

**EXPLORING THE NEURAL PRESENTATION OF
RHYTHMIC QURANIC RECITATIONS USING
FUNCTIONAL BRAIN CONNECTIVITY**

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by

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LIST OF SYMBOLS

μV	Microvolts
Ca^{2+}	Calcium ion
Cl^- ,	Chloride ion
fT	femto-tesla
K^+	Potassium ion
Na^+	Sodium ion
pT	pico-tesla

LIST OF ABBREVIATIONS

AAL	Automated Anatomical Labelling
ACC	Anterior Cingulate Cortex
ADHD	Attention Deficit Hyperactivity Disorder
AN	Attentional Network
BOLD	Blood Oxygen Level-Dependent
CS	Complete Synchronisation
DAN	Dorsal Attention Network
DBA	Deep Brain Activity
DLPFC	Dorsolateral Prefrontal Cortex
DMN	Default Mode Network
EEG	Electroencephalography
EPSP	Excitatory Postsynaptic Potential
ERP	Event-Related Potential
FA	Focused Attention
FDR	False Discovery Rate
FEF	Frontal Eye Fields
fMRI	Functional Magnetic Resonance Imaging
FMT	Frontal Midline Theta
GB	Giga Byte
GR	Gyrus Rectus
GS	Generalised Synchronisation
H	Hijri
HG	Heschl's Gyrus
HPA	Hypothalamus-Pituitary-Adrenal
HPI	Head Position Indicators
HRV	Heart Rate Variability
Hz	Hertz
ICA	Independent Component Analysis
ICBM	International Consortium of Brain Mapping
IFG	Inferior Frontal Gyrus
IOG	Inferior Occipital Gyrus

IPG	Inferior Parietal Gyrus
IPS	Intraparietal Sulcus
IPSP	Inhibitory Postsynaptic Potential
LF	Low Frequency
LOC	Lateral Occipital Cortex
LPA	Left Preauricular Point
MCC	Middle Cingulate Cortex
MEG	Magnetoencephalography
MNI	Montreal Neurological Institute
MOG	Middle Occipital Gyrus
MPFC	Medial Prefrontal Cortex
MSR	Magnetically Shielded Room
OFC	Orbitofrontal Cortex
OM	Open Monitoring
PBUH	Peace Be Upon Him
PCA	Principal Component Analysis
PCC	Posterior Cingulate Cortex
PET	Positron Emission Tomography
PLV	Phase Locking Value
PoA	Place of Articulation
PS	Phase Synchronisation
PT	Planum Temporale
RPA	Right Preauricular Point
SFG	Superior Frontal Gyrus
SMA	Supplementary Motor Area
SNR	Signal-to-Noise Ratio
SOG	Superior Occipital Gyrus
SPG	Superior Parietal Gyrus
SQUID	Superconducting Quantum Interference Detector
SSP	Signal Subspace Projection
STAI	State-Trait Anxiety Inventory
STG	Superior Temporal Gyrus
SWT	Subhaanahu Wa Taala
TB	Tera Byte

Thal_LGN	Thalamus Lateral Geniculate
Thal_VA	Thalamus Ventral Anterior Nucleus
TPJ	Temporo-Parietal Junction
tSSS	Temporally Extended Signal Space Separation
USM	Universiti Sains Malaysia
VAN	Ventral Attention Network
VTA	Ventral Tegmental Area

LIST OF APPENDICES

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PENEROKAAN PRESENTASI NEURAL TERHADAP BACAAN QURAN BERITMA MENERUSI RANGKAIAN OTAK BERFUNGSI

