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POTENTIAL OF QUANTITATIVE ELECTROENCEPHALOGRAPHY (QEEG) IN MEASURING COGNITIVE AND PSYCHOACOUSTICAL EFFECTS OF THE FATIHAH CHAPTER ACOUSTIC STIMULATION*

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ABSTRACT

The aesthetic experiences of Quranic recitation are receiving attention from scientific community. While the contribution of quantitative electroencephalography (qEEG) towards investigation of cognition especially language processing as well as psychoacoustical effects are abundant. Yet knowledge about the integration for these two domains are scarce, hence this powerful tool rarely applied in measuring the effects of its acoustic stimulation to listeners' brain physiology and psychology. This study aimed to review the potential of qEEG in assessing cognitive and psychoacoustical effects of acoustic stimulation from Fatihah Chapter recitation - the first chapter of The Holy Quran, the Muslims book of guide. This review article found that qEEG serves highly potential neuroimaging information those might improve the interpretation of the Fatihah Chapter and even Quranic acoustic stimulation effects.

Keywords: *Acoustic stimulation, Fatihah Chapter, quantitative*

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Electroencephalography (qEEG), psychoacoustics

1. INTRODUCTION

QEEG measurements reflect a range of frequency bands that are associated with various functional brain states [Basar et al., 1997; Davidson et al., 2000a; Klimesch, 1999; Schacter, 1977] in (Rubik, 2011). It is widely used in clinical studies for its non-invasive technique and precise spatial and temporal data. Nowadays there are growing researches assessing brain response towards musical acoustic stimulus (Jäncke, 2008; Miendlarzewska & Trost, 2014; Sanju & Kumar, 2016), and also the rhythmic acoustic of the Holy Quran (Nakhavali, 2013; Tzortzis, 2007) which having aesthetic linguistic features those make recitation and listening activities a hypnotic experience (Hanafi, 2016; Lutfi, Dosen, & Surakarta, 2017). This paper aims to see the potentials of qEEG technique in Fatihah Chapter study.

2. QUANTITATIVE ELECTROENCEPHALOGRAPHY (QEEG)

QEEG is a non-invasive method which poses minimal risk and discomfort to experimental participants. It is an index of neurophysiological activity measures the brain's electrical activity of collected and synchronously firing populations of neurons at the scalp level. The major advantage of qEEG is its highly precise temporal resolution which allows the investigation of neural activity at the level of mili-seconds (ms) (Light et al., 2010). This measurement of brain electrical activity uses the principle of when the neurons are activated, local current flows are produce.

QEEG measures the currents that flow during synaptic excitations of the dendrites of pyramidal neurons in the cerebral cortex area (Teplan, 2002). This electrical activity of pyramidal cells is the principal source for qEEG potentials which coming from those paralleling lined cells to one another that oriented perpendicular to brain surface. Furthermore, they often cross several layers and allow input from different cortical layers to be integrated along the dendritic tree. When the EEG recording electrodes are placed over the frontal, parietal, occipital and temporal lobes according to conventional scheme e.g., the International 10-20 system with electrode sites (Jasper, 1958), the summated voltage in inhibitory and excitatory postsynaptic potentials from thousands of pyramidal cells near each recording electrodes can be read by this device. EEG visualizes the voltage

differences between two cerebral locations that plotted over time which is yielded by the process of current flow through the tissues between the electrical generator and recording electrode termed volume conductance (Olejniczak, 2006) .

