SALAT AND BRAINWAVE SIGNAL ANALYSIS

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Abstract.   *Salat* is one of the ways for the Muslims to worship 'Allah' (God). This study investigates the brainwave signal after *salat* using Electroencephalograph (EEG) signal analysis and autonomic nervous activity. Twenty samples of EEG signal from five respondents (males with age range from 22 to 23 years old) were selected, and they were all free from cardiac, pulmonary, metabolic and other disease that would cause autonomic nervous system dysfunction. The analysis of the acquired EEG signal is done by comparing the samples of EEG signal between the activities after *salat* and after listening to the music using Principal Component Analysis (PCA) and Fast Fourier Transform (FFT) method. The highest amplitude of the power spectrum distribution was observed in the gamma band on EEG compared to other bands (delta, theta, alpha and beta) for both activities. It shows that these five subjects have a high gamma band after *salat* compared to after listening to music. It is suggested that when Muslim perform *salat*, they tend to forget all the worldly matters and thinks they are standing in front of the 'Allah'. This eventually help them to break their stress for a few times, hence reducing its intensity to facing the worlds' matter after *salat*.

Keywords: Salat; electroencephalograph (EEG) ; brainwave signal

Abstrak.   Solat adalah salah satu cara umat Islam untuk mengabdikan diri kepada Allah. Kajian ini bertujuan untuk mengkaji kesan selepas solat terhadap otak dengan menggunakan *Electroencephalograph* (EEG) dan kegiatan saraf autonomik. Sebanyak 20 sampel isyarat EEG daripada 5 responden (lelaki berumur di antara 22 hingga 23 tahun) dipilih, dan mereka bebas daripada masalah jantung, paru-paru, metabolik dan penyakit lain yang boleh menggangu kegiatan saraf autonomik. Analisa dilakukan dengan membuat perbandingan di antara sampel EEG bagi dua aktiviti berbeza iaitu aktiviti selepas solat dan aktiviti selepas mendengar muzik menggunakan kaedah analisa prinsip komponen (PCA) dan transformasi fourier (FFT). Hasil analisa ke atas isyarat mendapati amplitud tertinggi pada agihan spektrum kuasa adalah pada jalur gamma bagi EEG berbanding jalur-jalur lain (*delta, theta, alpha* dan *beta*) bagi kedua-dua aktiviti. Kajian juga menunjukkan kelima-lima subjek mempunyai jalur gamma yang tinggi selepas solat berbanding selepas mendengar muzik. Keputusan ini mencadangkan, apabila seseorang muslim melakukan

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solat, mereka akan melupakan seketika masalah mereka dan khusyuk mengadap Allah. Ini dapat membantu memulihkan tekanan yang dialami mereka untuk beberapa ketika, seterusnya lebih bersedia untuk menghadapi segala permasalahan dunia selepas solat

Kata kunci: Solat; *electroencephalograph* (EEG); isyarat gelombang otak

1.0   INTRODUCTION

Salat is the Arabic word for prayers offered by Muslim worshippers, and is the second pillar of the Islamic faith. The *salat* is a fundamental principle of the religion and is an obligatory practice which must be performed at set times in set conditions following a set sequence. Obligatory *salat* is a routine activity that a Muslim performs repeatedly five times day and night. The *salat* ritual practice has manifold significance. From the point of view of physical and mental health, *salat* can be a way to ensure good health [1,3]. Systematic and sequential body movements in *salat* can enhance the body performance which can bring about flexibility and agility. For a Muslim it is easy to understand how the prayer helps him in the upcoming life. His next life depends a lot on the prayer his says in this life, and also it's the most important source of spiritual contemplation for him. However, there are many medical, psychological and spiritual benefits of prayer as well.

