Original article

Activation of mental imagery neural network revealed during listening to Fatihah Chapter; a neuroimaging study

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Abstract:

Background: Listening to Quranic recitation has been claimed to enhance educational performance and cognitive functionality. Unfortunately, scientific evidence for this remains scarce. ***Aim:*** Hence, we aimed to investigate the neural mechanism underlined the psychoacoustic and cognitive enhancement effects from listening to Quranic recitation. Occipital lobe beta rhythms (14-30 Hz) were excerpted from electroencephalography (EEG) data during psychoacoustic stimulation from sham (Rest), Arabic news and the Fatihah Chapter recitation. The stimulation comes in random sequence in the same length of duration of 5,8,6,6,10, 8 and 20 seconds for verses 1 to 7, respectively. The brain's oscillatory waveforms were pre-processed using EGI System and then were analysed by Fast Fourier Transform (FFT) to derive the power spectrum in the Beta frequency band (14-30 Hz). Data were analysed by repeated-measures ANOVA and Discriminant Analysis from XLSTAT statistical package. ***Result***: A profound and significant reduction of the power spectrum was found in the left occipital lobe while listening to theFatihah Chapter. In contrast, no significant changes were observed in the occipital lobe during listening to Arabic news. It may be postulated that listening to the Fatihah Chapter activates an oscillatory neural network associated with visual mental imagery.

Keyword: Neuroimaging; Brain waves; Beta rhythm; Quranic sound; Acoustic stimulation

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Introduction:

The Quranic Fatihah Chapter sound has a great style from a literary perspective[1] his first chapter from The Holy Quran introduces the Muslims about God and the fundamental conception about Islam[2]. Although the Arabic language has many words for a single meaning, it selects the precise words to portray the intended meaning and build intense images in listeners' minds. There have been a few studies performed concerning cognitive enhancement by Quranic recitation listening.[3] found significant cyclic trends of slow-wave power spectrum predominantly in the global, frontal and temporal sites, which indicates the modifying capability of Quran on brain behaviour in health and disease. This has been suggested to be due to the Quran acting as an exogenous stimulus to

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human[4] to increase their rationality, which is essential in coping strategies and emotion regulation and gives rise to psychological well-being, functional status and enhance self-empowerment[5] .

Beta rhythms varying within the range of 14 to 30 Hz and are dominant rhythms in consciousness. They are associated with active thinking, intention and solving concrete problems and are usually found in normal adults[6,7]. Beta rhythms have been associated with building up evidence for decision making[8–10] by the parietal cortex, motor planning[11] and language processing[12]. A review paper on beta-band signalling has suggested that beta-band activities seem to be related to maintaining the current sensorimotor or cognitive state. They are expressed more strongly when the maintenance of the status quo is intended if it is changed[13]. Furthermore, beta activities have been reported to be suppressed during neuronal activity occurring during mental activation, which represents an accelerated process resultant of patterned neuronal activation consequent upon the presentation of stimuli in either visual or mental form[14] .

Mental imagery has been understood as a higher cognitive function associated with complex mechanisms, such as perception and motor control[15]. Mental imagery has also been described as a quasi-perceptual experience referring to visualising or seeing in the mind's eye, hearing in the head or imagining the feel. It resembles perceptual experience without stimulation. Imagery also plays a vital role in memory[16] and motivation[17]. This involves visuospatial reasoning and inventive or creative thoughts. It also refers to the ability to access or reactivate perceptual information from memory and the ability to manipulate this information dynamically for purposes of reasoning, planning, inference and flights of fancy. Indeed, it is believed to play a crucial role in all thought processes and provides the semantic grounding for language[18] .

