), which were consistent with previous study.

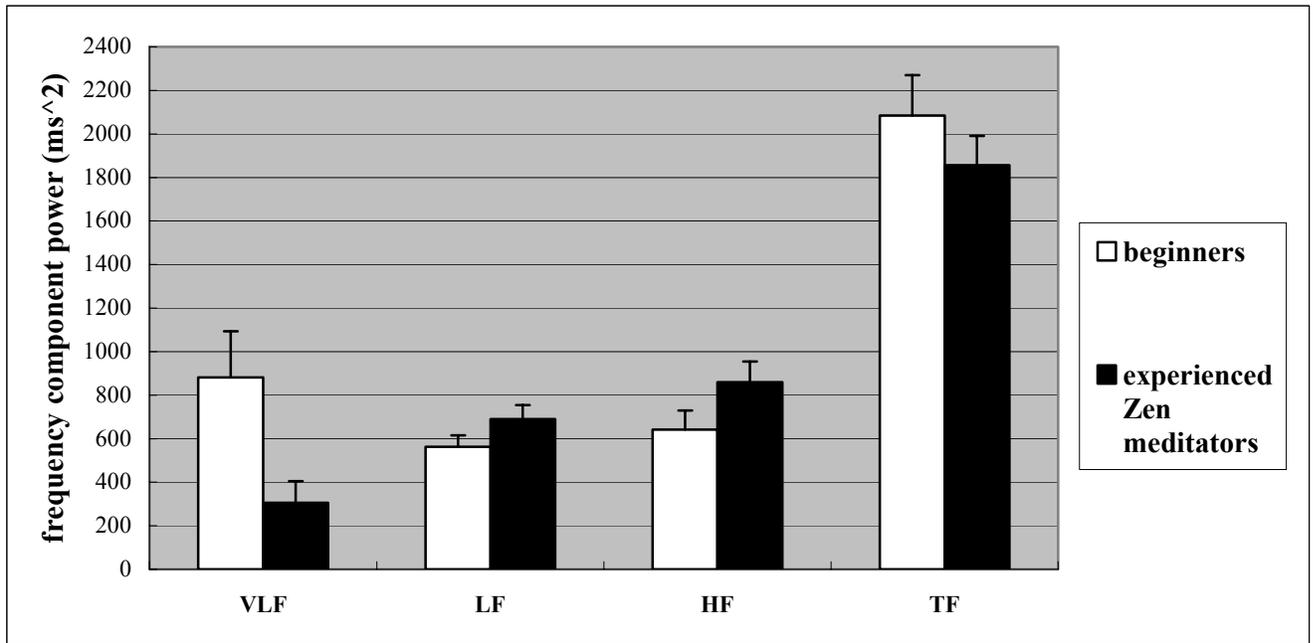


Figure 3. Frequency component power for VLF, LF, HF, TF of inter-beat intervals from ECG for beginners and experienced Zen meditators. Standard errors of the mean for 35 ECG segments per each group are presented as error bars.