Study has shown that the physical activities involved in the performance of *salat* helps in the rehabilitation process in disabled geriatric patients by improving blood flow and increasing muscoskeletal fitness [1]. The physiotherapist of the rehabilitation center who assists the patient to restore and preserve joint range of motion through mobilization techniques and exercise may take this prayer system as a model for restoring the residual strength of the patient. Elderly people and disabled person can gain significant health benefits with a mild to moderate amount of physical activity, like the performance of *salat* preferably daily. Physical exercise such as the *tai chi* involves the movement of the whole body, but *salat* is more than this because *salat* involves the recitation of Quranic verses and supplications (*du'a*) as well. These Quranic verses and *du'as* must be verbalized when the worshipper assumes certain postures and performs movements between postures. The main postures during the *salat* are standing (*qiyam*), bowing (*rukuk*), prostrating (*sujud*), and sitting during the salutation (*tahiyat*) [3,4].

According to [3], the position of prostration (*sujud*) is found can reduce the heart rate. A low pulse rate is good for heart well-being where at the meanwhile; the heart is in the resting condition. Some *salat* movements have been proven as the therapy for those patients suffers from low back pain and erection dysfunction. Other than physical effects, *salat* also has been scientifically proof that it enables to

provide calming effects for mental and thought. Therefore, *Salat is* one of the continuous, unique physical activity plays as a main role in maintain the physiological system flow, which including physically, mentally, spiritually, and emotional health. Chemical changes occur when the brain is active. The chemical processes that take place cause the movement of ions or atoms which carry electrical charges. When this happens electrical activities will occur. Nowadays, due to advancements in global knowledge and technology, these electrical charges emanating from the brain are capable of being measured by electrodes placed on the scalp. This realized on Electroencephalography (EEG) [2,14,15], which is the measurement of the brain signals resulting from these electrical activities. The EEG signal changes considerably depending on various internal states of the respondent. Most of the mental state studies rely on real-time statistical signal processing of EEG. In 24 hours, Muslims will pray a minimum of 17 obligatory prayers in which they make about 119 poses. Moreover, the poses are such that people of all ages can perform, and it is an exercise that causes no exertion or tiredness instead it earns us an internal bliss. However, for a certain Muslim, it is a burden for them to perform *salat* with thousand of reasons. So, it is practical to analyze the EEG signal and obtaining an active mind condition after performing *salat*. Thus, this study aims to investigate the benefit of after performing *salat* compared to another activity in order to prove the benefit of *salat* and its relationship with brainwave signal.

2.0 THEORY

The theory of Electroencephalography (EEG), Principal Component Analysis and Fast Fourier Transform (FFT) are discussed briefly in these following sub-topics.
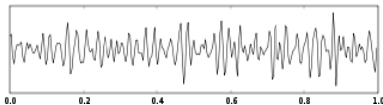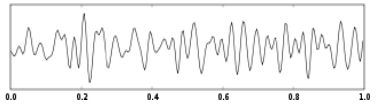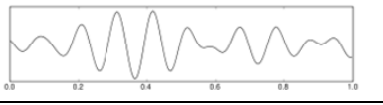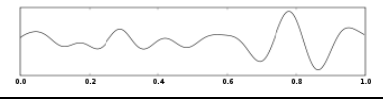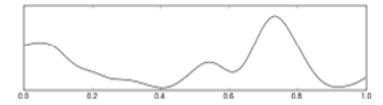
2.1 Electroencephalography (EEG)

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain [2]. An EEG is recorded from a number of electrodes placed on the scalp and typically the ears are used as ground. At each electrode, a superposition of the large number of brain cell (neuron) potentials is obtained. The results are weighed sums, where the weights depend on the signal path from the neurons to the electrodes. Because the same potential is recorded from more than one electrode, the signals from the electrodes are highly correlated. The potentials at the electrodes are in the milivolt (mV) range and therefore very sensitive to noise, so a special designed amplifier/sampler has to be used.

The first EEG recorded were alpha rhythms with frequencies about 10 Hz. This was done by Berger in 1929, who also found and named beta activity [14]. Beta is today used

to describe the frequency range from about 12 Hz to 30 Hz. Experiments show that the amount of alpha activity varies when eyes are closed and opened. Gamma frequency oscillations (30-80 Hz), which were found by Adrian in 1942, are today believed to correlate with binding and attention [18,19]. Binding is the process of combining sensory input to form the perception of one or more objects. Besides alpha, beta and gamma, the ranges over 0.25-4 Hz and 4-7 Hz are respectively named delta and theta. The frequency ranges are not strictly defined and different research use slightly different frequency intervals [18]. Table 1 describes the characteristic of brainwaves for every frequency [14].