ABSTRAK

Osilasi neuronal memberikan isyarat temporal dan ruangan yang berinteraksi dengan rangkaian neural bagi menyelaraskan proses neural yang pelbagai kepada fungsi kognitif aras tinggi. Gelombang otak berfrekuensi rendah iaitu teta (4 – 7 Hz) dan alfa (8 – 13 Hz) sering menjadi fokus utama dalam kebanyakan penyelidikan sebelum ini dalam mengkaji kesan mendengar bacaan Al-Quran. Ini berdasarkan tanggapan bahawa kehadiran gelombang ini menunjukkan kesan ketenangan dan santai ketika mendengar bacaan Al-Quran. Kajian ini meneroka peranan gelombang otak gama (30 – 80 Hz) beserta teta dan alfa, sebagai gambaran korelasi neural untuk bacaan Al-Quran beritma, satu aspek yang belum dikaji dalam kajian Al-Quran sebelum ini. Seramai 30 peserta (n = 15 Muslim, n = 15 bukan Muslim), telah direkrut secara rawak. Peserta menjalani rakaman magnetoensefalografi (MEG) dan elektroensefalografi (EEG) (M/EEG) secara serentak untuk merekodkan respons gelombang otak ketika mendengar secara pasif rangsangan auditori iaitu bacaan *Ayat Kursi* dalam *Murattal 'Asim*, *Murattal Susi* dan *Tarannum Asli*. *Ayat Kursi* ialah ayat paling agung di dalam Al-Quran yang mempunyai karakter linguistik dan estetika ritma yang menyembuhkan. Data M/EEG diproses dan dianalisa menggunakan perisian Brainstorm dan MATLAB sebagai asas. Purata anggaran sumber bagi osilasi neuronal dianggarkan daripada 170 kawasan otak berpandukan atlas AAL3. Aktiviti teta yang tinggi dapat dilihat di kawasan korteks singulat anterior (ACC) dan korteks midsingulat (MCC) dalam kumpulan Muslim dan hipokampus dalam kumpulan bukan Muslim. Aktiviti alfa yang tinggi dilihat di prekuneus dalam kedua-dua kumpulan,

menunjukkan terdapatnya peningkatan minda menerawang. Kedua-dua kumpulan juga menunjukkan aktiviti alfa yang tinggi di bahagian rangkaian visual, menganjurkan bahawa terdapat pengimejan visual secara mental. Bahagian tengah otak dilihat aktif untuk kesemua rangsangan auditori bagi kedua-dua kumpulan, menandakan terdapatnya proses persepsi bahasa dan pengucapan. Dapatan menunjukkan bahawa kedua-dua kumpulan Muslim yang biasa dengan bacaan berirama dan kumpulan bukan Muslim yang tidak biasa dengan bacaan Al-Quran menunjukkan pengaktifan otak yang meluas semasa bacaan Al-Quran, iaitu kawasan yang mempunyai peranan dalam emosi, kognitif, empati, pemprosesan memori, pengimejan visual dan persepsi bahasa. Kebanyakan bahagian otak di mana anggaran sumber dilakukan menunjukkan korelasi yang signifikan ($p < 0.05$). Rangkaian fungsian keseluruhan otak bagi data M/EEG dikira menggunakan Nilai Penguncian Fasa (PLV). Terdapat penyegerakan fasa teta yang signifikan antara girus frontal tengah (MFG) kanan dan girus angular (AG) kiri yang menunjukkan peranan MFG dalam mengorientasikan semula rangkaian perhatian dorsal dan ventral. Manakala, penyegerakan teta antara serebelum dan lobul parietal inferior dan peningkatan penyegerakan alfa pada bahagian tengah otak menunjukkan proses persepsi bahasa dan pemprosesan informasi fonologi. Rangkaian fungsian pada visual dan rangkaian mod ketentuan (DMN) dapat dilihat pada osilasi alfa dan gama. Selain itu, peningkatan keterlibatan operkulum Rolandic dan penglibatan ACC pada osilasi gama, berkait rapat dengan emosi positif ketika mendengar bacaan Al-Quran. Ringkasnya, kajian ini merupakan kajian pertama yang mengkaji gelombang teta, alfa dan gamma yang menunjukkan bahawa mendengar bacaan Al-Quran dengan ritma yang berbeza dapat mewakili gambaran neural yang mempengaruhi emosi positif, kognitif sosial, empati, kawalan perhatian dan proses memori melalui pemetaan rangkaian otak.

