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EEG Spectral Analysis on Muslim Prayers

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Abstract This study investigated the proposition of relaxation offered by performing the Muslim prayers by measuring the alpha brain activity in the frontal (F3–F4), central (C3–C4), parietal (P3–P4), and occipital (O1–O2) electrode placements using the International 10–20 System. Nine Muslim subjects were asked to perform the four required cycles of movements of *Dhuha* prayer, and the EEG were subsequently recorded with open eyes under three conditions, namely, resting, performing four cycles of prayer while reciting the specific verses and supplications, and performing four cycles of acted *salat* condition (prayer movements without any recitations). Analysis of variance (ANOVA) tests revealed that there were no significant difference in the mean alpha relative power (RP_α) between the alpha amplitude in the *Dhuha* prayer and the acted conditions in all eight electrode positions. However, the mean RP_α showed higher alpha amplitude during the prostration position of the *Dhuha* prayer and acted condition at the parietal and occipital regions in comparison to the resting condition. Findings were similar to other studies documenting increased alpha amplitude in parietal and occipital regions during meditation and mental concentration. The incidence of increased alpha amplitude suggested parasympathetic activation, thus indicating a state of relaxation. Subsequent studies are needed to delineate the role of mental concentration, and eye focus, on alpha wave amplitude while performing worshipping acts.

Keywords Salat · Muslims prayer · EEG · Alpha wave · Prostration

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Introduction

The brain is an electrochemical organ, which functions as the portal for integrating and processing information, as well as the controlling center (Applegate 1995; Schlogl et al. 2002). There were also several studies that showed that the brain frequency rhythm may have correlation with spiritual activities, such as yoga (Vialatte et al. 2009; Arambula et al. 2001), tai chi (Field et al. 2010), and Zen meditation (Fumoto et al. 2004). One of the most commonly studied brain wave is alpha wave, which is indicative of relaxation or mental inactivity. The production of alpha waves is normally promoted by the parasympathetic nervous system with suppression of the symphathetic system. (Applegate 1995; Takahashi et al. 2005).

Religious meditations and prayers have been found to possibly promote relaxation, as well as a healthier, more balanced condition to the human mind and body (Lee et al. 2007; Reibel et al. 2001). Banquet (1973) performed a spectral analysis during transcendental meditation and discovered that the frequency rhythm of both alpha and theta waves increased during meditation. Kasamatsu and Hirai (1966) demonstrated the appearance of alpha and theta waves during Zen meditation. In addition, Arambula et al. (2001) investigated whether the physiological response correlated with a well-trained Kundalini yoga meditator, and found that alpha wave EEG activity was enhanced during meditation when compared to the pre-and

post-baselines. There has been no study conducted on Muslim prayers, except by Ibrahim et al. (2008) who measured at the gamma waves of EEG following a prayer session. It was proposed that the practice of the Muslim prayer was capable of producing a higher state of calmness in the human mind, likely to be due to an increase in concentration and focus during the prayers. On the other hand, a number of studies found that negative side-effects were also experienced following the practice of meditations. Shapiro (1992) found that 63% of the subjects reported adverse effects during and after meditation, and 7.4% experienced profoundly adverse effects. Furthermore, Craven (1989) described uncomfortable kinaesthetic sensations, mild dissociation, feelings of guilt and, via anxiety-provoking phenomena, psychosis-like symptoms, grandiosity, elation, destructive behaviour and suicidal feelings following recorded meditation sessions.

The Muslim prayer, known as *salat* in Arabic, is a worshipping act which encompasses both physical movements of the body, as well as the *Quranic* recitations and other specific supplications. The prayer is obligatory to all Muslims and is a routine daily activity that is performed at specific prescribed time and duration (Ibrahim et al. 2008). There are four main positions involved in the prayer, namely standing, bowing, prostrating and sitting. In addition to these physical movements, a fundamental part of the Muslim prayer is the recitation of *Quranic* verses and specific supplications that must be verbalized when the worshipper assumed certain positions and performed specific movements.