Table 1   Characteristic of brainwaves for every frequency

Type of Brain Wave	Frequency	Characteristic	Wave Pattern
Gamma	30-80 Hz	Processing activity	
Beta	13-30 Hz	Awake	
Alpha	8-13 Hz	Relaxed state	
Theta	4-8 Hz	Sleepy, Half-awake	
Delta	0.5-4 Hz	Deep sleep	

2.2   Principal Component Analysis (PCA)

Principal component analysis (PCA) is a method to transform a multi-variable data set by a rotation. A rotation is found so that the first axis corresponding to the first component is rotated to the direction where the variance of the data set is greatest. The next component will then be the direction perpendicular to the first with the most variance and so on. In this study, the purpose of PCA is to reduce the

number of channels to analyze. The concept of eigenvalues and eigenvectors has to be introduced before describing how to find the transformation, which gives the principal components. PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. A good tutorial of PCA can be found in [5].

## 2.3   Fast Fourier Transform (FFT)

The Fast Fourier Transform (FFT) is an extremely important and widely-used method of extracting useful information from sampled signals [7]. The Fourier Transform is a mathematical procedure which can be thought of as transforming a function from the time domain to the frequency domain. In digital signal processing, the spectrum of a signal refers to the way energy in the signal is distributed over its various frequency components. The Fourier transform operates on continuous functions. This continuous functions are defined at all values of the time t. Digital signal processing involves discrete signals (signals which are sampled at regular intervals of time) rather than continuous signals. A modified form of the Fourier Transform, known as the Discrete Fourier Transform or DFT, is used in the case of sampled (discrete) signals.

When the DFT is applied to a discrete signal, the result is a set of sine and cosine coefficients. When sine and cosine waves of appropriate frequencies are multiplied by these coefficients and then added together, the original signal waveform is exactly reconstructed. The sine and cosine waves are the frequency components of the original signal, in the sense that the signal can be built up from these components. The coefficients determined by the DFT represent the amplitudes of each of these components. This is applied in brainwaves signal in order to represent the amplitudes of each bands of different frequencies. Details of FFT theory could be found in [7,8,9,10].

3.0   METHODOLOGY AND IMPLEMENTATION

The setup of the experiments is as shown in Figure 1. Electrode adapter is used to connect the cap to EEG instrument (Neurofax EEG-9100). The wire or connector pin colour combination determines the electrode placement of each wire. The location of electrodes in the cap is according to the International 10/20 placement system. The next step is to ensure that respondent's hair should be dry

and all bobby pins barrettes and earrings must be removed. First of all, the respondent is required to set up in a straight back chair. Next, fix the cap in place and filled the holes on the cap with ECI Electro-Gel by using a syringe. Impedance checking is done to ensure the electrodes are well-connected to the scalp.
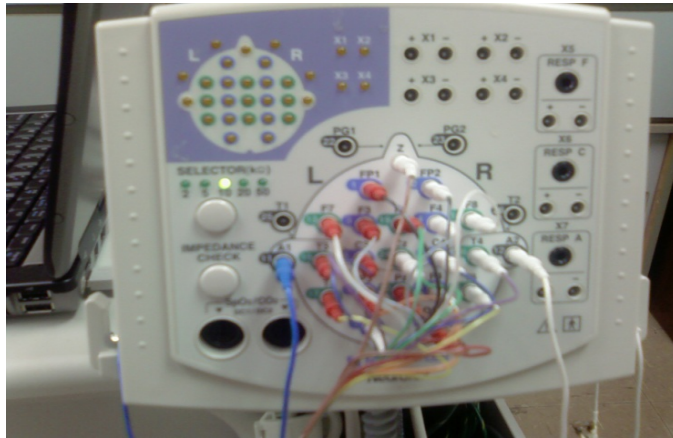
Figure 1 Electrode board adapter of Neurofax EEG-9100.