EXPLORING THE NEURAL PRESENTATION OF RHYTHMIC QURANIC RECITATIONS USING FUNCTIONAL BRAIN CONNECTIVITY

ABSTRACT

Neuronal oscillations provide temporal and spatial signals that interact with the neural network to coordinate distinct neural processes into a higher cognitive function. The low-frequency neuronal oscillations, i.e., theta (4 – 7 Hz) and alpha (8 – 13 Hz), were the focus of most studies studying the effect of listening to Quranic recitations. This was based on the notion that these oscillations indicate the calmness and relaxation effect induced when listening to the Quranic recitation. This present study expanded the role of neuronal oscillations to include the high-frequency gamma waves (30 – 80 Hz) and the theta and alpha waves for previously unexplored neural correlate of rhythmic Quranic recitations. Thirty (30) healthy participants (n = 15 Muslim, 15 = non-Muslim) were randomly recruited and subjected to simultaneous recording magnetoencephalography (MEG) and electroencephalography (EEG) (M/EEG) to record the brainwaves response during passive listening to three different Quranic recitation styles, i.e., *Murattal Asim*, *Murattal Susi* and *Tarannum Asli* of the *Ayatul Kursi* verse. *Ayatul Kursi* is the greatest verse in the Al-Quran, which has healing linguistic and rhythmic aesthetics. The recorded M/EEG data were pre-processed and analysed using Brainstorm software in MATLAB environment. The average volume source estimation of the neuronal oscillations was estimated from the 170 brain regions of the AAL3 atlas. Higher theta activities were found at the anterior cingulate cortex (ACC) and midcingulate cortex (MCC) in the Muslim group and hippocampus in the non-Muslim group. High alpha activities could be seen at the precuneus in both groups, indicating increased mind-wandering. Both groups also showed alpha activation in the

brain regions correlated to the visual network, proposing visual mental imagery of the auditory stimuli. The central regions of the brain seemed to be activated in all auditory stimuli in both groups, indicating there were language and speech perceptions involved. The results emphasize that, despite the likely extent of familiarity differences to rhythmic Quranic recitation between the Muslim and non-Muslim groups, widespread brain activations were shown involving regions that have roles in emotion, cognition, empathy, memory processing, visual imagery and language perception. The majority of the brain regions where source estimations were made had shown significant correlations ($p < 0.05$). Whole brain source-level functional connectivity of the M/EEG data was quantified using Phase Locking Value (PLV). There was significant theta phase synchrony between the right middle frontal gyrus (MFG) and the left angular gyrus (AG), points to the role of MFG in reorienting the attention, presumably from the shifting of attention from mind-wandering to focusing on the Quranic recitation. Meanwhile, synchronising the cerebellum and the regions at the inferior parietal lobule in theta and increased alpha synchrony at the central regions might point to language perception and processing of the phonological information. Functional connectivity at the visual and default mode networks (DMN) could also be seen in alpha and gamma oscillations. Furthermore, increased Rolandic operculum and ACC engagement in gamma oscillation correlate to a positive feeling when listening to the rhythmic Quranic recitation. To summarise, the current study is the first of its kind of theta, alpha, and gamma neuronal oscillations to show that listening to Quranic recitations with different rhythmic styles of *Ayatul Kursi* may represent the neural correlate that underlie the anecdotal claims reported to influence positive emotion, social cognition, empathy, attention, language perception, and memory processing with the evidence of the brain connectivity mapping.

CHAPTER 1

INTRODUCTION

1.1 Background

The brain is the most intricate, complex, and powerful single organ, serving as the command centre for all bodily functions. It is enabled by the interconnection of neuron synapses that form the massively interconnected neural network. This serves as the biological hardware foundation from which all of our thoughts, perceptions, feelings, and behaviour emerge (Fornito, Zalesky, & Bullmore, 2016; Goldblum, 2004).

The degree of brain capabilities is yet to be precisely known. To date, however, numerous studies have been conducted using newer and more innovative neurotechnology and methodology to unravel the mystery of the human brain. Moreover, there is a recent trend in searching for more holistic and alternative interventions in mind-body behaviour because of its potent abilities.