QEEG is usually classified to five distinct brainwave rhythms which are delta (0.5-3Hz), theta (4-7Hz), alpha (8-13Hz), beta (14-30Hz) and gamma (31-50Hz) which reflects the brain condition. Delta rhythm is a predominant feature recorded during deep sleep (Louis & Frey, 2016) and some reported that delta also appear during deep meditation and deep Samadhi which have been seen through functional Magnetic Resonance Imaging (fMRI) and EEG (Lenaagala Siriniwasa, 2015). Delta is associated with deep healing and regeneration, underlining the importance of deep sleep as a neuroprotective mechanism. Sleep has been proven to improve memory recall, regulate metabolism and reduce mental fatigue (Eugene & Masiak, 2015). In delta stage, its waveforms typically have large amplitudes (75–200 mV) and show strong coherence at all the scalp over. Theta rhythms are hardly found in adult humans because during awake moment, human are always experiencing alpha and beta waves. Theta brainwaves associated with creative (Gruzelier, 2014) and focused mind (Chan, Han, & Cheung, 2008; Lagopoulos et al., 2009). Activity in theta band may occur in emotional or some cognitive states. As for alpha, alpha rhythms are predominant during wakefulness and are most pronounced in the posterior regions of human brain (Lagopoulos et al., 2009). They are best observed when the eyes are closed and the subject is in a relaxed state. According to latest investigations, theta and alpha oscillations found in narrow frequency bands and are reflecting multifunctional neuronal networks associated with affective and cognitive processes. Theta power synchronization reveals positive emotional experience mechanism and its absence is explained by frustration feelings in subjects (Aftanas & Golocheikine, 2001).

Beta waves are characteristics for the states of increased alertness and focused attention where the mind is strongly engaged (Herrmann, 1997). People with suffiecient beta waves can think fast, generate new ideas quickly, and live in high state of functioning. Furthermore, Hayashi et al., (2009) showed that non stress people have higher beta activity in frontal and temporal areas compared to stress people. Gamma activity is connected with information processing and the onset of voluntary movements. Gamma band are considered brain's optimal frequency of functioning where it is associated with increased level of compassion, feeling of happiness and optimal brain functioning. Gamma also relates to state of self-awareness (Voss et al., 2014), higher level of insight and

attention (Landau, Esterman, Robertson, Bentin, & Prinzmetal, 2007; Tallon-baudry & Bertrand, 1999). Numerous studies reported gamma band activities in meditative states among contemplative tradition practices (Braboszcz, Rael Cahn, Levy, Fernandez, & Delorme, 2017; Davis & Vago, 2013; Fell, Axmacher, & Haupt, 2010; Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004) which then be suggested to be a marker of brain plasticity for long lasting meditative training that remains during restful to deep sleep (Fell et al., 2010; Ferrarelli et al., 2013).

3. THE FATIHAH CHAPTER ACOUSTIC STIMULATION

The Fatihah Chapter is the first and important chapter from The Holy Quran. It is flourished with literary structure includes rhyme, meter and rhythm. It has beauty sound and intonation which was suggested to have capacity to relax, heal people and eliminate negative thoughts and stress besides embracing positive thoughts and emotions (Khan et al., 2010a). Besides that, its sweet euphony psychoacoustically gives harmonious effect to brain as it generates synchronization with neuronal oscillation during listening to its verses (Reza et al., 2012).

According to Al-Quran, Part 29, Chapter 73, verse 4, "Quran was suggested to be recited with a measured rhythmic recitation or in a slow style. The Prophet (peace be upon him) said, "Allah does not listen to anything as He listen to the Prophet reciting the Quran in a nice, loud and pleasant tone." Sufyan the companion then said, "This Hadeeth (saying of Prophet) means: The Prophet Muhammad (peace be upon him) regards the Quran as something that makes him dispense with much worldly pleasure" (Sahih Al-Bukhari, vol 6. Hadeeth No. 542).

Reciting The Fatihah Chapter in an appropriate way is crucial and is indispensable in Islamic worship such as prayers. Tajweed, a set of rules for proper pronunciation and Quran recitation is taught through processes named talaqqi and musyafahah to ascertain that the The Holy Quran are recited correctly (Ibrahim, Zulkifli, & Mohd, 2011). This set of rules is considered as an art that govern on how the Quran should be read. Being a divine scripture, The Fatihah Chapter conveys a universal message for the whole mankind irrespective of time, zone and spaces (Mainiyo & Shuni, 2014). In fact, its recitation touched millions of people's hearts although they may understand it or not. It is recorded that Egyptian Qari, Abdul Basit has recited some verses from Chapter Taha from

Quran before the top Soviet leaders during a meeting when he accompanied President of Egypt, Gamal Abd Nasir. Instantly, four of the Soviet leaders were shedding tears prudently as they had dissolved and their heart had melted into the something that they don't understand it even a single word (Ahmad, 2013). This anecdote is consistent with case of Umar al-Khattab r.a who bowed into Islam after listening to a piece of Quran recitation. These historic anecdotes show human seems to be particularly rhythmic creatures those having brains of tune-in to the fine degrees of rhythmic information in The fatihah Chapter (Gyorgy Buzsáki, 2006).