Once the impedance check is passed, the recording process is started. The generated signal is recorded for ten seconds before listening to *natura* music. *Natura* music or *natura* sound therapy [16] is the ideal tool to improve quality of life. Featuring 34 nature and music sounds and an abundance of special visuals, *natura* can help concentrate for work or study, unwind and relax, or even fall asleep more quickly. *Natura* offers instant access to customized mood enhancement with combinations of sounds, colors, visuals, and brainwave frequencies. Figure 2 shows a respondent before listening to *natura* music with EEG-9100 connected to the scalp electrode.

After thirty seconds recording, the respondent is asked to plug in the earphone and *natura* music will be played for five minutes. The generated signal is recorded again for ten seconds after listening to *natura* music. Then, the respondent will take a rest for fifteen minutes. After taking a rest for fifteen minutes, the generated signal of the respondent is once again recorded for ten seconds before *salat*. Finally, the respondent performed *salat* for five minutes, and the generated signal is recorded again for ten seconds after *salat*. After all signals were recorded, the data is then exported and save in ASCII form. The useless ASCII data were pruned and the EEG spectral distribution was calculated using the Principal Component Analysis (PCA) [5]. The highest amplitude was

identified and the frequency at that amplitude was referred. The frequency was then classified according to the EEG bands.


Figure 2 A respondent connected to the scalp electrode with EEG-9100 before listening to the *natura* music

4.0 RESULTS AND DISCUSSIONS

The analysis is divided into two parts. The first part is the analysis by principal component analysis (PCA) for every bands and the second part is the analysis by Fast Fourier Transform (FFT) for the gamma band for both activity. Firstly, the principal component analysis (PCA) is used to analyze a periodic EEG signal of after *salat* activity. These steps were executed by using Matlab software. The output was the percentage of each EEG band. Percentage was used because of the frequency range of each EEG band is different as described in Table 1. The percentage of every band was taken for every channel, and this percentage is then been averaged. The process is done for twenty samples of EEG signal from five respondents (males with age range from 22 to 23 years old) and Table 2 presents one of the examples of the result from a subject. From Table 2, it shows that gamma band has the highest percentage (39.931%) compared to other bands. This is proven that gamma band is suitable to analyze the individual respondent's brain activity after *salat* and after listening to the natura music. The results of percentage of every frequency band for all five respondents after *salat* are shown in Figure 3. It shows that all five respondents have quite similar characteristics in terms of the frequency band, which the gamma band is the highest percentage compared to others. Based on these observations, the next analysis will focus on the gamma band for every channel for each data.

**Table 2**   Percentage of every band for all channels (after *salat*).

| Percentage (%)	Delta (1-4Hz)	Theta (5-8Hz)	Alpha (9-13Hz)	Beta (14-30Hz)	Gamma (31-50Hz)
Channel 1	7.854	7.891	10.002	34.354	39.898
Channel 2	8.015	8.115	9.916	33.946	40.008
Channel 3	7.985	8.112	10.180	33.814	39.909
Channel 4	8.017	8.107	10.052	33.773	40.051
Channel 5	7.818	7.954	9.914	34.184	40.130
Channel 6	8.092	7.943	10.029	34.330	39.607
Channel 7	8.026	8.004	9.976	34.050	39.944
Channel 8	8.097	7.974	9.903	33.943	40.084
Channel 9	8.071	8.085	9.975	33.726	40.144
Channel 10	7.808	7.963	9.874	34.034	40.321
Channel 11	8.144	7.822	9.935	34.572	39.528
Channel 12	8.003	8.072	10.209	34.497	39.219
Channel 13	8.024	7.868	9.660	34.386	40.063
Channel 14	7.987	7.969	10.168	34.125	39.751
Channel 15	7.858	7.965	9.936	33.950	40.291
Channel 16	7.849	7.868	10.099	34.208	39.975
Channel 17	8.154	7.857	9.795	34.290	39.903
Channel 18	7.793	7.975	9.869	34.144	40.220
Channel 19	8.028	7.994	9.903	34.434	39.641
Average	**7.980**	**7.976**	**9.968**	**34.145**	**39.931**
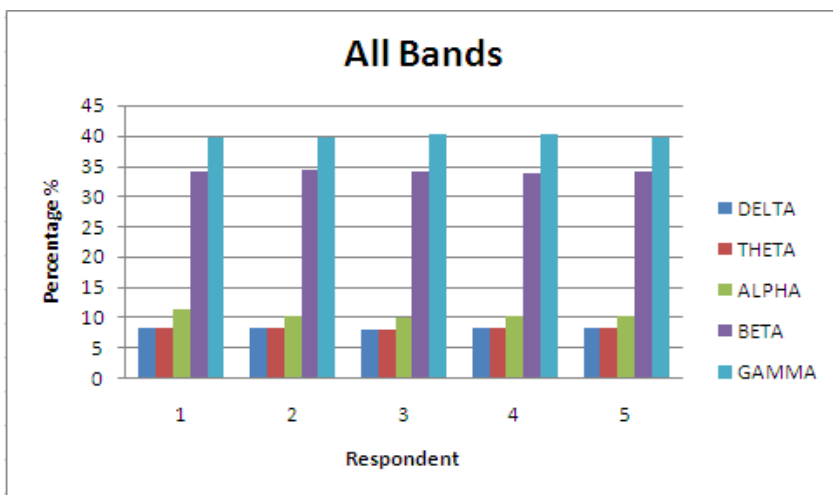
Figure 3   Result after *salat* of all respondents for all frequency bands