This could be seen from the myriad neuroscientific studies that have reported through alternative mind-body interventions such as meditation practices and music therapy (listening and/or performing music) with brain signalling activities, structure and neural connectivity can be altered (Kaneshiro, Nguyen, Norcia, Dmochowski, & Berger, 2020; Lee, Kulubya, Goldin, Goodarzi, & Girgis, 2018; Reybrouck, Vuust, & Brattico, 2018), positive results in mental health progress (Innes, Selfe, Khalsa, & Kandati, 2016; Khalsa, 2015; Weingarten, Levy, & Berghella, 2021), improved immune system (Khalsa, 2015; Rebecchini, 2021), enhanced attention (Kozasa et al., 2012; Taruffi, Pehrs, Skouras, & Koelsch, 2017), increased emotional self-regulation (Aalbers et al., 2017; Manuello, Vercelli, Nani, Costa, & Cauda, 2016; Supnet, Crow,

Stutzman, & Olson, 2016), reduced cellular ageing (Innes et al., 2018), and improved learning and cognitive performances (Gold, Frank, Bogert, & Brattico, 2013; Ramirez-Barrantes et al., 2019).

In the same vein, listening to Quranic recitation has been shown to have all these beneficial effects (Che Wan Mohd Rozali et al., 2022; Frih et al., 2017; Ghiasi & Keramat, 2018; Mehrafsar & Mokhtari, 2018; Putra, Gumilar, Kusuma, Purnomo, & Basumerda, 2018). This is due to the background knowledge that the Quran is the Word of God and the musical elements that the Quranic recitation comprises. Furthermore, the anecdotal evidence from faithful Muslims claims that listening to Quranic recitation can give an inner sense of calmness, leading to research on the effect of listening to Quranic recitation (Shab et al., 2017; Vaghefi, Nasrabadi, Golpayegani, Mohammadi, & Gharibzadeh, 2015; Reza, Begum, Omar, Muzaimi, & Abdullah, 2012). This could be due to the involvement of attention control and internalised emotions. This experience is similar to when one meditates or listens to music, as deduced from several neuroscientific studies on meditation and music (Lee, Kulubya, Goldin, Goodarzi, & Girgis, 2018; Innes, Selfe, Khalsa, & Kandati, 2016; Supnet, Crow, Stutzman, & Olson, 2016). Nonetheless, the neuroscientific research on the effect of Quranic listening is built on the notion that the rhythmic and melodious sound from the Quranic recitation, coupled with the connectedness to the Almighty, can give inner calmness and tranquillity.

The Quran can be portrayed as a meditative Islamic scripture in which the holy scripture is recited melodiously with *alhan* (eloquent), *tajweed* (intonation/rules in recitation) and *tarannum* (hymn-like), resulting in the experience of “Quranic chills” as experienced by Muslims worldwide (Mustapha, Rani, Reza, Daud, & Ghani, 2016). This “Quranic chills” is said to be equivalent to that of an experience one gets when

listening to music that gives them the “musical chills”, i.e. the intense internalised emotional often accompanied by an autonomic or psychophysiological element (Blood & Zatorre, 2001; Colver & El-Alayli, 2016).

Furthermore, the semantic content of the Quran, which is full of messages from the Almighty, can heighten emotion, particularly in the case of those who understand Arabic. This phenomenon can be traced back to the story of Khalifah Umar Al-Khattab embracing Islam. Upon hearing and understanding the meaning of the recitation of the Quran (Surah Taha, 20:14), he wept intensely and later embraced Islam (as-Suyuti, 1995). This story particularly shows the significance of “Quranic chills”, which could arise from the involvement of both rhythmic and semantic elements.