Method:

Participants and Stimulation

Twenty-eight normal volunteers (male = 14 & female = 14) who were habitual daily listeners to the Fatihah Chapter were selected. A written informed consent form was received from each participant before the study. This study was approved by the Human Ethical Committee of HUSM (Human Ethical Committee of University Sains Malaysia (USMKK/PP/JEPeM[234.3.(09)]. The recitation of the Fatihah Chapter by Egyptian Qari Sheikh Abdul Basit bin Abdul Samad, Sham and Arabic News stimulus came in a random sequence. They were in the same lengths of 5, 8, 6, 6, 10, 8 and 20 seconds at 65 dB for verses 1 to verse 7 each. This acoustic stimulus was given to

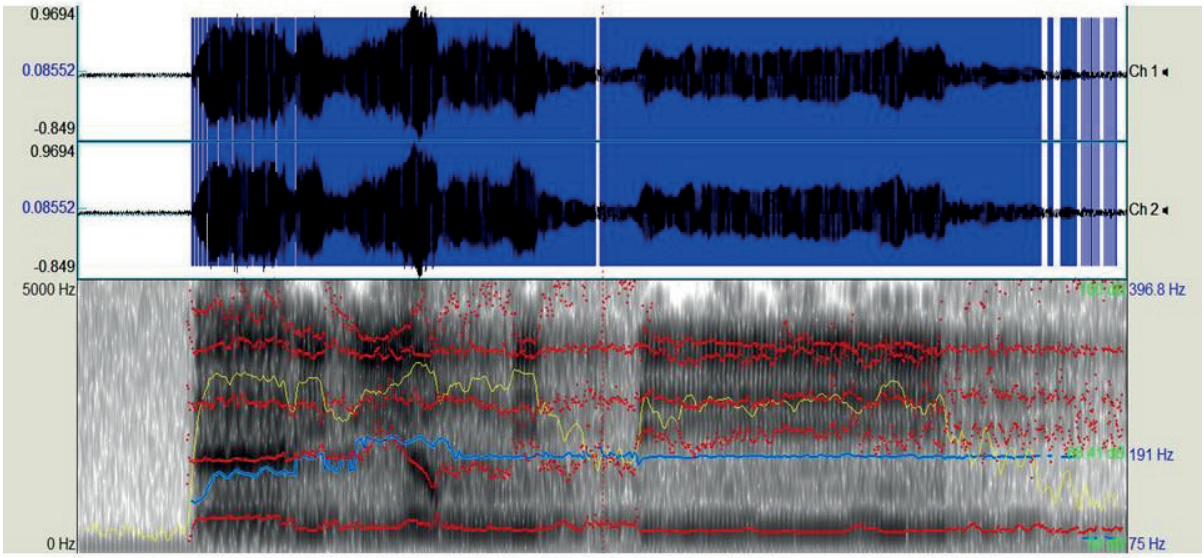

Figure 1 (a) (Above) Sound waveforms and (below spectrogram of Verse 4 of Fatihah Chapter. The blue line shows the pitch contour, the yellow line shows the intensity contour, and the red line shows the formants. The formants, pitch and intensity contours showed that the Fatihah Chapter sound waveforms are more rhythmic than Arabic news.

