EMANATION OF BRAIN FRONTAL MIDLINE AND BRAIN MENTAL THETA SIGNALS AS THE SOURCE TO EXPLORE THE NEURAL SUBSTRATES OF MELODIC AND RHYTHMIC HOLY QURAN

NUR SYAIRAH BINTI AB RANI

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by

NUR SYAIRAH BINTI AB RANI

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AAL	Automated Anatomical Labelling Atlas 3
ACC	Anterior cingulate cortex
ACCpre	Anterior Cingulate Cortex pre-genual
ACCsub	Anterior Cingulate Cortex sub-genual
ACCsup	Anterior Cingulate Cortex supracallosal
ACG	Anterior Cingulate Gyrus
AMYG	Amygdala
DBA	Deep brain area
DMN	Default mode network
ECD	Equivalent Current Dipole
ECG	Electrocardiography
EEG	Electroencephalography
FMG	Frontal middle gyrus
EMG	Electromyographic
FFT	Fast fourier transform
FMT	Frontal midline theta
ICA	Independent Component Analysis
ICBM	International Consortium for brain mapping
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
MBT	Mindfulness Based Therapy
MCC	Middle cingulate cortex
MEG	Magnetoencephalography
MNI	Montreal Neurological Institute
MRI	Magnetic Resonance Imaging

PCC	Post cingulate cortex
PFC	Pre-frontal cortex
PFCventmed	Ventral medial pre-frontal cortex/Frontal medial Orbital
PSD	Power spectrum density
PSP	Post-synaptic potential
PBUH	Peace Be Upon on Him (only for Prophet Muhammad)
ROI	Region of interest
SFG	Superior frontal gyrus
SFGmedial	Frontal superior medial
SSP	Signal Space Projection
STAI	State trait anxiety inventory
TSSS	Spatiotemporal signal space separation

EMANASI ISYARAT GARIS TENGAH FRONTAL OTAK DAN TETA MENTAL OTAK SEBAGAI SUMBER UNTUK MENEROKA SUBSTRAT NEURAL MELODI DAN RITMA AYAT SUCI AL-QURAN

ABSTRAK

Teta garis tengah frontal (FMT) dan teta mental frontal, sepertimana direkodkan daripada elektroensefalografi (EEG) dan magnetoensefalografi (MEG), telah menjadi substrat neural untuk fungsi kognitif otak yang mempunyai korelasi dengan kesan positif muzik dan terapi komplementari yang berkaitan dengan meditasi. Kesan positif yang sama juga dikaitkan dengan mendengar dan membaca alunan ritma dan melodi ayat suci Al Quran. Walaubagaimanapun, terdapat limitasi dari segi kajian ke atas gelombang otak, terutamanya gelombang alfa, yang direkodkan dalam situasi pembacaan ayat Quran, dengan ketiadaan kajian terdahulu yang berkaitan dengan gelombang otak teta, dalam pengetahuan kami. Dalam kajian ini, kami telah meneroka potensi pembabitan isyarat-isyarat teta garis tengah frontal (FMT) (EEG) dan teta mental frontal (MEG) sebagai substrat neural dalam pemetaan representasi serebrum oleh melodi dan ritma pembacaan Quran dalam kalangan kumpulan Muslim dan bukan Muslim. Sejurus selepas izin maklum dan profail Instrumen Trait Keresahan Kebangsaan (STAI), sejumlah 30 subjek yang sihat direkrut ke dalam kajian sebagai kumpulan dua kepercayaan (Muslim, n=15 and bukan Muslim, n=15). Setiap subjek menjalani rakaman EEG-MEG sambil didedahkan kepada pelbagai stail pembacaan surah Quran iaitu ayat Kursi secara pendengaran pasif dan rawak (iaitu Murattal Asim, Murattal Susi, Tarannum Asli and Hadr) dan juga ritma bukan Quran (iaitu berita bahasa Arab, Sajak bahasa Arab, Harekrishna dan Monokod). Data mentah EEG-MEG dianalisis menggunakan

Brainstorm dengan MATLAB, berdasarkan 20 bahagian otak yang berkepentingan (ROI) untuk lokasi serebrum termasuk ACCpre, ACCsub, MCC, PCC, AMYG, PFCventmed, SFG, FMG dan SFGmedial. Skor STAI menunjukkan tiada perbezaan signifikan yang ditemuid alam kalangan kumpulan dan jantina, dengan satu subjek (kumpulan Muslim) yang mempunyai skor STAI yang sangat tinggi (dan dikeluarkan daripada analisis seterusnya sebagai satu pisahan). Dalam keadaan rehat, anggaran sumber untuk FMT dalam data EEF menunjukkan kedua-dua kumpulan mempunyai pengaktifan yang sama pada SFGmedial manakala data mental frontal MEG menunjukkan bahawa kumpulan Muslim mengalami pengaktifan pada MCC berbanding dengan bukan Muslim yang mempunyai pengaktifan pada ACC dan PCC. Dari segi stail pembacaan Quran (kumpulan Muslim), MCC membabitkan stail Murattal Asim (tempo sederhana), FMG, ACC, ACC dalam Murattal Susi (tempo sederhana), PCC dan MCC dalam Tarannum Asli (slow tempo) dan PCC, MCC dalam hadr (tempo pantas). Secara kontras, bagi kumpulan bukan Islam, Murattal Asim mempunyai pengaktifan pada PCC, Murattal Susi dalam ACC dan PCC, Tarannum Asli dan Hadr mempunyai penemuan yang sama dalam PCC. Bagi analisis korelasi dalam kalangan ROI otak, data EEG menunjukkan bahawa kesemua 20 ROI dalam FMT mempunyai korelasi yang kuat dan positif. Bagi data MEG, kumpulan Muslim menunjukkan korelasi yang kuat dan positif dalam ROI terpilih bagi stail pembacaan Quran yang berbeza. Dalam kumpulan-kumpulan Muslim, AMYG, SFG, ACCsup, dan ACCsub diaktifkan semasa mendengar stail Murattal Asim, Murattal Susi dan Hadr manakala MCC dan PCC terlibat dalam pembacaan Tarannum Asli (tempo perlahan). Dalam kumpulan bukan Muslim, ACCpre, ACCsup,SFG, PFCventmed, dan AMYG didapati diaktifkan semasa mendengar Murattal Asim, Murattal Susi dan Hadr manakala SFG dan ACCpre terlibat dalam pembacaan Tarannum Asli (tempo perlahan). Sebagai perbandingan di antara kumpulan dan dalam stimulus Quran dan bukan Quran, gabungan ANOVA ke atas data EEG tidak menunjukkan perbezaan signifikan di antara kumpulan dalam PCC kanan, dan dalam interaksi di antara stimulus dan kumpulan dalam AMYG kiri. Secara keseluruhan, kedua-dua kumpulan Muslim dan bukan Muslim menunjukkan representasi neural yang berbeza dalam beberapa kawasan otak. Isyarat-isyarat FMT (EEG) dan teta mental frontal (MEG) mewakili novel yang berada di permukaan substrat neural pembacaan Quran dalam stail yang berbeza yang melibatkan ROI otak untuk fungsi-fungsi kognitif seperti emosi, pembuatan keputusan, stimulus yang bernilai dan perancangan. Anggaran sumber EEG menunjukkan sedikit perbezaan berbanding dengan MEG kerana sensitivity EEG selalunya pada permukaan kulit kepala manakala MEG boleh mendapatkan signal berpotensi daripada kawasan-kawasan otak dalam.