Circuitry for processing rhythmical acoustic stimuli was found in human combined with recruitment of set of cognitive and executive information processing as well as during rhythmic and melodic stimuli perception (Thaut, Trimarchi, & Parsons, 2014). Exploring back to its early revelation, The Fatihah Chapter is commanded not to read but to recite. Even its very word 'Quran' can be translated as 'recitation'. Reciting it means recite to its original scripture, that grant its reciters or listeners such direct, historic and aesthetic connection to the Prophet and to the actual language of God. The sound of The Fatihah Chapter recitation permeates almost all Muslim's sonic landscape, and being official events opener. The powerful presence of the rhythmic cadence of The Fatihah Chapter recitation is everywhere even in tradition or modern Muslim society since its scripture is scrupulously memorized, recited and transmitted over and over. Nevertheless, its linguistic and stylistic phonetics features bring enormous influence on world literature and poetry, which are inspired by the poetry and rhythms from the QV and The Holy Quran the whole.

The QV's aesthetic sound falls into various linguistic features including rhythm. Rhythm is a foremost contributing factor to its style and beauty. Its rhythm impact has been noted by litterateurs throughout history as beautiful and unique that exemplifies the peak of literary beauty. Rhythm heightens the impact of messages and enhances human psychological effects as was mentioned in Chapter 39, verse 23, "Allah has sent down the best statement: a consistent Book wherein is reiteration. The skins shiver therefrom of those who fear their Lord; then their skins and their hearts relax at the remembrance of Allah. That is the guidance of Allah by which He guides whom He wills, and one whom Allah leaves astray-for him there is no guide".

From abovementioned verse, there are astound influential mechanisms surround its reciters and listeners. Researchers believed that this is caused by

synchronization between the Quran rhythm and brain rhythms that is called as brainwave entrainment. Brainwave entrainment is a popular therapy nowadays in managing consciousness, anxiety other psychological turbulence found to raise participant's life quality and quality of perception (Cruceanu & Rotarescu, 2013). The concept lies on wave interaction with other waves which then produce enormous effects when they resonate. By applying a constant resonance frequency to a standing wave, this interaction can alter by intensifies, reinforces and prolongs the standing frequency of that wave. Similarly, this concept of resonance possibly induces altered brain states (Brahmankar, Dange, & Mankar, 2012). QEEG was used to investigate interbrain synchronization patterns in participants interacting through speech (Pérez, Carreiras, & Duñabeitia, 2017). They reported that entrainment is stronger at low frequencies and more generalized in speakers than listeners. This entrainment was explained by multiple linear regression which predicted the brain-to-brain synchronization based on brain-audio synchronization between speaker and listeners. Results of multiple coefficients (R2) summarized from all electrode channels and five frequency bands which are delta, theta, alpha, beta and gamma. This experiment support our hypothesis that effects of listening to the acoustic stimulation by The Fatihah Chapter on human brain can be measured through QEEG where it is believed that the Quranic rhythms entrain or lock-in with brain rhythms thus resonate into balanced frequencies.

4. OVERVIEW OF QURAN'S COGNITIVE AND PSYCHOACOUSTICAL EFFECTS

Rhythm is perceived by brain, and its meter or rhyme in the verses structure gives an impact on aesthetic liking, emotional involvement and affective valence attributions (Obermeier et al., 2013). The idea that poetic structure influences the reception of poetry is not new. It was emerges since Greek antiquity. Rhetoricians and philosophers had long debated on how stylistic figures affect the listeners. Aristotle even claimed with the sweetness of meter and harmonic sound, people can feel the pleasure even in tragic plots. Even more, he asserted that poetry style linked to memory formation (Aristotle, 1932).

Previous researches exhibited that The Holy Quran gives psychoacoustical effects to human such as lessen the stress and give relaxation effects. In fact, religious coping strategies were used by 80% of people to cope with mental health problem (Tepper, L., Rogers, Coleman, & Malony, 2001).