In addition to the obligatory prayer, there are other optional prayers such as Dhuha prayers that Muslims voluntarily perform for certain reasons. *Dhuha* prayer is performed for the purpose of expressing gratitude for the new day and appealing for good fortune, commonly performed in the morning. This paper presents the alpha wave signal activity in the brain of Muslim subjects while performing their *Dhuh*a prayer.

Materials and Methods

Subjects

Nine Muslim subjects between 20 and 29 years old were recruited in this study (six males and three females). None of them reported any neurological or psychiatric disorder, and a consent form was obtained from each subject.

EEG Recording

The EEG data was recorded from eight electrode positions on the scalp (homologous frontal (F3, F4), central (C3, C4), parietal (P3, P4) and occipital (O1, O2) sites) according to the International 10–20 system of electrode placement, referenced to the linked ear lobe electrode (Fig. 1). These electrode sites selections were based on previous studies that recorded EEG during meditations or relaxation techniques (Surwillo and Hobson 1978; Uebaba et al. 2005; Sim and Grewal 1989; Takahashi et al. 2005). Electrode impedance was less than 5 k ohm. The signals were sampled at a frequency of 250 Hz and recorded using the MP150 EEG acquisition system (*BIOPAC* Systems Inc., California, USA).

The experimental protocol for each of the subjects consisted of three sessions. The first sessions commenced with the subjects sitting on a chair in a relaxed position with their eyes opened for 1 min then they were asked to close their eyes for another minute; and finally to open their eyes for another minute. The EEG was subsequently recorded and the data were used as a baseline for consecutive analyses. The subjects were asked to relax for an additional 3 min prior to the commencement of the second sessions.

In the second sessions, the subjects performed the *Dhuha* prayer for four cycles. The prayer began with the upright standing position, which took approximately 30–60 s to complete. It was followed by bowing; with the trunk of the body being fully horizontal at 90-degree angle with the legs, and both hands pressing down on the knees. The subject then recited a specific supplication during this position that took approximately 5 s to complete. The subject then briefly stood up for approximately 2 s, before subsequently prostrating with both palms and the knees touching the floor. This position lasted for about 10 s, with

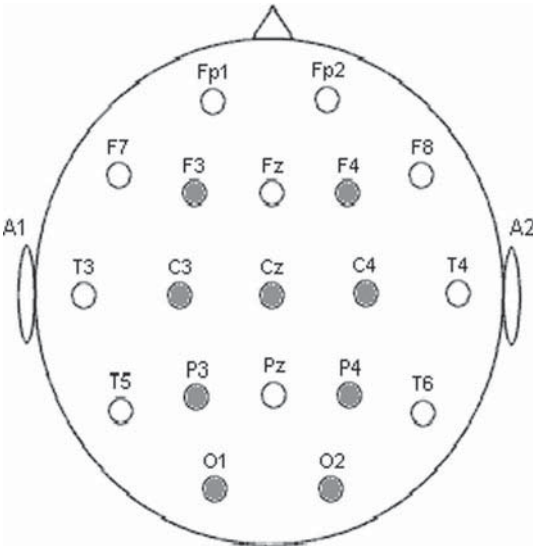

Fig. 1 Electrode positions on the scalp

the subject reciting a specific supplication. The subject then sat and recited a supplication for about 5 s, followed by a second prostration. Finally the subject sat for the second time, lasting for about eight seconds, completing a single cycle of the prayer movements as shown in Fig. 2a. The subject then stood to continue with the subsequent cycles of movements (Fig. 2b, c). The only difference lies in the final cycle, where the subject took approximately 20–30 s to complete the recitation. At the end of the recitation, the subject gave *salam,* which indicated the end of the prayer (Fig. 2d). Subjects were reminded to keep their eyes opened during the prayer session.

In the third sessions, the subjects were instructed to perform the physical movements of the prayer without reciting any Quranic verses or supplications. The subjects were only required to act out the *salat* positions in the proper sequence without actually praying. The acted sequence was repeated for four cycles and each position took approximately 15 s.