EMANATION OF BRAIN FRONTAL MIDLINE AND BRAIN MENTAL THETA SIGNALS AS SOURCE TO EXPLORE THE NEURAL SUBSTRATES OF MELODIC AND RHYTHMIC HOLY QURAN

ABSTRACT

Frontal midline theta (FMT) and frontal mental theta, as recorded from electroencephalography (EEG) and magnetoencephalography (MEG) respectively, had been regarded as the neural substrates for the cognitive brain function that correlate with the positive effects of music and meditation-related complementary therapy. Similar positive effects are also linked with the listening and recitation of rhythmic, melodic Holy Quran. However, limited studies on brainwave, in particular alpha wave, had been previously reported in the setting of Quranic verse recitation, with no previous study exists in relation to theta brainwave to our best knowledge. In this study, we explored the potential involvement of the frontal midline theta (FMT) (EEG) and frontal-mental theta (MEG) signals as the neural substrates in mapping the cerebral representations of the melodic and rhythmic Quran recitation among Muslim and non-Muslim groups. Following an informed consent and psychological State Trait Anxiety Instrument (STAI) profile, a total of 30 healthy subjects were recruited into the study as dual faith groups (Muslim, n=15 and non-Muslim, n=15). Each subject underwent a simultaneous EEG-MEG recording whilst being exposed to a random, passive listening of different known styles of Quranic recitation of Ayatul Kursi verse (namely Murattal Asim, Murattal Susi, Tarannum Asli and Hadr) as well as non-Quranic rhythms (namely Arabic News, Arabic Poem, Harekrishna and Monochord). Raw EEG-MEG data were analysed using Brainstorm with MATLAB, based on 20 brain regions of interest (ROI) for cerebral localization

which included ACCpre, ACCsub, MCC, PCC, AMYG, PFCventmed, SFG, FMG and SFGmedial. The STAI scores indicated no significance differences found among groups and gender, with one subject (Muslim group) with very high STAI score (and was excluded from subsequent analysis as an outlier). In resting state condition, the source estimation for FMT in EEG data showed both groups had similar activations at SFGmedial while frontal mental MEG data indicated that the Muslim group had activation at MCC compared to non-Muslim which had activation at ACC and PCC. In Quranic recitation styles (Muslims group), MCC involved in Murattal Asim style (moderate tempo), FMG, ACC, MCC in Murattal Susi (moderate tempo), PCC and MCC in Tarannum Asli (slow tempo) and PCC, MCC in Hadr (fast tempo). In contrast, for the non-Muslim group, Murattal Asim has activation at PCC, Murattal Susi in ACC and PCC, Tarannum Asli and Hadr has similar finding in PCC. For correlation analysis among brain ROI, EEG data showed all 20 ROIs in FMT with strong, positive correlations. For MEG data, Muslim group showed strong, positive correlations in selected ROIs for the different Quranic recitation styles, and likewise the case for non-Muslim group but with key differences for certain recitation styles and ROIs. In Muslim groups, AMYG, SFG, ACCsup, ACCsub were activated during Murattal Asim, Murattal Susi and Hadr styles while MCC and PCC involved in Tarannum Asli recitation (slow tempo). In non-Muslims group, ACCpre, ACCsup,SFG, PFCventmed, AMYG were found activated during Murattal Asim, Murattal Susi and Hadr while SFG and ACCpre involved in Tarannum Asli recitation (slow tempo). In comparison between group and within Quranic and non-Quranic stimuli, mix ANOVA on EEG data showed no significant difference between the groups and within stimuli while MEG data indicated a significant difference between group in right PCC, and in the interaction among stimuli and group in left AMYG. Overall, both Muslims and non-Muslims groups showed different neural representation in several brain areas. FMT (EEG) and frontal mental theta (MEG) signals represent the novel underlying neural substrates of the Quranic recitation in different styles which involved brain ROI for cognitive functions such as emotion, decision making, rewarding stimuli and planning. The source estimation of EEG showed a slight difference compared to MEG as sensitivity of EEG mainly at scalp surface while MEG can capture the potential signals from the deep brain areas.

CHAPTER 1

INTRODUCTION

1.1 Background

Most people suffer from stress and exhaustion due to modern lifestyle and work-related matters that impinge on the harmony of their psychological and bodily health. There are also numerous internal and external aspects that are known to exacerbate this imbalance in life (Bhui *et al.*, 2016). Despite modern treatment that offers conventional medicines to patients and society, there are other more natural ways such as alternative and complementary therapy that include meditation and innovative use of music or sound. These approaches have gained a significant attention, partly due to the ease of access, low cost, and often, more convincing with an uncomplicated method involved. For instance, meditation has received much attention in the past decade, and with recent neuroscience interests that are linked with changes in the brain, the desirable effect on the body, and its potential usefulness in clinical setting (van der Velden and Roepstorff, 2015).

Similarly, music has also gained much interests with the claims on reducing stress among patients as a complement during their conventional medical treatment. Music therapy has been used in rehabilitation to stimulate brain functions involved in movement, cognition, speech, emotions, and sensory perceptions (Bradt *et al.*, 2010). For moderate depression, individuals are encouraged to use music therapy and proven beneficial to enhance the improvement in their symptoms compared to psychological support alone (Castillo-Pérez *et al.*, 2010). More recently, further evidences to support such anecdotal claims had emerged from neuroscience research, in particular brainwaves analysis and brain activation patterns with the aid of non-invasive technology.