Religious Cognitive Behavioural Therapy (CBT) has been shown to produce effects faster than conventional CBT (Azhar, Varma, & Dharap, 1994; Rosmarin, Pargament, Pirutinsky, & Mahoney, 2010). According to Rafique, Anjum, & Raheem (2017), the efficacy are more applied to Muslim community than other religious groups because theoretically Muslims have a stronger belief in efficacy of religious and Quranic verses. This was parallel with Loewenthal, Cinnirella, Evdoka, & Murphy (2001) who found that cognitive restructuring through the application of religion and Quranic verses were found more useful to Muslim followers than other religions.

Rafique, Anjum, & Raheem (2017) showed that women diagnosed with depression reported reduced level of depression after listening to Ar-Rahman Chapter compared to control at the post-assessment level. This indicates that Ar-Rahman Chapter is helpful in managing symptom of depression among Muslim women. Pridmore & Pasha (2004) proved the efficacy of Quranic text and recitation in alleviating depressive symptoms. Ebrahimi, Neshatdoost, Mousavi, Asadollahi, & Nasiri (2013) found a remarkable improvement in depressive Muslims who were treated with spiritual and psychotherapy in CBT programme over conventional CBT. Their treatment used Quranic recitation listening, Quranic verses lectures and encouragements to read The Holy Quran. At the end of the research, they concluded that Quranic verses along with religious beliefs and coping strategies are highly effective in dealing with psychiatric concerns in Muslims. This research was supported by statement from an eminent medical professional, Dr Javed who was serving as the head of Services Hospital's ICU and a consultant physician during this study was run. He said, "During the treatment of direly ill patient, Ar-Rahman Chapter was continuously played by his bedside and this Chapter acted as an antidote," (Rafique et al., 2017).

Khan et al., (2010) performed their experiment by using multimedia system to stimulate auditory, visual and tactile systems. Their finding shows that permanent relaxation can be achieved by the help of recitation of the Holy Quran on daily basis in daily life and decrease the aggressive mode in person. They also showed that female take less time to get relaxed compared to male due to the sensitive factors of feminine. Other research done by Abdullah & Omar, (2011) proved that human can feel relax and calm during listening to Quran recitation compared to rest or hard music. While research by Atefeh Hojjati, Vela Musavi, Alireza Agha Usefi, Marzieh Shahsiah (2011) showed that Quran and music both decreased patient's anxiety but Quran sound affects human personality and covert anxiety in addition to situational anxiety.

As for cognitive domain, several researches were performed engaging activities related to Quran with cognitive effects. For instance, Al-Attas (2011) studied the relationship between religiosity of memorizing the Quran and the enhancement of memory. The study was performed on 580 people from both gender aged from 20 to 40 years old. They are 580 people altogether with half of them were Quran memorizer. The test used was a designed paper contained a questionnaire and two tests, which were Test Your Memory and 10 words test by Dr Gary Small. Using the Qui-Square, they found that the group of Quran memorizer had higher more A-Gades in both tests. Their hypothesis was accepted where the Quran is an influential factor to strengthen memory. In parallel, Suteja Putra, Gumilar, Rahma Kusuma, Purnomo, & Basumerda (2018) also showed that listening to the Quran provides a significant increase in the brain ability. They proved that concentrations of respondents increased after listening to the murottal, a kind of Quranic recitation. Another study done using EEG by using acoustic stimulation of The Fatihah Chapter showed an activation in the right medial temporal which suggesting for increased performance of its listeners in controlling short term memory, hence lead to increased space for new information to be installed (Samhani, Husain, et al., 2018). Study on effects of Quran memorizing also found a significant improvement in academic performance of Huffaz with $p<0.01$. Hifz activity involves memory exercise which makes the brain skilled and automatized for other learning and memory-based tasks and practices. This automaticity ease the Huffaz to perform other memory based learning activities in their formal education (Nawaz & Jahangir, 2015). This experiment was done by questionnaires containing close-ended and open-ended questions those disseminate to the Huffaz and their parents.