Secondly, the analysis is done to the gamma band for different activities. The data were analyzed using Fast Fourier Transform (FFT) method. Once again, the FFT algorithm was applied using Matlab software and also been averaged for each channel. The first analysis is the comparison between before and after *salat*. The second analysis is a comparison between after s*alat* and after listening to the *natura* music
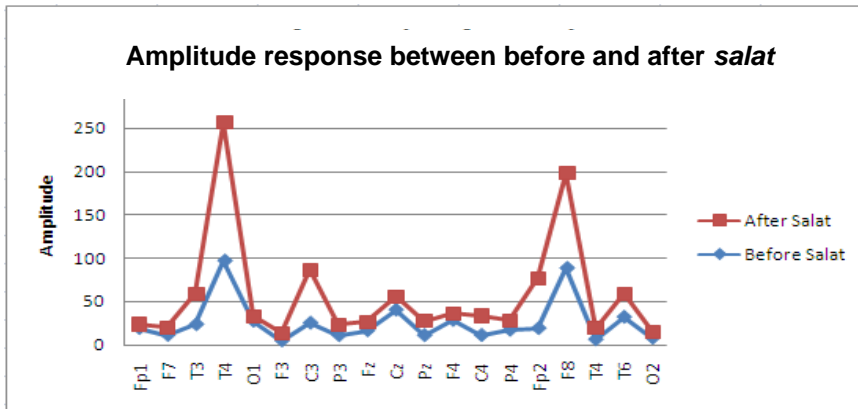
(a)   Comparison of gamma band amplitude before and after *salat*
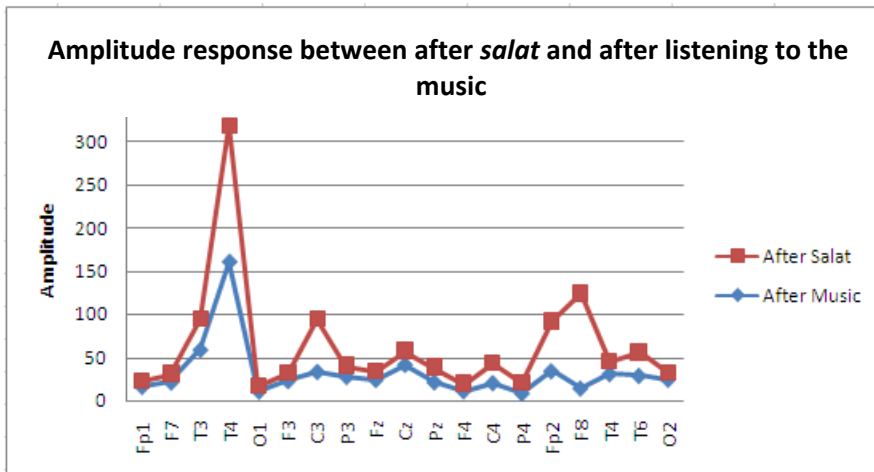
(b) Comparison of gamma band amplitude after *salat* and after listening to the music