Several brain areas are known to be involved in the processing of musical features (Alluri *et al.*, 2013). An increased in the activity of the default mode network (DMN) has been reported whilst listening to music (Hodges and Wilkins, 2015). DMN is the interconnected region in the brain that becomes active during resting and mindful wandering (Tang *et al.*, 2015). It will become less active when individuals become more engaged with the outside world and while performing tasks. In addition, listening to preferred and favourite music appeared to increase the connectivity at the frontal part of the brain (Hodges and Wilkins, 2015). This observation also corresponded with the spectral power changes that had been reported in the theta and alpha frequency bands emanated in the state of relaxation and/or during meditation approaches (Jacobs and Friedman, 2004; Jirakittayakorn and Wongsawat, 2017a; Tang *et al.*, 2019).

Meditation approaches include a group of intricate practices such as mindfulness meditation, mantra meditation (such as *Hare Krishna*), yoga, and *Zen* meditation (Pasquini *et al.*, 2015; Damerla *et al.*, 2018; Gao *et al.*, 2019). Apart from these, monochord sounds have also been reported to alleviate pain, enhance body perception and relaxation, and are often used as a form of music therapy (Lee *et al.*, 2012). In these practices, reported spectral power changes for the brainwaves theta and alpha frequency bands are frequently used as the neural basis for the positive effects seen (Jacobs and Friedman, 2004; Jirakittayakorn and Wongsawat, 2017a; Tang *et al.*, 2019). Theta brainwaves in particular, have received considerable attention from researchers (Hsieh and Ranganath, 2013) with observation of activations in the pre-frontal cortex and the anterior cingulate cortex of the brain. Such brain signals can be recorded using electroencephalography (EEG) and magnetoencephalography (MEG) (Bressler and Kelso, 2001; Kamal *et al.*, 2013).

Frontal midline theta (FMT) from EEG data and frontal mental theta from MEG data had previously been targeted as the neural substrates in relation to spiritual and meditation effects from human brain (Iramina *et al.*, 1996; Aftanas and Golocheikine, 2001; Kubota *et al.*, 2001; Ding *et al.*, 2015; Pratzlich *et al.*, 2016; Tang *et al.*, 2019) Thus, these approaches emphasize on the emanation of brain signals from the middle part of frontal region with a focus on the theta brainwave. This study attempted to extend the involvement of FMT and frontal mental theta with the known calming effects of the melodic Qur'anic recitation which are not previously established.

Throughout Islamic culture, Quran is the guidebook that can be recited as a variation of melodious rhythms called *maqamat*. There are seven *maqamat* that conveyed emotions including joyful, sad, strong, empathy and others. It should be recited to its laws, *tajweed*. In comparison to music, the Quran recitation is conventionally recited to sense in terms of harmony and rhythm for the clarity of the Holy Text; therefore, it acts as a descriptive song of the Quran. The research conducted earlier in Quranic recitation showed that alpha brainwave significantly affects reciter and listener in relaxed and pleasant minds (Kamal *et al.*, 2013; Mahjoob *et al.*, 2016). Nevertheless, theta brainwaves in relation to the calming effects of rhythmic Quran recitation remains unexplored (Mustapha *et al.*, 2016), unlike in music and meditative practices with the known positive, calming effects.

Recent developments in neuroscience, especially in MEG/EEG, have led to a renewed interest in brainwave analysis as the neural representation to different human behaviours(Shin and Fujioka, 2018; Niso *et al.*, 2019). Numerous well-designed MEG/EEG studies had provided leads to suggest the neural representations during meditative practices, focused attention, and emotional tasks. Furthermore, MEG and EEG are suitable modalities that have the capability to encode the time course of neuronal responses to auditory stimuli and are acoustically noise-free as data are being recorded in magnetic-shielded rooms. The localisation source of the brain activity can be determined for further verification on the neuroanatomical correlates of brain functions and/or behaviours. It is also a completely non-invasive technique safely tested on various populations as well as enabling repeated measurements.

1.2 Problem statement and study rationale

In recent years, there has been an increasing number of scientific findings on the effects of musical rhythms to the brain. These findings are supportive of the positive emotions as substrates of cerebral representations that shape human behavior (Trost *et al.*, 2014; Hodges and Wilkins, 2015; Salimpoor *et al.*, 2015). In this context, one can also further assess Quranic recitation which also has musical syntax characteristics (i.e. melody and rhythm) known as Tarannum. In addition, ways to recite (and in essence using the Tarannum) is coupled by rules of *Qiraat* (Nelson, 1982; Nelson, 1985; Abdullah *et al.*, 2014). Hence, this combo of Quran recitation styles is accustomed among the nearly 2 billion Muslim, worldwide.

Similar to music that has rhythm and intonation which give beneficial effects to the listener, the rhythmic melody of Quran recitation can also evoke positive emotions and well-being. Muslim have been performing the recitation all over the world since the past 1400 years. The calmness effects during or after reciting the Quran have been widely reported (Kamal *et al.*, 2013; Mahjoob *et al.*, 2016; Saged *et al.*, 2018; Vaghefi *et al.*, 2019). However, the precise neural representations for the attentiveness and affective melody of the Quran verses (i.e. 'Quranic chills') as recited in numerous recitation styles remain unexplored (Mustapha *et al.*, 2016).

Al Quran was unveiled in the manner of how it was recited in the Arabic language in separate Qiraat. People were divided into various tribes according to specific characteristics. The Arab race had separate tribes on the Arabian Peninsula. Examples are the Qurais, Thaqif, Kinanah Yaman, Huzail, Khurasan and Tamim tribes, each with their dialects and accents in various Arabic languages. That is why Al-Quran's insight is revealed in different Qiraats. It helps to make the different tribes feel more secure in learning the language and the recited sounds of Al-Quran as the conducts of Prophet Muhammad (PBUH).

To date, limited number of studies had employed EEG (especially 10-20 EEG technique) to relate brainwaves and behaviour in healthy subjects to correlate the neural representation involved (Barnby *et al.*, 2015). The 10-20 EEG technique is believed to be able to load information from human brainwaves to encode the potential neuronal activities during Quran recitation. So far, most such studies have applied limited channels of 20 and below with consideration of artefacts that may be involved during data acquisition. More recently, only one study had used EEG 128-dense array electrodes to explore the cerebral representation during a Quran verse recitation (Samhani *et al.*, 2019).