5. QEEG AS A POTENTIAL MEASURING TOOL FOR COGNITIVE AND PSYCHOACOUSTICS EFFECTS IN QURANIC STUDIES

Not much study was done on cognitive and psychoacoustics effects of Quran using qEEG but there are high attention given on the scientific exploration of it, yet integration of Quranic or religious knowledge with science is now rapidly growing. People may benefit the outcomes to strengthen their belief and spirituality.

Looking at neurophysiological basis of qEEG, human nervous system composed of two main nervous cells called neuron and glial cells. In resting states,

their potential are approximately -80mV with the inside being negative. The difference of potentials across cell membrane comes from the difference of cations concentrations (K+, Na+ and anion Cl-). Ca++ ions are less abundant but they play an important regulatory role. The potential difference of inside and outside of cell membrane is maintained by active transport of K+ to inside of cells and Na+ to outside of cells. When electrical excitation exceeds the thresholds, action potential occurs and thus manifests electrical activities that obey the rule of 'all or none'. When the action potential arrive the synapse, it secretes neurotransmitters which then change the permeability of the postsynaptic membrane of the next neuron. Subsequently, ions traverse the membrane and potential difference is created. EPSP or IPSP then generated as the negativity inside the neuron is decreased or increased by influx of Na+. The electrical activity of neuron impetus currents along the cell membrane producing electric field (Blinowska & Durka, 2006). These current flows are the basis of qEEG recording in brain. Electrical potential can be monitored by placing at least two electrodes on the scalp and measuring the voltage difference between them. The monitored qEEG is summation potentials of multiple neurons acting in synchronously (Kutas & Dale, 1997).

QEEG explores the spectral analysis of rhythmical brainwaves response from the The Fatihah Chapter's acoustic stimulation. Spectral analysis is mathematical operation that provides the frequency, amplitude and phase parameters of each component of sine waves. It states that any waveform can be decomposed into a sum of sine waves at different frequencies with different amplitudes and different phase relationships. Fast fourier transform (FFT) represents the amplitude and phase relationship at each sine wave frequencies component. Squaring and summing of its coefficients yielding the power of frequency. A plot of power is called as power spectrum (Walczak, Chokroverty, Medicine, & Edition, 2009) which represents the cognitive of psychological states of listeners. Time frequency analysis, source localization and coherence are among analysis that can be performed. Researches are also allowed to examine the language processing involving different kinds of operations at different times and temporal scales in multiple brain areas (Kutas & Dale, 1997). Application of qEEG also can produce other information such as brain connectivity (Horwitz, 2003; Li, Witon, Marcora, Bowman, & Mandic, 2014; Rubinov & Sporns, 2010; Sakkalis, 2011; Wendling, Ansari-Asl, Bartolomei, & Senhadji, 2009), brain areas activation (Beres, 2017; Lopes da Silva, Gonçalves, & De Munck, 2010) cortical entrainment to the musical sound (Kumagai, Arvaneh, & Tanaka, 2017; Sammler, Grigutsch, Fritz, & Koelsch, 2007; Sanju & Kumar, 2016; Särkämö et al., 2008), recognize the emotion responses during presentation of

sound (Lin, Wang, Wu, Jeng, & Chen, 2008; Sourina & Liu, 2011), brain mapping (Kramarenko & Tan, 2003; Lachaux, Rudrauf, & Kahane, 2003; Nuwer, 1997) and cognitive correlates of acoustic stimulation (Coffey, Musacchia, & Zatorre, 2017).

In assessing the effectiveness of 'communication' with The Fatihah Chapter sound stimulus, the on-going rhythmic neural activity of listeners must be coupled with the quasi-rhythm sound signal called brain entrainment (Pérez et al., 2017). This is because when the auditory cortex is stimulated by The Fatihah Chapter sound, resting oscillatory activities will temporally structure, synchronize according to the phase of the stimulus. Auditory cortex strongly responsive to signals with amplitude (AM) and frequency (FM) domains and can promote synchronization or entrainment between The Fatihah Chapter rhythms and brain rhythms (Giraud & Poeppel, 2012). Neural oscillation and entrainment which are basis of all brain activities including cognition, behaviour and emotional processes (Fries, 2015; J. Trost, Labbé, & Grandjean, 2017; Melloni et al., 2007) and synchronization of neuron populations will code the emergence of emotional feeling. For instance, synchronization of frontal polar reflects the attentive state of individual which is associated with inhibition of rumination and negative thoughts activity that promotes depressive episodes in human (Samhani, Begum, et al., 2018). Synchronization with acoustic stimulus also manipulate cognitive processes such as memory (Fell & Axmacher, 2011), attention (Foxe & Snyder, 2011; Womelsdorf & Fries, 2007) and creativity (Charyton, 2015).