Figure 4   Amplitude analysis of gamma band using FFT

Figure 4 (a-b) shows the amplitude of the gamma band for one of the respondents for both analysis of comparison between before and after *salat* as well as a comparison between after *salat* and after listening to the music respectively. Base on the result, amplitude of the gamma band after *salat* is higher than amplitude of the gamma band after listening to natura music for all respondents.

One of the reasons was, the movements in *salat* have given the positive impact to the respondent who has been proven by previous research [3,4,6,12,13]. Although research done on *natura* music [16] said that by listening to it will give positive impact on respondent too but this study has proven that amplitude gamma band after *salat* is higher than after listening to *natura* music.

The comparisons of gamma band amplitude before and after salat as well as after *salat* and after listening to the music for all five respondents are shown in Figure 5 and Figure 6 respectively. It can be seen that all respondents have higher gamma band amplitude after *salat* compared to before *salat* or after listening to the music.
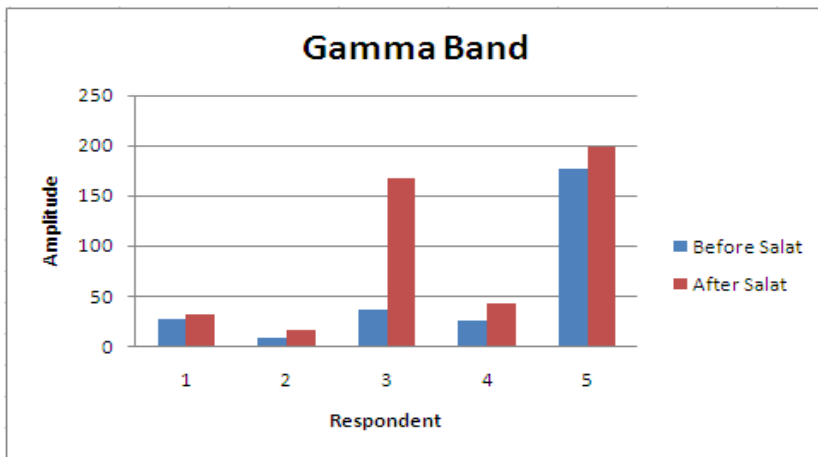
Figure 5   Comparison before and after *salat* of all respondents.
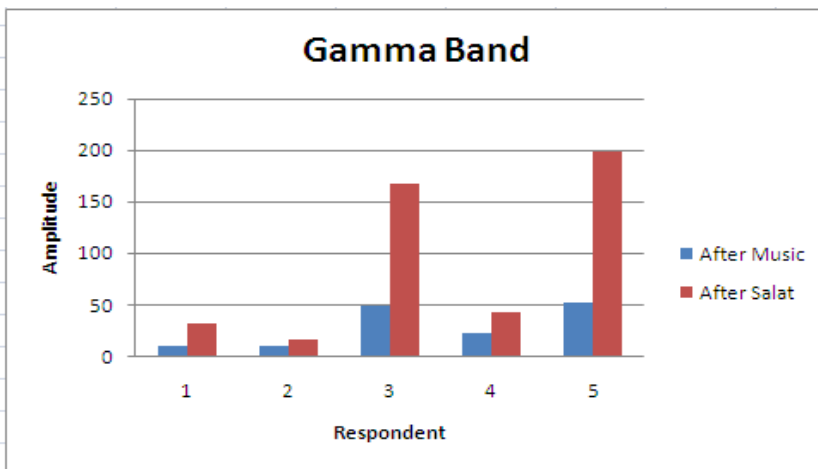
Figure 6   Comparison after *salat* and after listening to the music of all respondents.