Signal Analysis

To avoid any artifacts due to physical movements, only four static positions (standing, bowing, sitting and prostrating) were analyzed, while the signal in between movements were excluded. The EEG data was filtered using Finite Impulse Response (FIR) band-pass filter between 1.0 and 100 Hz with the number of coefficient is 4,000 and Hanning window with 50% overlap. Fast Fourier Transform (FFT) was then performed to the selected data for every 1 s segment and the power spectral density (PSD) data in (μv^2) was obtained. The PSD was segmented into alpha (8–13 Hz) and into the generic EEG brain wave (0–95 Hz). Alpha relative power (RPα) representing the energy of the signal in the frequency range was calculated as follows:

$$\mathrm{RP}_{\alpha} = \frac{\int_{fl}^{fh} S_x(f)df}{\int_{0}^{f\,\max} S_x(f)df} \cdot 100 \qquad (1)$$

where $fmax = 95$ Hz, $fl = 8$ Hz, $fh = 13$ Hz (Amodio et al. 2009).

Finally, the mean of RP_{α} for every position was computed. Analysis of variance (ANOVA) was used to test the significance of the changes of the mean RP_{α} between the actual and acted prayers at *p-values* <0.05 at eight electrode positions.

Results

Brain signals from all the nine subjects were analyzed. The average prayer duration performed in this study was 7.29 ± 1.73 min. Figure 3 shows the mean RP_{α} for all four prayer positions during the complete actual *salat* cycle, and also during the resting condition. The results clearly depicted the increase of mean RP_{α} at parietal and occipital electrode positions during the prostration position, suggesting that the subject is experiencing the highest level of