In this study, we had coupled the use of EEG (Antneuro cap) with MEG (Elekta Neuromag) in order to incorporate high temporal resolution afforded by MEG to gather additional information in neural activities, allowing source estimation of primary brain signals, and extended statistical analysis. The modern Elekta Neuromag modality has an excellent artefact removal technique known as Maxshield filter as reported by others (Taulu and Simola, 2006; Haumann *et al.*, 2016; Siems *et al.*, 2016b; Puce and Hamalainen, 2017).This simultaneous recording of MEG and EEG will provide additional information and robust findings due to the different sensitivities in capturing signals from the brain (Tadel *et al.*, 2011; Dubarry *et al.*, 2014; Gavaret *et al.*, 2015; Puce and Hamalainen, 2017; Tadel *et al.*, 2019; Tang *et al.*, 2019).

Furthermore, research in Quranic recitation to date, have been largely on alpha brainwaves (8-13Hz) rather than other slow brainwaves, including theta wave (4-7Hz) which is also recognised to associate with calmness and relaxation effects. Thus, data from alpha wave may not fully explain the calmness evoked by Quranic recitation. This is particularly relevant, given that theta brainwaves had been shown to be involved during meditation, as well as in deep relaxation and calmness (Gärtner *et al.*, 2015; Jirakittayakorn and Wongsawat, 2017b).

In addition, specific brain areas affected should also be identified in order to load more information as the cerebral localisations of the neural mechanisms. However, past Quranic recitation studies using EEG modality alone would not suffice to attain this. Thus, this study attempted to shift the focus on theta brainwave, and determine the various powers in spectrum analysis, trends of theta oscillations, source estimations of EEG and MEG, and advanced statistical analysis in order to establish novel neuroscientific leads in Quran recitation using the different *Qiraat* and *Tarannum*.

1.3 Research Questions

The current study explored from neuroscience context, the neurobiology of the human brain responses resulting from the melodic and rhythmic recitation of the Quran, in both among the Muslims and non-Muslims. The questions addressed by the study were as follows:

1. Do slow brainwaves such as theta demonstrate the calmness effects from the melodic and rhythmic recitation of the Quran?
2. How does the brain perceive the different intonations of the Quran recitation?
3. Are the frontal-midline and frontal-mental theta signals representative of the Quranic rhythm?
4. Where are the source estimations for the *Tarranum* and the different *Qiraat* in the human brain?
5. Do the different *Qiraat* show differences in cerebral representation?
6. Do the different tempos of Quran recitation show differences in cerebral representation?
7. What are the correlation data between regions of interest (ROIs) in EEG and MEG measurements?
8. How do the topography of the EEG and MEG look like in Quranic stimuli and non-Quranic stimuli?
9. Do the different faiths in groups show significant differences during Quran recitation and non-Quran recitation?

1.4 Research hypotheses

1.4.1 General hypothesis

The frontal midline EEG theta (FMT) and frontal-mental MEG theta brain signals provide the leads for the cerebral localisation of the neural substrates associated with the focused and melodious Quran recitation (‘Quranic chills’).

1.4.2 Alternative hypotheses

1. There are significant differences on theta power in two groups, Muslim and Non-Muslim during the Quranic recitation.

2. There are significant differences within stimuli according to frontal midline brain region during Quranic recitation.

3. There are significant differences in theta power correlation among frontal midline regions in EEG and MEG data.

1.4.3 Null hypotheses

1. There are no significant differences on theta power in two groups, Muslim and Non-Muslim during the Quranic recitation.

2. There are no significant differences within stimuli according to frontal midline brain region during Quranic recitation.

3. There are no significant differences in theta power correlation among frontal midline regions in EEG and MEG data.

1.5 Objectives

1.5.1 General objective

The study aimed to investigate the involvement of the frontal midline theta (FMT) (EEG) and frontal-mental theta (MEG) signals as the neural substrates in mapping the cerebral representations of the melodic and rhythmic Quran recitation among Muslim and non-Muslim groups.

1.5.2 Specific Objectives

i) To establish the psychological profile (state-trait anxiety) among study subjects using State-Trait Anxiety Inventory (STAI)

ii) To determine the source estimation of the resting state FMT from EEG recording

iii) To determine the source estimation of the resting state frontal mental theta from MEG recording

iv) To establish the FMT wave estimation in response to the receptive listening of rhythmic verses of the Quran using 61-channel EEG recording

v) To establish the complementary frontal mental theta wave estimation in response to the receptive listening of rhythmic verses of the Holy Quran using 306-channels MEG recording

vi) To correlate the theta power of regions of interest (ROI) from the EEG and MEG data recording during Quranic recitation

vii) To compare the similarities and differences in the neural representation between Quranic rhythm and non-Quranic rhythm

1.6 Significance of study

Meditation practice in Islam has a different approach and different method known as *Muraqabah* which essentially means being close to Allah. There are many practices that can achieve *Muraqabah* such as prayers, Quran recitation, *tafakkur*, and *dzikir*. All these practices require individuals to pay attention the most to God, mandating a specific hygiene and intention before performing the religious activities. Previous studies found that all these practices have positive effects and act as natural mediation for complementary and alternative therapy (Alwasiti *et al.*, 2010; Doufesh *et al.*, 2012; Doufesh *et al.*, 2014; Risser, 2018).

The modern neuronal activity recording techniques with simultaneous recordings of MEG and EEG provide the opportunity to explore in greater depths, the neural substrate and cerebral representation for better understanding of distinctive nature of the melodic recitation of Holy Quran on the brain. The current study offers a novel and scientifically sound evidence on the brain responses during receptive listening of melodic, Quranic recitation involving the slow theta brainwave as the neural substrate. This is to lend further support to the previous research in Quranic studies of alpha wave. Theta brainwaves play an important role in the cognitive study as they are related with meditation practice, music and/or deep relaxation. To the best of our knowledge, this study is the first to determine brainwave theta wave role in relation to the diversity in rhythm, intonation, and tempo of the Holy Quran recitation. Hence, the current study offers potential new finding as the neural basis of 'Quranic chills' (synonymous to 'musical chills' for music) which would guide its merit as a complementary therapy in a clinical setting for related future studies.

CHAPTER 2

LITERATURE REVIEW

This chapter elaborates the contributions of the alternative and complementary medicine as part of the natural therapy as the complementary medicine. The verses begin with the role, functions and effects of the music to the brain, followed by meditation practices as the religious chanting to evoke the calmness effect. Then, follows by deliberation on the Islamic meditation as practiced by Muslims, and the current knowledge on the roles of neural substrates as the potential neurobiological bases that lead to the knowledge gap that motivates the current study.