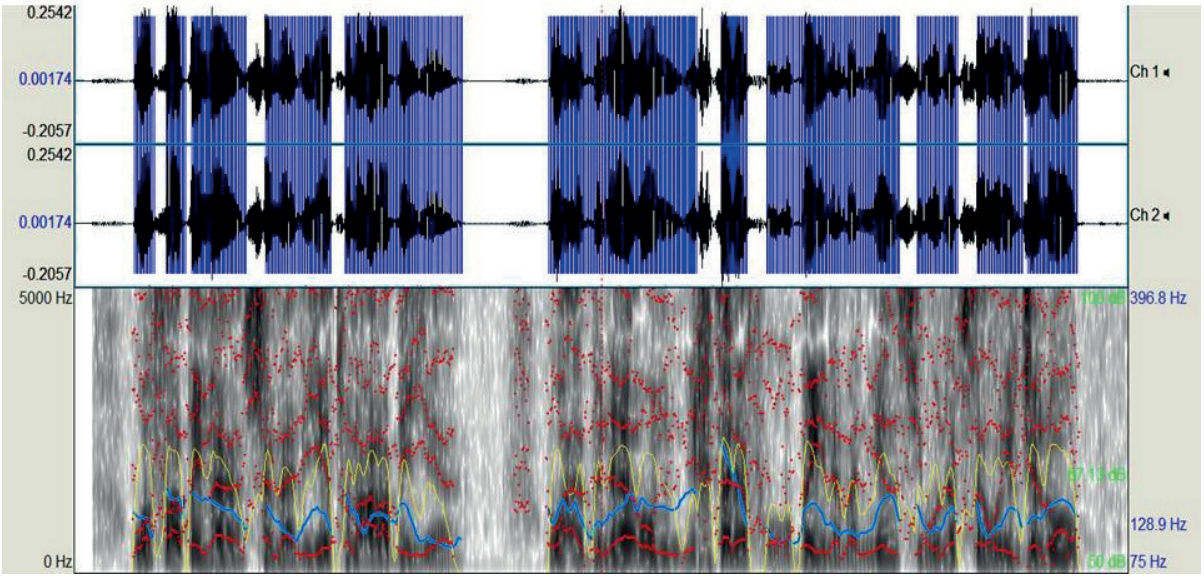

Figure 1(b) (Above) Sound waveforms and (below) spectrogram of Verse 4 of Arabic news. The blue line shows the pitch contour, the yellow line shows the intensity contour, and the red line shows the formants. Arabic news formants, pitch and intensity contours are less rhythmic than those ofthe Fatihah Chapter.

the respondents in a sound-treatedroom with dim light.

Electroencephalography recording

EEG recording was performed at Event-Related Potential / Magnetoencephalography (ERP/MEG) laboratory in Hospital Universiti Sains Malaysia (HUSM) in a sound-treated quiet room with dimmed light by using a 128-electrode sensor net (Electrical Geodesics, Inc.) with an impedance of ≤ 50kΩ. The net was placed over the frontal, parietal, occipital and temporal lobes in accordance with the International 10-20 system. The brain's electrical current was measured at a sampling rate of 250 Hz with aCz electrode reference.

Brain electrical data analysis

Upon EEG recording, pre-analysis processes (filtering in the bandpass range from 0.3 Hz to 50 Hz, artefact detection, bad channel replacement and montage operation) were applied. EEG waveforms were analysedvia Fast Fourier Transform (FFT) to yield spectrum in power (amplitude squared, μV^2) in the beta frequency band using BESA Research 6.1 Software, Germany. The data were then transferred to XLSTAT for statistical analyses.

Data analysis

Repeated measures ANOVA was used in this study. In addition, DA was also utilised to determine which electrode discriminated between the electrodes in expressing the electroencephalography data. DA is a multivariate technique used to determine the variables responsible for separating the observations into different groups[19] . It is used when the membership of objects to particular groups or clusters is known. DA produces discriminant factors calculated by the software using the following equation:

$$f(G_i) = k_i \sum_{j=1}^{n} w_{ij} P_{ij}$$

Where$_i$ is the number of groups, k_i is the constant inherent to each group, n is the number of parameters used to classify a set of data into a given group, and w_j is the weight coefficient assigned by DF analysis to a given parameter (p_j).Currently, DA widely being used in medicine, chemistry and machine learning field.

Result

A total of 40 healthy normal respondents who were habitual daily Quran listeners were recruited. Twenty-eight normal volunteers remained as participants for data analysis. They were free from any neurological or psychiatric disorders or vision or hearing problems. Those who were pregnant who had standard contraindications to EEG examination (such as cardiac pacemakers and implanted pumps)

or had a history of drug use were also excluded.

Demographic background of participants

Table 1 shows the demographic characteristics of the participants. 14 (50%) were male, and 14(50%) were female. 9(32%) were between 16-25 years old, 11(39%) were 26-35 years old, 4(14%) were 36-45 years old, and 4(14%) were 46-55 years old. A majority of 26(93%) were right-handed. They were all Malay staff members of Universiti Sains Malaysia, Muslim, who reported daily Quran listening.