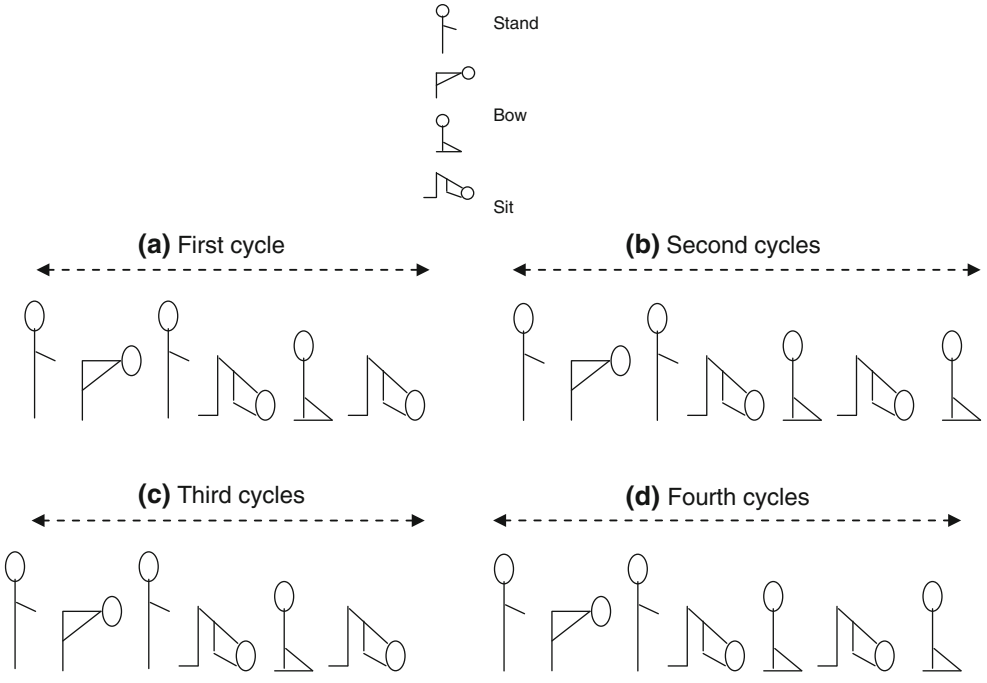

Fig. 2 The four cycles of *salat* positions employed in the study

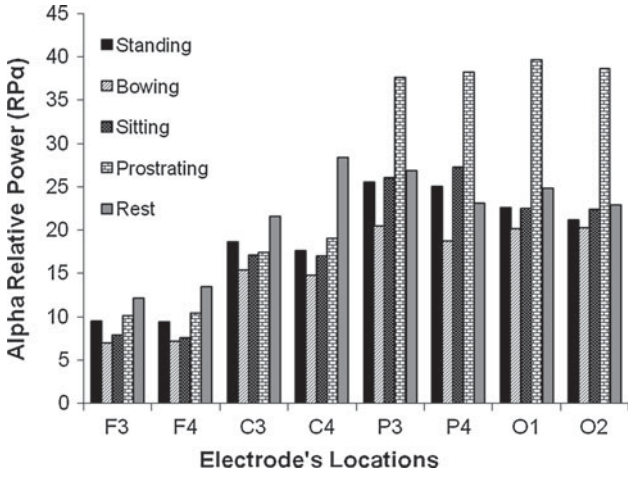

Fig. 3 Mean alpha relative (RPα) during resting and the actual *salat* for the standing, bowing, sitting and prostrating positions

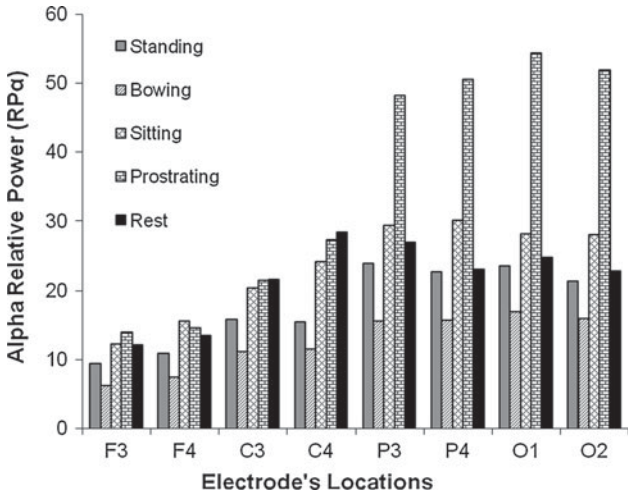

Fig. 4 Mean alpha relative (RPα) during resting and acted *salat*: for the standing, bowing, sitting and prostrating positions

relaxation while performing it. In addition, this increase of mean RP_α was also observed in the prayer sessions without recitation at the parietal, occipital and F3 frontal electrode positions (Fig. 4). Tables 1 and 2 demonstrate the comparison of means and standard deviations of RP_α for the actual and the acted *salat* positions (standing, bowing, sitting and prostration) with the resting condition, respectively. It was also observed that the prostration in the acted s*alat* experienced a higher value of the mean RP_α when compared to the corresponding position in the actual *salat*. Tables 3 and 4 show the Mean and standard deviation (M ± SD), the standard error and confidence interval of RPα between the all positions of the actual and the acted *salat* conditions. The ANOVA test results showed that the RP_α was not significantly different ($p < 0.05$) at

Table 1 Mean and standard deviation (SD) for the alpha relative power (RP_α) of the actual *salat* positions

RPα								
Positions	F3	F4	C3	C4	P3	P4	O1	O2
Standing	9.56 ± 2.52	9.39 ± 1.52	18.67 ± 5.63	17.64 ± 5.26	25.54 ± 10.08	24.99 ± 11.62	22.61 ± 9.39	21.15 ± 9.18
Bowing	6.93 ± 1.94	7.20 ± 2.69	15.41 ± 12.03	14.79 ± 11.00	20.44 ± 15.89	18.73 ± 13.34	20.18 ± 15.61	20.24 ± 17.25
Sitting	7.83 ± 2.75	7.56 ± 2.04	17.12 ± 5.53	17.04 ± 6.19	26.07 ± 11.74	27.22 ± 13.80	22.48 ± 10.63	22.42 ± 11.65
Prostrating	10.10 ± 4.36	10.38 ± 4.94	17.40 ± 9.90	19.05 ± 13.29	37.62 ± 22.76	38.16 ± 25.49	39.65 ± 24.33	38.58 ± 25.08
Rest	12.16 ± 7.53	13.52 ± 7.44	21.59 ± 9.66	28.39 ± 14.37	26.88 ± 15.96	23.13 ± 11.97	24.86 ± 15.07	22.87 ± 14.18