2.1 Music and the brain

Why do people listen to music? Human brain has musical inclination as music can attract emotions (Peretz, 2001). Research relating to music and the human brain have gained attention as shown by the wealth of published literatures (see Figure 2.1). Previous research indicated that musical functions mobilise neural mechanisms in both hemispheres with multiple brain regions activated at the same time within each hemisphere (Peretz, 2002; Patel, 2003; Koelsch, 2005; Webster and Weir, 2005; Juslin and Vastfjall, 2008; Koelsch, 2011; Arbib, 2013; Juslin and Sloboda, 2013; Nakhavali and Seyedi, 2013; Thaut, 2013).

Many studies have found that the areas of brain activation are related to goals-oriented and emotion processing, namely in thalamus, hippocampus, amygdala, prefrontal cortex, orbitofrontal cortex, midbrain, cingulate cortex, and periaqueductal gray (Koelsch, 2005; Juslin and Vastfjall, 2008; Kuzmanovic *et al.*, 2018; Gao *et al.*, 2019). Apart from that, another important finding is that human brain has specialisation in music (Altenmüller *et al.*, 2002; Peretz, 2002; Babiloni *et al.*, 2017; Papatzikis *et al.*, 2019). The concept of brain specialisation is the dominance or lateralization in the specific brain activation. Hemispheric specialization or dominance is characterized as a hemispheric-dependent relationship between a specific feature and a collection of brain structures, which includes both hemispheric interactions within a given hemisphere of specialized networks with unique functional properties and mechanisms that allow efficient interhemispheric coordination (Idris *et al.*, 2017).

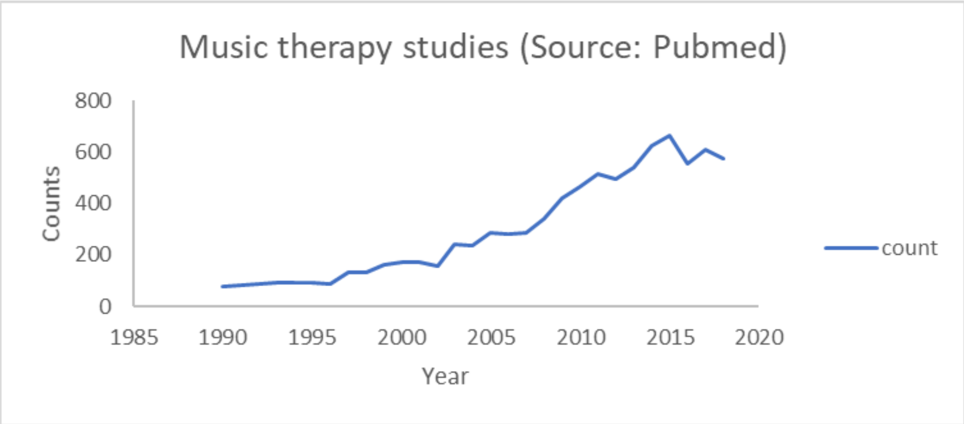

Figure 2.1 The graph shows the trends of studies related to music therapy between 1990 – 2020 (source: PubMed database)

Music is subjective and has more than a simple sequence of tones. Articulation of music relies on subtle variations in timbre, timing, pitch, dynamics, and interactions between performers (Herholz and Pantev, 2014). Musical harmonies are organised in a musical syntax. Some previous research investigated musical chords and chord progressions, where no special musical training is required to detect untypical chords (Maess *et al.*, 2001). Thus, irrespective of its combination elements, musical harmony appears to offer positive effects as a rewarding stimulus from neurobiological perspective.

2.1.1 Music and reward system in the brain

The prediction of rewarding stimuli or events is the principal goal in the research of cognitive neurosciences. Recent evidences in music research have revealed the interactions between sensory, cognitive, and emotional systems for musical pleasure. Dopamine is released in response to rewarding stimuli that are vital for life such as food and sex but some rewards such as music can come in abstract forms which are often taken as 'better than expected' (Kringelbach *et al.*, 2012; Oei *et al.*, 2012).This kind of 'better than expected' reward is subjective and requires the integration of individualised cortical processes that are known to shape by their personal experiences. It is also known that musical reward involves several neural and behavioural mechanisms, where it relies on the generation of expectations, anticipation in development, and reward predictions (Rohrmeier and Koelsch, 2012).

Rhythm is a part of music and composed of distinct temporal components such as pattern, meter, and tempo as illustrate in Figure 2.2. Numerous studies have attempted to explain the rewarding stimuli of musical rhythms to the brain. Exploratory studies on the effects of distinct rhythmic elements on different neural mechanisms had implicated several activations brain area, which include right frontal middle gyrus (FMG), right superior frontal gyrus (SFGR) and bilateral anterior cingulate cortex (ACC) (Thaut *et al.*, 2014).

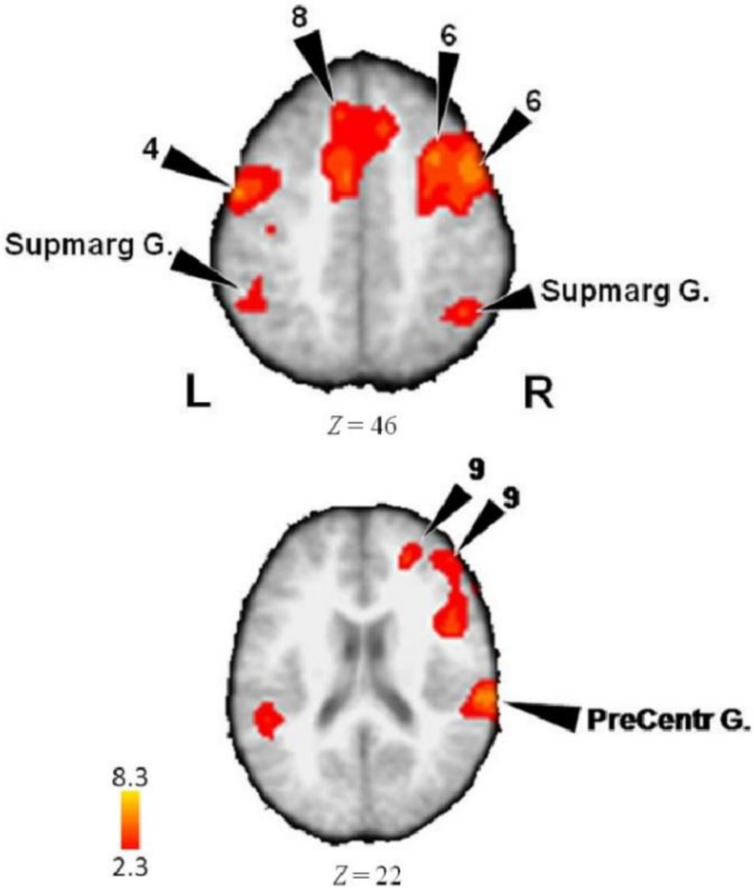

Figure 2.2 Activations in musical rhythm. Top image shows the activations of brain in supramarginal and medial frontal gyri, pre-central, and middle frontal areas. The colour scale represents the intensity of activations (in Z values). Bottom image shows the activations in inferior frontal, medial frontal, and pre-central gyri. Reproduced and adapted from Thaut et al. (2014).