Several other researchers have demonstrated the potential of qEEG within Quranic studies. Sheka, Hassan, & Othman (2013) examined physiological responses of eleven healthy students who were listened to Quran, hard music, soft music and sham. qEEG was used by recording from brain evoked potentials from occipital and frontal lobes. The experiment was conducted in three minutes and showed that alpha magnitude was higher during Quranic recitation with closed eyes, followed by Quranic recitation with opened eyes compared to other conditions.

Zulkurnaini, Kadir, Murat, & Isa (2012) also tested the respondents' brainwaves when they were listening to Yasin Chapter recitation and classical music through Mp3 player. QEEG data of alpha brainwaves were taken, and subsequently the respondents were interviewed about their feeling. They revealed that the brainwaves of right and left hemisphere are more balance during listening to Quran hence giving better performance in daily life.

6. CONCLUSION

There is no doubt that QEEG can be applied in Quranic researches as showed by these abovementioned studies in which applying QEEG in Quranic research provides more information about brain processing to language and rhythm, that relates to brain functioning in cognitions and psychoemotions of its listeners or reciters.

7. ACKNOWLEDGMENTS

This research was funded by USM Short Term Research Grant (304/PPSP/61313160) and Incentive Grant and approved by the Human Ethical Committee of University Sains Malaysia (USMKK/PPP/JEPeM[234.3.(09)]. We thank our colleagues especially Dr Tahamina Begum from the Neurosciences Department and all the staffs in MEG/ERP laboratory who provided insight and expertise that greatly assist this research. No conflict of interest presented.This anlysis will demonstrate how the revelations were a dialogical process between God – through his messenger – and mankind, within specific contexts (i.e. not a narrative), within which the *Quran* had to legitimize itself. It will begin by first analyzing what textual referentiality is and the nature of self-referentiality within the *Quran*. It will then proceed to address why such referentiality was necessary in order to accomplish the three goals prescribed above. It will conclude by demonstrating how, by using self-reflexivity, the *Quran* was able to establish its legitimacy and assert itself as the final continuation within the same prophetic line as previous scripture. This research draws from numerous different sources, and uses myriad verses from the *Quranic* text itself to support the assertions made. A dual historical and textual methodology is employed in order to explain how the text felt it was necessary to use self-reflexivity based on the particular context at hand.

This analysis does not seek to advance the theological position or argument of any particular tradition, but rather seeks to examine why self-referentiality was deemed necessary from the point of view of the text itself. While most studies on the topic of self-referentiality acknowledge the first two objectives listed above (Wild, 2006; Sinai, 2006; Neuwirth, 2006), they tend to neglect the overriding importance of the third objective, which is arguably the most critical element of the *Quranic* text itself. Let me explain: if the first two objectives – demonstrating that the text is indeed from God and establishing it on an equal

stratum as revelations given to previous prophets – were the sole intention of the *Quranic* text, then what was the necessity of this revelation? In other words, if the *Quran* was meant solely as a "confirmation of what came before it", what makes this revelation unique, or even necessary? Similarly, if this is the only assumed goal, why then does the text go to such great lengths to criticize the previous recipients of God's word, and seek to steer them toward a different end? In seeking to answer these questions, it is quite possible that the third objective is traditionally disregarded because it wades too deeply into the realm of theological polemics. Therefore, section (3) on "culmination" is primarily derived from my own textual analysis of the *Quran*, situating this objective into the overall calculus of self-referentiality. This being the case, I would like to state again that this study does not seek to advance the theological position of any particular religious tradition, but rather aims to analyze the ultimate meaning behind the self-referential aspects of the *Quran's* dialogical engagement with man, through Muhammad.

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