Table 2 Mean and standard deviation (SD) for the alpha relative power (RP_{α}) of the acted *salat* positions

RPα								
Positions	F3	F4	C3	C4	P3	P4	O1	O2
Standing	9.40 ± 3.19	10.88 ± 2.63	15.82 ± 6.40	15.49 ± 7.15	23.97 ± 11.50	22.71 ± 14.15	23.64 ± 10.14	21.35 ± 9.81
Bowing	6.24 ± 1.97	7.35 ± 2.26	11.11 ± 3.16	11.52 ± 2.93	15.57 ± 6.86	15.67 ± 5.67	16.89 ± 6.64	15.93 ± 7.50
Sitting	12.16 ± 7.73	15.49 ± 11.31	20.28 ± 13.30	24.19 ± 18.40	29.34 ± 20.86	30.05 ± 24.92	28.08 ± 20.34	27.96 ± 22.42
Prostrating	13.92 ± 7.71	14.51 ± 7.59	21.40 ± 13.88	27.22 ± 19.43	48.19 ± 24.61	50.57 ± 30.59	54.36 ± 25.03	51.82 ± 28.13
Rest	12.16 ± 7.53	13.52 ± 7.44	21.59 ± 9.66	28.39 ± 14.37	26.88 ± 15.96	23.13 ± 11.97	24.86 ± 15.07	22.87 ± 14.18

Table 3 Mean and standard deviation (M ± SD), standard error and confidence interval of alpha relative power (RPα) between standing and bowing positions of the actual and the acted *salat*

RPα												
Positions	Standing						Bowing					
					CI						CI	
Electrodes	Actual	Acted	SE	Sig.	Lower	Upper	Actual	Acted	SE	Sig.	Lower	Upper
F3	9.56 ± 2.52	9.4 ± 3.19	2.37	1	−7.41	7.73	6.93 ± 1.94	6.2 ± 1.97	2.37	1	−6.88	8.26
F4	9.39 ± 1.52	10.88 ± 2.63	2.68	1	−10.07	7.01	7.20 ± 2.69	7.3 ± 2.26	2.68	1	−8.73	8.43
C3	18.6 ± 5.63	15.82 ± 6.40	4.5	0.99	−11.54	17.24	15.41 ± 12.03	11. ± 3.16	4.5	0.99	−10.09	18.69
C4	17.6 ± 5.26	15.49 ± 7.15	5.77	1	−16.29	20.59	14.79 ± 11.00	11.5 ± 2.93	5.77	1	−19.14	17.74
P3	25.5 ± 10.08	23.97 ± 11.50	7.83	1	−23.49	26.62	20.44 ± 15.89	15. ± 6.86	7.83	1	−23.49	26.62
P4	24.9 ± 11.62	22.71 ± 14.15	8.73	1	−25.65	30.2	18.73 ± 13.34	15. ± 5.67	8.73	1	−24.86	30.98
O1	22.6 ± 9.39	23.64 ± 10.14	7.78	1	−25.91	23.85	20.18 ± 15.61	16. ± 6.64	7.78	1	−21.6	28.17
O2	21.1 ± 9.18	21.35 ± 9.81	8.31	1	−26.77	26.37	20.24 ± 17.25	15.9 ± 7.50	8.31	1	−22.26	30.88

SE standard error, *Sig*. significance difference of actual and acted *salat*, *CI* confidence interval

Table 4 Mean and standard deviation (M ± SD), standard error and confidence interval of alpha relative power (RPα) between sitting and prostration positions of the actual and the acted *salat*