5.0   CONCLUSION

As a conclusion, the analyses proved that gamma band is increase after performing the *salat*. On the other hand, the amplitude of the gamma band after *salat* is higher than after listening to the music. This result could be an alternative conclusion of the benefit of performing *salat* from science perspective. Although most research concentrate on the benefit of body movement during performing *salat*, it is also good to analyse the benefits of after performing the *salat* compared to other life activities such as listening to music, sport activities, reading the books and after working hours. In future, increasing the number of respondents is suggested in order to get more accurate result from the analysis. The analysis could also be expanded for various activities.

REFERENCES

[1]   Reza, M. F., Y. Urakami , Y. Mano. 2002. Evaluation of a New Physical Exercise Taken from Salat (Prayer) as a Short-Duration and Frequent Physical Activity in the Rehabilitation of Geriatric and Disabled Patients. Annals of Saudi Medicine. 22(3-4): 177-180.
[2]   Michael V. 2002. AEP Analysis In EEG From Schizophrenic Patients Using PCA. Personal Module. June 7.
[3]   Fatimah Ibrahim, Wan Abu Bakar Wan Abas, Ng Siew Cheok. 2008. Salat, Benefit from Science Perspective. Department of Biomedical Engineering, Universiti Malaya.
[4]   Khalid Abu Syadi. 2008. *Meraih Puncak Kenikmatan Shalat.* Perpustakaan National (KTD).
[5]   Lindsay I. S. 2002. A Tutorial of Principal Component Analysis (PCA). Personal Module. February, 26.
[6]   Fahrur Muis, 2009. *Berubat dengan Solat.* PTS Islamic Sdn Bhd.
[7]   Cooley, J. W., J. W. Tukey. 1965. An Algorithm for the Machine   Calculation   of Complex Fourier Series. *Math. Computation.* 19: 297-301.
[8]   Potts, D., G. Steidl, and M. Tasche. 2001. Fast Fourier Transforms for Nonequispaced Data: A Tutorial. In: J.J. Benedetto and P. Ferreira ed. Modern Sampling Theory: Mathematics and Applications. Birkhauser.
[9]   Cormen, T. H., C. E. Leiserson, R. L. Rivest, and C. Stein. 2001. Introduction to   Algorithms. 2nd. Ed. MIT Press and McGraw-Hill.
[10]   Schatzman. J. C., 1996. Accuracy of the discrete Fourier Transform and the Fast Fourier Transform. SIAM Jurnal on Scientific Computing. 17(5): 1150-1166.
[11]   Griths. D. F., 1996. An Introduction to Matlab. Department of Mathematics, University Dundee, Scotland.
[12]   Dr Yusof Abbas. 2008. *Bio-Mekanik SOLAT.* Nur Tijarah Enterprise.
[13]   Abdullah Al-Qari bin Hj Salleh. 2008. *160 Faedah Utama Dan Terapi Solat & Padah Meninggalkannya.* Al-Hidayah Publication.

[14]   Farah Hanan Bin Azimi. 2009. EEG Signal Classification Of Prayer Concentration Using   Time Frequency Analysis." Bachelor Thesis. Universiti Teknologi Malaysia.Malaysia.

[15]   Nurul Sahadah Bt Ismail. 2009. EEG Analysis During Resting and Mental Task.   Bachelor   Thesis, Universiti Teknologi Malaysia. Malaysia.

[16]   Mohd Nazri Bin Bajuri. 2009. Feature Extraction of EEG Signal in Music Listening Using PCA. Bachelor Thesis. Universiti Teknologi Malaysia. Malaysia.

[17]   Congedo, M., Joel F. Lubar, David Joffe. 2004. Low-Resolution Electromagnetic Tomography Neurofeedback. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*. 12(4): 387-397.

[18]   Chawla**,** G., A. Gupta, S. Sengar. 2004. A Wavelet Base Detection and Analysis of Gamma Rhythms in EEG Signal. *IEEE Proceedings on Signal   Processing and Communication*. 22-26.

[19]   Ghafar, R., N. Md. Tahir, A. Hussain. 2007. EEG Analysis of Wake-sleep Data using UMACE Filter. Proceedings of IEEE 5th Student Conference on Research and Development (SCOReD). 1-5.