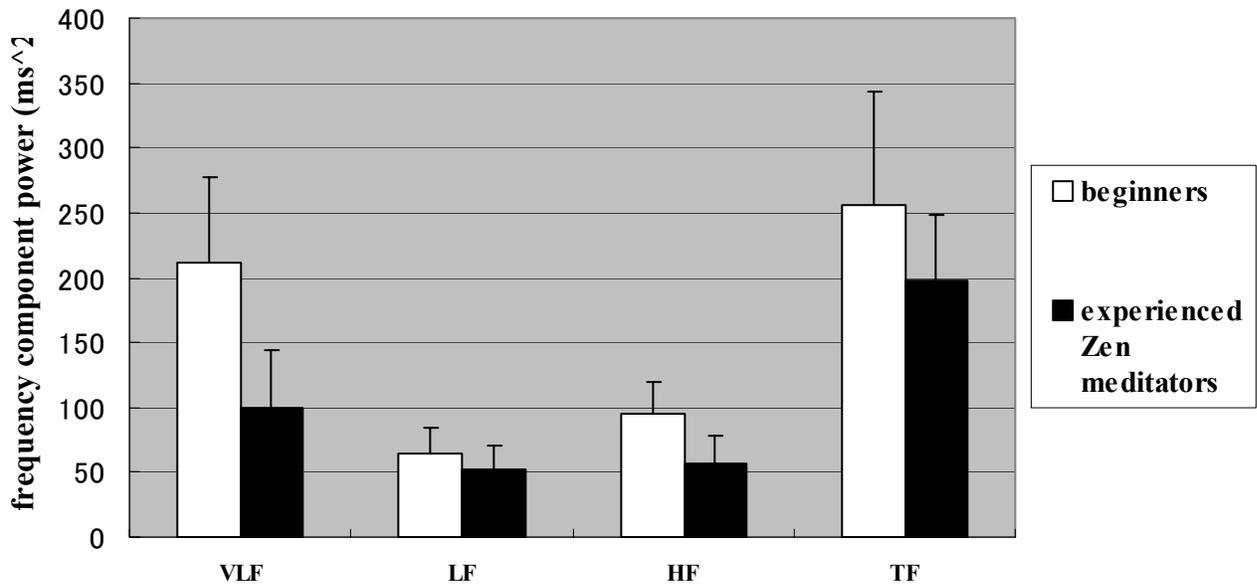


Figure 4. Standard deviations for VLF, LF, HF, TF of inter-beat intervals from 7 sets of measurements within each subjects. Standard errors of the mean per each group are presented as error bars.

We calculated standard deviations for VLF, LF, HF, TF of inter-beat intervals from 7 sets of measurements within each subjects. Most notably, standard deviations

for VLF and HF of inter-beat intervals within each subjects were significantly low for experienced meditators ( $p=0.05$ ), showing increased repeatability (Fig. 4).

#### 4. Discussion and conclusions

During Zen practice, we seat ourselves in a lotus posture, practice Tanden respiration, i.e., lower abdominal breathing, and keep mind free from specific state of consciousness. Deep meditative state of Zen, namely Zanmai, can be accomplished after several years of Zen practice. This study was designed to elucidate the heart rate response to Zanmai by comparing beginners with experienced and practicing Zen meditators.

We could not find any difference in mean heart rate between beginners and experienced group. Significant differences exist between the two groups in frequency components of the heart rate power spectrum. High frequency component is around the frequency of respiration, because it corresponds to respiratory sinus arrhythmia. Parasympathetic nervous system can transfer as high as 1Hz where respiratory sinus arrhythmia is transferred, but sympathetic nervous system cannot transfer fluctuations higher than 0.15Hz. High frequency component is modulated by parasympathetic nervous system, but not by sympathetic nervous system [6,7]. Mayer wave [8] in arterial blood pressure reflect itself to heart rate through arterial baroreflex which generates low frequency component of the heart rate variability [9,10]. Recently this low frequency component has also been found in heart rate fluctuations under the artificial heart control suggesting central origin of this autonomic nervous rhythm [11]. Since the low frequency component is within the transferable frequency of sympathetic nervous system, this component is modulated by both sympathetic and parasympathetic nervous system.

As mentioned above, low frequency component and high frequency component increased for the experienced group. We attribute the increase in high frequency component to the response of parasympathetic neural enhancement [12], and the increase in low frequency component to the response of both parasympathetic and sympathetic arousal mechanism during Zanmai state of deep Zen meditation. The decrease in VLF components could be attributed to the less easily distracted meditation.

We mentioned that standard deviations for VLF and HF components of inter-beat intervals within each subjects were significantly low for experienced meditators. The increase in repeatability of VLF could be attributed to the effective regulation of mind and body movement. We could attribute the increase in repeatability of HF to the steady regulation of parasympathetic nervous system during experienced Zen meditation toward the edge of sleep, but not quite over it.

This result suggests the possibility of HRV repeatability as a handy and quantitative evaluator for Zen meditation.

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