Table 1 Demographic status of participants (n=28)

Variables	Total (n = 28) n%
Sex	
Male	14 (50%)
Female	14 (50%)
Age	
16-25	9 (32.14%)
26-35	11 (39.29%)
36-45	4 (14.28%)
46-55	4 (14.29%)
Handedness	
Righthandedness	26 (92.86%)
Left-handedness	2 (7.14%)
Other demography	
Staffs	28 (100%)
Students	0 (0%)
Races	
Malay	28 (100%)
Chinese	0 (0%)
Others	0 (0%)

*Number (%)

Data analysis

Table 2 The result of the repeated measures ANOVA of the EEG recording during acoustic stimulations of the Fatihah Chapter and Arabic news

Treatment	Variable	Lambda	F	DF1	DF2	*p-value*
Fatihah Chapter vs Rest	01	0.986	5.561	1	390	0.019*
	02	0.996	1.675	1	390	0.196
Arabic news vs Rest	01	1.000	0.110	1	390	0.741
	02	0.999	0.552	1	390	0.458

Independent variables: time course (Time), acoustic stimulations (Stim), and EEG channels (Channel); dependent variable: FFT power spectral in the Beta frequency band. The ANOVA revealed left Occipital electrodes (O1) from Fatihah Chapter acoustic stimulation was significantly different, while there were no significant changes during listening to the Arabic news. The asterisk indicates significant p-values (P<0.05).

The repeated measures ANOVA (28 respondents x 7 verses x 3 treatments x 2 electrode channels) were calculated for Beta frequency. It revealed that only one channel, O1, was significantly different. The results of the statistical analysis are summarised in Table 2.The left occipital lobe, O1, shows a significant difference (p=0.019) when listening to Fatihah Chaptercompared to rest, while for the Arabic news stimulation, no significant difference was found, P-value = 0.741.

The variation of power spectral values in occipital lobes EEG electrodes were evaluated by DA using the data set from FFT. The indices of spectral power were treated as dependent variables, and the occipital lobe electrodes channels were treated as independent variables. The discriminant function and the classification matrices (CM) were obtained from the DAstepwise, as depicted in Figure 2.

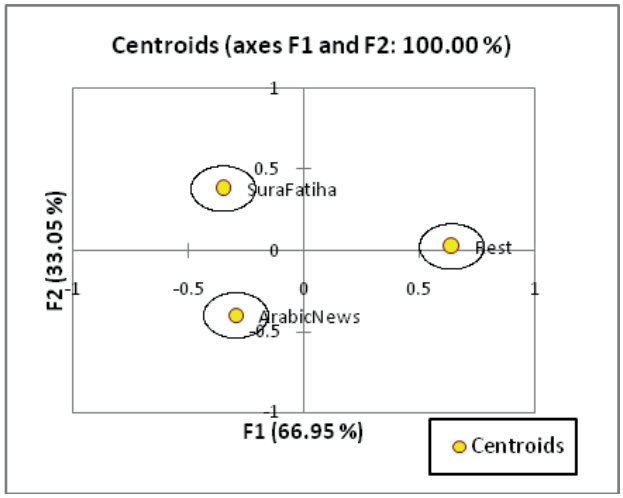

Figure 2 DA stepwise model of the occipital lobe spectral power during listening to the Fatihah Chapter (SuraFatihah) compared to Rest and Arabic news compared to Rest. Fatihah Chapterwas discriminated well with Rest and, Arabic newswas discriminated well. Unidimensional test of equality of the means of the classes shows that O1 from the Fatihah Chapter was significantly different while there was no significantother in Arabic news. This result from DA supported the result gained through ANOVA analysis.