Another related study is frequency dependent brain network during passive listening of music (Astor Piazolla) using 64 EEG channels in healthy participants (Carpentier *et al.*, 2019) as shown in

Figure 2.3 for the source localisation of alpha and beta bands. The findings of the alpha band oscillations have been traced in basic cognitive processes, which are linked to suppression and selection of attention, while beta rhythms appearing in bil[illegible] superior frontal gyrus are linked to musical perception.

(a)

(b)

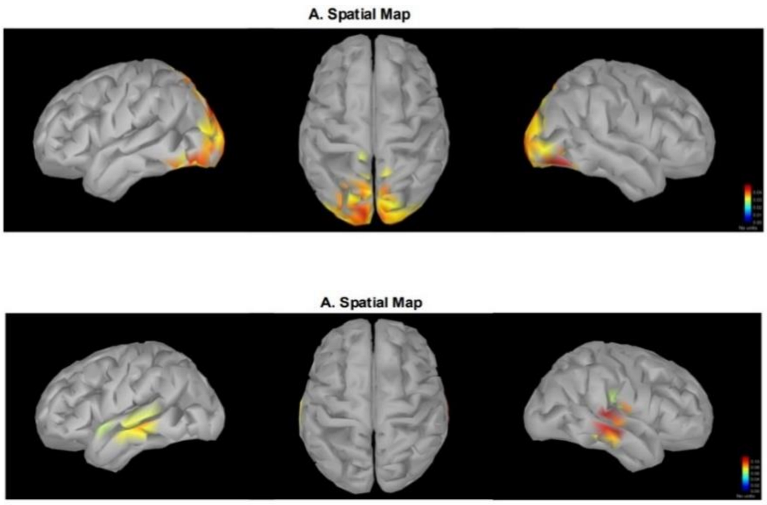

Figure 2.3 Source localization for alpha and beta bands. (a) Alpha frequency band during music listening. (b) Beta frequency band during music listening. Adapted from Carpentier *et al.* (2019).

2.1.2 Music Therapy

Recent evidences support that music has many positive effects that weight favourable potential in complementary therapy and within the clinical setting (Thaut, 2013). A randomised controlled clinical trial by Siedliecki and Good (2006) conducted on 60 subjects with chronic non-malignant pain syndromes (neck, back or joint pain for the past 6 months) who practiced not more than one natural therapy had found that listening to music in a certain frequency resulted in reduced pain, diminished depression symptoms, improved motor power, and improved abilities.

The role of music therapy in patients during radiotherapy treatment had also been reported by Rossetti *et al.* (2017). The research explored the impact of music therapy on anxiety and distress to patients who had first-time diagnosis of head, neck, or breast cancer. The study used STAI and Symptom Distress Thermometer as the parameters. The findings showed that the group with music therapy had significant reductions in anxiety and distress during the radiotherapy treatment compared to the control group without music therapy.

The first concept of state and trait anxiety was introduced by Cattell (Cattell & Scheier, 1961; Cattell & Warburton, 1961) and elaborated by Spielberger (Marteau & Bekker, 1992). STAI has been adapted to more than 60 different languages and dialects with citations in over 14,000 studies (Spielberger & Reheiser, 2009). STAI is a questionnaire to examine the levels of anxiety of individuals (Spielberger, 1970). It has also been used as self-report scales for assessing state and trait anxiety in research and clinical practices (Spielberger & Reheiser, 2009). In particular, STAI measures individuals' inclination to perceive diverse stimuli as threatening. As a result, individuals with traits of anxiety will tend to answer with anxiety-related responses (Buela-Casal & Guillén-Riquelme, 2017).

Mizuki *et al.* (1989) proposed FMT as a possible marker in patients with anxiety. In their research, the status of STAI score was used as a psychiatric measure to determine pre- and post-treatment anxiety rates. They find that anxiety relief represents the presence of FMT raise. In another study, music therapy was used for depressed patients by Fachneret al. (2013) that showed significant correlation of FMT with Hospital Anxiety and Depression Scale-Anxiety subscale (HADS-A) in reduction of anxiety and FMT power changes, where music therapy seemed to reduce anxiety in patients with depression as FMT power increased.

The basis for the potential of music as a therapy can be viewed from different configurations of music type that is known to induce different emotions ('musical chills'). Emotions constructed from musical expressions come with a few dimensions such as mode, consonance or dissonance, pitch, tempo, loudness, and complexity (Laukka *et al.*, 2013). Often considered relaxing music with slow tempos, this music type reduced physiological responses such as blood pressure, heart rate, and respiratory rate as compared to fast tempos. Moreover, ‘sad’ music with slow tempo evoked smaller responses on autonomic measures as compared to ‘happy’ music (Andrade and Bhattacharya, 2018).

Music is also classified as a form of an expressive expression and is commonly recognized as one of the main instruments for thrilling human emotions and feelings. Art love and enthusiasm is essential to all cultures and races. Art has multiple psychotherapeutic effects. The positive effect was later used in scientific complementary medicine. Like music which is used as an aid to natural healing, meditation is also increasingly accepted in the same role but with different approaches.

2.2 Meditation practices

Meditation practices exist all over the world. They are not confined to certain civilizations but have been widely practiced (Banquet, 1973; Lutz *et al.*, 2008; Braboszcz *et al.*, 2010; Mustapha *et al.*, 2016). Meditation refers to a practice that has high focus attention to physical or mental objects. It requires one’s attention for self-regulation in aiming a state of well-being and religious purposes (Manuello *et al.*, 2016; Van Dam *et al.*, 2018). Nowadays, people tend to practice it as a part of complementary and alternative treatment (de Castro, 2015; Pratzlich *et al.*, 2016; Black *et al.*, 2019) due to apparent positive effects on mental and physical health. Furthermore, the term “meditation” today is used in wide range of practices for self-regulation of emotion and attention (Braboszcz *et al.*, 2010). Meditation practices have gained attention from scientific researchers in terms of their influences on the brain and in clinical setting as shown by the growing number of publications in the area (see

Figure 2.4).