RPα												
Positions	Sitting						Prostrating					
					CI						CI	
Electrodes	Actual	Acted	SE	Sig.	Lower	Upper	Actual	Acted	SE	Sig.	Lower	Upper
F3	7.83 ± 2.75	12.16 ± 7.73	2.37	0.66	−11.9	3.24	10.10 ± 4.36	13.92 ± 7.71	2.37	0.8	−11.39	3.75
F4	7.56 ± 2.04	15.49 ± 11.31	2.68	0.09	−16.5	0.65	10.38 ± 4.94	14.51 ± 7.59	2.68	0.83	−12.71	4.44
C3	17.12 ± 5.53	20.28 ± 13.30	4.5	0.99	−17.55	11.23	17.40 ± 9.90	21.40 ± 13.88	4.5	0.99	−18.4	10.38
C4	17.04 ± 6.19	24.19 ± 18.40	5.77	0.95	−25.58	11.3	19.05 ± 13.29	27.22 ± 19.43	5.77	0.89	−26.6	10.28
P3	26.07 ± 11.74	29.34 ± 20.86	7.83	1	−28.33	21.78	37.62 ± 22.76	48.19 ± 24.61	7.83	0.91	−35.63	14.48
P4	27.22 ± 13.80	30.05 ± 24.92	8.73	1	−30.75	25.09	38.16 ± 25.49	50.57 ± 30.59	8.73	0.89	−40.33	15.52
O1	22.48 ± 10.63	28.08 ± 20.34	7.78	0.99	−30.48	19.29	39.65 ± 24.33	54.36 ± 25.03	7.78	0.62	−39.59	10.18
O2	22.42 ± 11.65	27.96 ± 22.42	8.31	0.99	−32.11	21.04	38.58 ± 25.08	51.82 ± 28.13	8.31	0.8	−39.81	13.33

SE standard error, *Sig.* significance difference of actual and acted *salat*, *CI* confidence interval

all eight electrode positions during the prostration position for both the actual and the acted *sala*t (Fig. 5).

Discussion

The alpha brain wave indicates cortical inactivation and relaxation in the human brain, and spontaneous alpha rhythms are best observed with the eyes closed. That is one of the reasons why the alpha brain waves are commonly regarded as an 'idling rhythm'.

Many studies investigating the effects of meditation on the human brain showed that alpha wave increased during meditation and this occurred primarily in the frontal (Sim and Grewal 1989; Travis 2001; Murata et al. 2004), central, parietal (Travis 2001) and occipital (Sim and Grewal 1989) regions. It must be noted however, the meditation techniques involved in these studies only required static posturing i.e. sitting or lying supine, while the Muslim prayer involved active physical movements. Increased alpha amplitude in the Muslim prayer was possibly mitigated by the absence of alpha blocking due to muscle movement, and vision focus in the movement cycles.

The results of the current study suggest that the Muslim prayer generated alpha waves of significantly higher amplitude during prostration in comparison to the other positions. It is possible that the increase is due to the higher state of calm and focus as the head touched the ground (Fig. 2). Prior to the commencement of the recording sessions, the subjects were reminded not to close their eyes during both Sessions 2 and 3. Subjects reported after the experiment that they kept their eyes opened during all of the sessions.

Since the subjects kept their eyes opened during the prayer, the vision was focused on a single point on the floor during prostration. This transient increase in focus maybe the reason of the increased alpha wave activity, as previously reported by Oishi et al. (2007). In addition, the increase of alpha wave activity may be caused by the absence of alpha blocking when the face was near the ground, thus obfuscating the effects of efferent motor command generation to muscle (Peper 1971).

The significance of performing proper Muslims prayer movement (i.e. prostration) regardless with or without recitation will result in an increased of alpha activity, thus achieving relaxation state (Figs. 3, 4).