Table 3 Confusion Matrix of Discriminant Analysis validating the percentage connection of the spectral power indices.

from \ to	*Arabic news*	*Rest*	*Fatihah Chapter*	*Total*	*% correct*
Rest	57	98	41	196	50.00%
Arabic news	86	50	60	196	43.88%
Fatihah Chapter	41	43	112	196	57.14%
Total	**184**	**191**	**213**	**588**	**50.34%**

The standard DA mode was used to construct DFs that contain occipital lobes variables during psychoacoustic treatment by the Fatihah Chapter, Arabic news and rest. Indices of rest were 50% discriminated correctly, while values for Arabic newswere 43.88% discriminated correctly and those of Fatihah Chapter were 57.14%. This leads to a total confusion matrix value of 50.34%.

ROC curve (Figure 3) shows that the area under the curve (AUC) of the FFT value from the Fatihah Chapter was 0.778, making it more sensitive and specific thanthe AUC of the Arabic news was 0.737[20].

Wilk's Lambda test revealed lambda values of 0.810 and 0.770 ($p<0.0001$), respectively. Further, the DA stated that the null hypothesis, H_0, were equal for the means vectors of the Fatihah Chapter compared to rest and Arabic news compared to rest. In the alternative hypothesis, H_a stated that at least one of the mean vector is different from the others as the computed p-value was lower than the significance level alpha ($p<0.05$). This study accepted the alternative hypothesis, H_a. The risk of falsely rejecting the null hypothesis H_0 is lower than 0.01%. Thus, DA analysis suggested that Fatihah Chapter, Arabic news and rest were discriminated well and that the Occipital lobe EEG electrodes for the left-brain hemisphere (O1) was significantly different during listening to the Fatihah Chapter as compared to rest.

Table 4 Lambda values for the Fatihah Chapter and Arabic news

	Fatihah Chapter	Arabic news
Lambda	0.810	0.770
F (observed value)	4.579	5.832
F (critical value)	1.615	1.612
DF1	19	19
DF2	372	372
p-value	< 0.0001	< 0.0001
alpha	0.05	0.05

Discussion

This study was carried out to investigate the neural correlation in the Beta frequency (14-30Hz) when listening to Quranic recitation from the Fatihah Chapter. Through the power spectrum of EEG analysis that emphasizes the occipital lobe, we found that the left occipital (O1) area was significantly reduced when listening to the Fatihah Chapter (p-value= 0.019). However, neither the right nor left occipital lobe was affected by Arabic news stimulation. The significant variation of the power spectrum during Fatihah Chapter sound stimulation shows activation in the neural oscillations responsible for visual functioning. However, the experiment was performed with closed