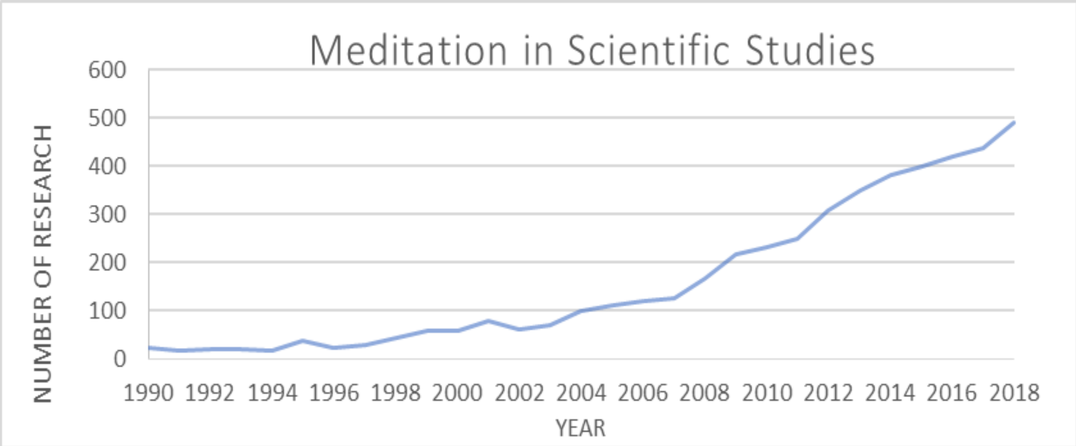

Figure 2.4 The trend of published studies related to meditation in scientific journals between 1990 – 2018 (source: PubMed database).

There are a few studies that explore the effects of these practices on physiological, attentional, and affective levels (Lehmann *et al.*, 2012; Manuello *et al.*, 2016). In neuroscience context, the goals are to identify the mapping of brain functions with mental processing (Proust, 2009) and alterations in brain morphology (Tang *et al.*, 2015). Meditation has also been reported to instigate changes in the mental functions with contrasting effect between beginner versus advanced meditators, and in healthy individuals versus patients (Holzel *et al.*, 2011; Ding *et al.*, 2015; Tang *et al.*, 2015). These contrasting effects are thought to be due to the fact that different conscious states are gained from different neurophysiological states (Cahn and Polich, 2006; Braboszcz *et al.*, 2010). In particular, the altered sensory, self-awareness, and cognitive experiences in meditation (i.e. meditation-induced state condition) serve as the bases for neuroscientific exploration (Vago and David, 2012). The neurophysiological effects observed during meditation-induced state had been proposed as a result of two factors: immediate changes that occur during meditation practices and accrual changes that build up over months or years (Braboszcz *et al.*, 2010).

In one meditation practice known as mindfulness, the known behavioural effects reported to occur in emotion regulations, attention control and self-awareness (Tang *et al.*, 2015). Correspondingly, studies involving mindfulness had found activations in several brain areas involved in emotion regulations (multiple prefrontal areas, limbic, and striatum), attention control (anterior cingulate cortex and striatum), and self-awareness (medial prefrontal cortex, posterior cingulate cortex, insula, and precuneus) as depicted by Figure 2.5. A few clinical studies in mindfulness meditation had also being applied on several disorders such as deficit disorder, depression, addiction, generalised anxiety and attention deficit (Bowen *et al.*, 2009; Hofmann *et al.*, 2010; Bowen *et al.*, 2014). A total of 1,140 patients who received Mindfulness Based Therapy (MBT) were involved in these studies. The most common condition observed was cancer, depression, generalized anxiety disorder, social anxiety disorder, bipolar disorder, chronic pain, chronic fatigue syndrome, fibromyalgia, attention deficit hyperactivity disorder, arthritis, binge eating disorder, diabetes, heart disease, hypothyroidism, insomnia, organ transplant, stroke, and traumatic brain injury (Hofmann *et al.*, 2010). Effect size (Hedges’ g) estimations suggest that MBT on perception was successful in the reduction of anxiety (Hedges = 0.63) and mood problems (Hedges' g = 0.59) both before and after diagnosis of the studied group.

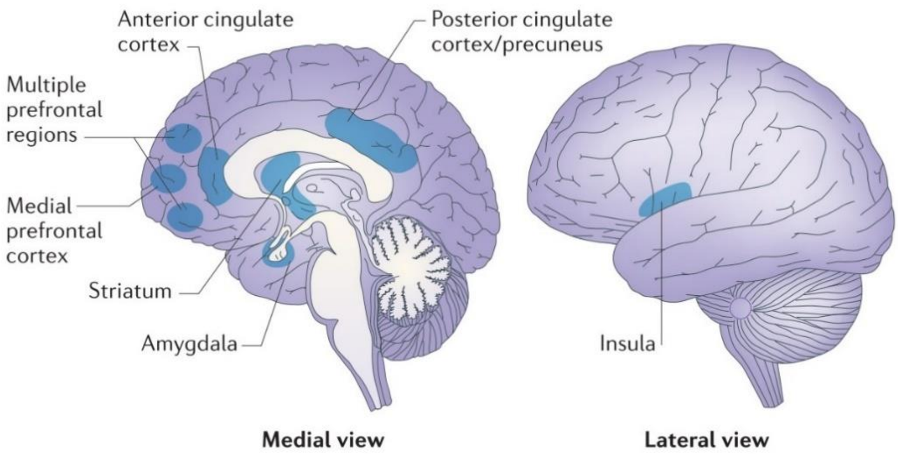

Figure 2.5 Schematic view of brain responses during mindfulness meditation in specific brain regions. Adapted from Tang *et al.* (2015).

As discussed above, the functions of the music and meditation practices had been shown to significantly improve the good of well-being including, both in selected clinical trial and from neurosciences perspectives. Hence, in this context, related Islamic practices that are also being reported to affect psychospiritual well-being as practiced by Muslims from numerous approaches, is the focus of the next section in this chapter.

2.3 Islam and meditation

The concept of meditation or mindfulness approach in Islam is known as *Al-Muraqabah*, a conscious state of comprehensive awareness of Allah with our inner states in relation to Him. It is the highest spiritual state attainable and has good realisation of excellence in faith known as *Al-Ihsan* (Parrott, 2017). There are many types of practices to achieve *Al-Muraqabah* from Islamic perspective, one of them is through learning and reciting the Quran.