Conclusion

The results showed that a significantly higher alpha wave activity was recorded during the prostration position of the Muslim prayer. Although the sample size was comparably small, the findings were in accordance with previously

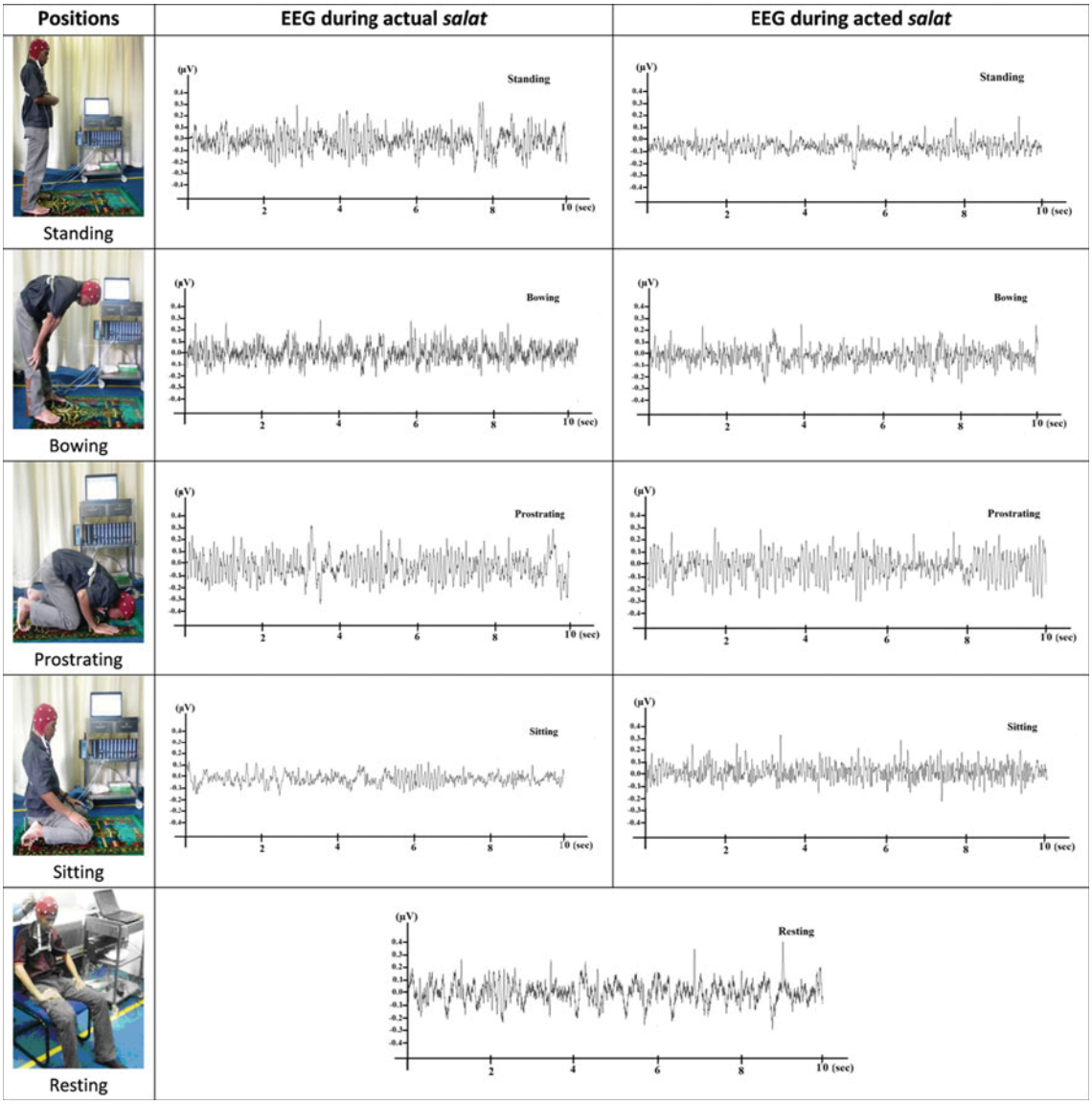

Fig. 5 EEG from channel (O1) during different actual and acted *salat* positions for one subject

published results on recorded EEG that confirmed the correlation between high alpha wave activity with a relaxed state of mind (Lee et al. 2007; Reibel et al. 2001; Kasamatsu and Hirai 1966; Arambula et al. 2001). It is proposed that further studies with larger sample size is needed to explore the role of focus, concentration, visual cue, and the length of recording time.

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