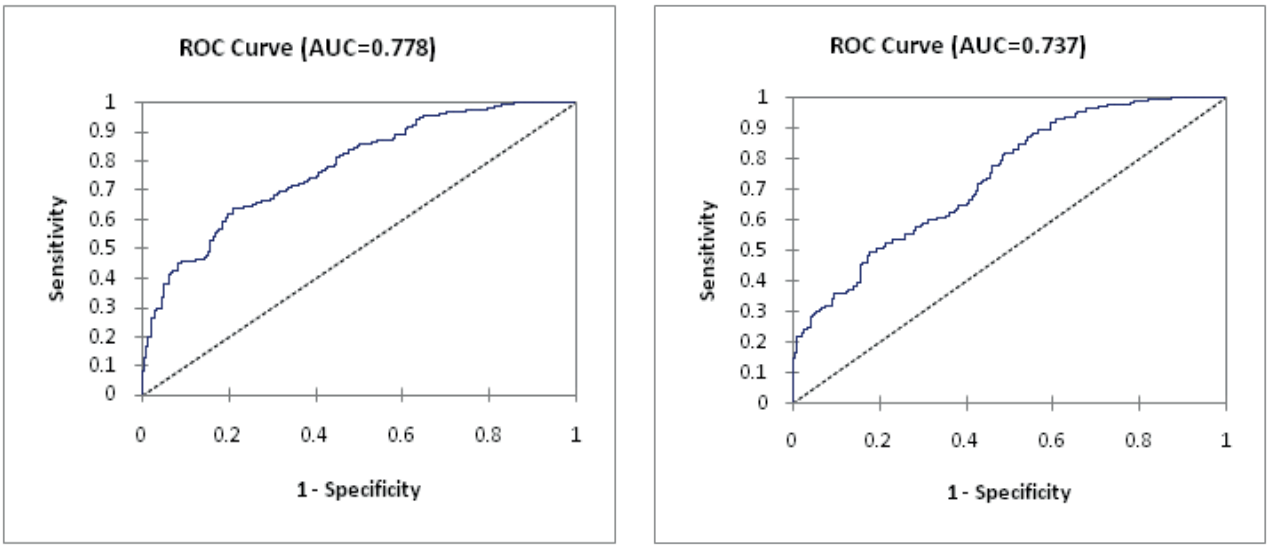

Figure 3 shows the ROC Curve of (left) Fatihah Chapter and (right) Arabic news listening.

eyes, suggesting activation of visual mental imagery. Visual mental imagery has played a crucial role in the learning process and memory consolidation. The student with more outstanding mental imagery capabilities is excel in their studies. Since listening to Quranic sound activates neural network for mental imagery[18], it is suggested that listening to Quranic recitation may enhance academic performance in students. In addition, research shows that mental imagery was long used in much mental health disorder management, and this brain activity plays an increasingly important role in treatment[15] .

The beta power spectrum is associated with attentional processing and generation of images. Although the images were not present, visual imagery relies on the exact mechanism of visual working memory to manipulate visual information[21]. [22] also found a pattern of brain activity suppression during mental imagery in primary visual and auditory cortices. They proposed such suppression assists in the processing of internally-generated images or sounds by shielding the associative sensory regions from external perceptual input. Beta oscillations have been discovered to be reduced in the occipital areas during mental imagery activities[23]. Data show that beta rhythms are systematically reduced during the performance of a mental task involving the matching of memories of visual images. They found that the source of reduction appeared to be in the visual cortex, a finding which was consistent with local cerebral blood flow studies by[24].[25] also found that activation pattern corresponds to imagery, including mental imagination of shapes, sounds, touches, odours, flavours, self-perceived movements and internal sensations. Additionally, a PET study by[26] revealed relative power spectrum reduction within primary visual areas during imagery.

Sound waveforms from Fatihah Chapter and Arabic news show contour differences in formants, pitch and intensity, which indicate that Fatihah Chapter is more rhythmic compared to Arabic news. This rhythmical pattern of the sound waves is believed to strike human brainwaves and interact with its physical properties of frequency and entrained it. Desynchronisation occurs due to activation of the beta brainwaves and activates the visual mental imagery neural circuits responsible for the activation of the autonomic nervous system and amygdala in a similar way to perception, which leads to physiological and psychological changes, as described by [27]. The imagining threatening events can increase heart rate, skin conductance and breathing rate, as we believe inhaving occurred during listening to the Fatihah Chapter or other Quranic verses, as mentioned in the Quran, *"Allah has revealed the most beautiful Message in the form of a book, consistent with itself, yet repeating. The skins of those who fear their Lord tremble thereat; then their skins and their hearts do soften to the celebration of Allah. Such is the guidance of Allah. He guides in addition to that whom He pleases, but such as Allah leaves to stray, can have none to guide" (Chapter Az-Zumar 39:23)*.

Conclusion

A growing body of evidence shows that visual mental imagery can accelerate learning, enhance all sorts of skills and ignite cognition for better educational performance. Our study found that listening to Quranic recitation from the Fatihah Chapter activated the neural oscillations associated with visual mental imagery, improving students' academic performance.

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Consent for Publication

All authors reviewed this article and have agreed to be accountable for all aspects of the work, including any issues related to accuracy or integrity.

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Authorship Contribution

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, in drafting, writing, and reviewing.

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