Muslim all over the world have been practising and reciting the Quran well over 1400 years ago and using the same version of Quran. The main reasons of the Quran revelation are to guide mankind and heal the minds as described in Figure 2.6, Figure 2.7, Figure 2.8 and Figure 2.9.

From Figure 2.6, the Quran is revealed by God as an instruction manual of how people can manage their life. There are no contradictions and errors in the Quran as proof for those who believe that God created the world with a clear purpose, to worship Him. Muslims must understand and practice the teachings from the Quran as the priority in their lives.

ذَٰلِكَ ٱلۡكِتَٰبُ لَا رَيۡبَۛ فِيهِۛ هُدٗى لِّلۡمُتَّقِينَ ٢

Figure 2.6 Al-Baqarah (2:2) – This is the Book about which there is no doubt, a guidance for those conscious of Allah.

Figure 2.7 explains about fasting in the month of Ramadhan. Quran was revealed during this month through Prophet Muhammad SAW as the guidance for mankind until the end of day. This text highlights the words of guidance, and clear proof of guidance and creation. In order to understand the value of guidance, people should be able to conceptualise its purpose and appreciate the relationship between guidelines, standards, and outcomes. Fasting in Islam means abstaining from food, drink, sexual intercourse with spouse, and other things that can nullify the validity of the fast from dawn to dusk (Ibrahim, 2015). Fasting takes at least 13 hours to avoid people from fasting pretense and train them to focus on matters of worship. All the rules of fasting are described in the Quran as guidance. Muslim should obey these rules as the standards to achieve *Al-Muraqabah* during fasting to train themselves to be better individuals, empathise with lesser privileged people, and perform good deeds. After creating the world and mankind, God never leave us without any guidance to achieve the good life and the best outcomes. Allah SWT states this categorically in Ayatul Kursi (Al-Baqarah, 2: 255) as stated in Figure 2.8.

شَهْرُ رَمَضَانَ ٱلَّذِىٓ أُنزِلَ فِيهِ ٱلْقُرْءَانُ هُدًى لِّلنَّاسِ وَبَيِّنَٰتٍ مِّنَ
ٱلْهُدَىٰ وَٱلْفُرْقَانِ ۚ

Figure 2.7 Al-Baqarah (2:185) – The month of Ramadhan (is that) in which was revealed the Al-Quran, a guidance for the people and clear proof of guidance and creation.

ٱللَّهُ لَآ إِلَٰهَ إِلَّا هُوَ ٱلْحَىُّ ٱلْقَيُّومُ ۚ لَا تَأْخُذُهُۥ سِنَةٌ وَلَا نَوْمٌ ۚ لَّهُۥ مَا فِى ٱلسَّمَٰوَٰتِ وَمَا فِى
ٱلْأَرْضِ ۗ مَن ذَا ٱلَّذِى يَشْفَعُ عِندَهُۥٓ إِلَّا بِإِذْنِهِۦ ۚ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ ۖ
وَلَا يُحِيطُونَ بِشَىْءٍ مِّنْ عِلْمِهِۦٓ إِلَّا بِمَا شَآءَ ۚ وَسِعَ كُرْسِيُّهُ ٱلسَّمَٰوَٰتِ وَٱلْأَرْضَ ۖ وَلَا
يَـُٔودُهُۥ حِفْظُهُمَا ۚ وَهُوَ ٱلْعَلِىُّ ٱلْعَظِيمُ ﴿٢٥٥﴾

Figure 2.8 Al-Baqarah (2:255) – Allah, there is no deity except Him, the Ever-Living, the Sustainer of all existence. Neither drowsiness overtakes Him nor sleep. To Him belongs whatever is in the heavens and whatever is on earth. Who is it that can intercede with Him except by His permission? He knows what is presently before them and what will be after them, and they encompass not a thing of His knowledge except for what He wills. His *Kursi* extends over the heavens and the earth, and their preservation tires Him not. And He is the Highest, the Greatest.

The Holy Quran is the admonition, the cure, the mercy, and the guidance. The entire Quranic chapter are sources of healing for humans. Only six chapter directly address healing, one of them is from Figure 2.9. This verse discusses the instruction from God as rules to mankind, guidance, mercy, and healing therapy. Quranic chpater can be an alternative and complementary therapy for the believers.

يَٰٓأَيُّهَا ٱلنَّاسُ قَدۡ جَآءَتۡكُم مَّوۡعِظَةٞ مِّن رَّبِّكُمۡ وَشِفَآءٞ لِّمَا فِي ٱلصُّدُورِ وَهُدٗى
وَرَحۡمَةٞ لِّلۡمُؤۡمِنِينَ ٥٧

Figure 2.9 Yunus (10:57) – O mankind, there has to come to you an instruction (Al-Quran) from your Lord and healing for what is in the breasts and guidance and mercy for the believers.

Reciting the Quran is one of Islamic commandments and is highly encouraged to be done every day. It contains the manual of life and educates people on how to become good Muslim. Apart from that, Quran describes the rules, motivations, history, healing, and signs of creation and divinity (Akhtar, 2007). Previous studies had reported the effects of listening and reciting the Quran on human beings with scientific evidences. Listening to Quran can elicit positive emotions among patients or healthy subjects as well as enhancing health by attending Quranic therapy regularly (Mahjoob *et al.*, 2016; Saged *et al.*, 2018). Most of the studies focused on alpha brainwaves as the targeted neural oscillations to predict the behaviour during listening or reciting the Quran (Kamalet al., 2013; Zulkurnainiet al., 2012). The synopsis of the all Quranic studies (published in English) from neuroscience perspectives are summarised in Table 2.1.

Throughout several chapters and surah in the Quran, some of the chapters are specially used for healing and are used as an alternative therapy in Islam, for instance with the ritual use and recitation by Muslim of the *Al-Kursi* verses. This surah has seven verses, easy to read, and is used for recovery or healing of pain for mild care as the Isa (2015) wrote:

> *For everything there is a hump (pinnacle) and the hump (pinnacle) of the Quran is Surat Al-Baqarah, in it there is an Ayah which is the master of the Ayat in the Quran; that is Ayat Al-Kursi.*

The other important verses in Al-Kursi are the Name of God in the verses. The great advantages of ayat al-Kursi are due to the compilation of the names and characteristics of Allah such as Wahdaniyyah (The One), al-Hayah (The All-Living One), al-Qayyumiyah (The Eternal One), al-'Ilm (The All-Knowing One), al-Mulk (The Authority), al-Qudrah (The All-Powerful One) and al-Iradah (The Will) (Ayoup, 2016)