Recent advances in neuroscience research, particularly using magnetoencephalography (MEG) and electroencephalography (EEG) (M/EEG), have renewed interest in brainwave analysis as a neural representation of various human behaviours. Several studies using M/EEG have been conducted recently to investigate the effects of Quranic recitations on changes in brain oscillations (theta, alpha and gamma brainwaves) and the cognitive effects. Such studies have reported that receptive listening to Quranic recitation increases the theta (Reza, Begum, Omar, Muzaimi, & Abdullah, 2012; Shab et al., 2017; Vaghefi, Nasrabadi, Golpayegani, Mohammadi, & Gharibzadeh, 2015) and alpha power (Al-Galal & Alshaikhli, 2017). There is also an increase in the gamma power as the high-frequency brainwave when listening to the Quranic recitation (Taha Alshaikhli, Yahya, Pammusu, & Alarabi, 2014).

The presence of neuronal oscillations has provided leads to suggest the neural correlation of listening to Quranic recitation to various cognitive processes such as attention and memory (Reza et al., 2012). Besides, their presence also indicates the

relaxation and calm effect elicited by the Quranic recitation towards the listeners, regardless of their understanding of the Quranic verses.

Neuronal oscillation synchronisation has been proposed as a mechanism for selective functional integration of neural populations mediating perceptual and cognitive brain networks. The synchronisation of neuronal oscillations activates the brain's networks, assisting in the efficient broadcasting of information between relevant brain regions (Helfrich & Knight, 2016). The synchronisation of the different brainwaves has its role in supporting cognitive and emotional processes that need further investigation regarding rhythmic Quranic recitation which to date, remain unexplored in relation to the rhythmic Quranic recitations.

However, not many neuroscientific studies have been done regarding the effect of listening to Quranic recitation on the brain using current neurotechnological methods and data analysis. In this context, instead of analysing the varying brainwaves power of the neuronal oscillation in isolation as reported in the previous literature, this current study explored the neural connectivity during receptive listening of rhythmic Quranic recitation between the brainwave oscillations of theta, alpha and gamma frequency bands. By doing this, we can elucidate the brain regions and the neuroanatomical associations of the brain regions' functions in processing auditory stimuli. Thus, giving a novel knowledge in the neural representation of various rhythmic Quranic recitations used in this study.

Hence, this study explored the effects of receptive listening of different styles of Quranic verse recitation on neural connectivity through the lens of the neuronal oscillations (theta, alpha and gamma frequency bands) using simultaneous M/EEG. To date, there are still limited studies on the effects of receptive listening of Quranic

recitations of the brainwave analysis, and none on the connectivity analysis to our best knowledge.

1.1.1 Scope of the study

For this study, we emphasised our investigation of the neural correlations of a universal religious practise among Muslims worldwide: the recitation of the Quran. We explored the neural connectivity of the different Quranic recitation styles through three leading neuronal oscillations within the following study scopes:

1.1.1(a) Scope of Ayatul Kursi

This study chooses *Ayatul Kursi* (The Throne) verse from the second chapter *Al-Baqarah* as the Quranic recitation verse. *Ayatul Kursi* is the 255th verse of *Al-Baqarah* and is a relatively short verse that describes Allah's greatness and how nothing else in the universe is considered comparable to Allah. It is said to be the most well-known single verse in the Quran, and it is one of the verses that is memorised by heart by Muslims worldwide.

1.1.1(b) Scope of different Quranic recitation styles

Three different recitation styles of the *Ayatul Kursi* verse, namely, *Murattal 'Asim*, *Murattal Susi* and *Tarannum Asli*, were used in this study. The three recitation styles were chosen based on their tempo, rhythm and phonological differences.

1.1.1(c) Scope of neural connectivity

Neural connectivity was examined by Phase Locking Value (PLV) using Brainstorm software on M/EEG simultaneous continuous data.

1.1.1(d) Scope of synchronisation effects

Synchronisation effects on neuro-affective and cognitive functions were examined in theta, alpha and gamma brainwaves. This was done by analysing the

neural network involved and then explained according to their functional neuroanatomy.

1.2 Problem statement and significance of the study

Presently, there is growing interest in the neuroscientific exploration of the effects of rhythmic Quranic recitation concerning the overall impact on the mind and body. The appeal comes from the notion that the melodious rhythmicity of Quranic recitation elicits positive effects as the musical rhythms to the brain. This is because the Quranic recitation also has musical syntax characteristics rooted in its internal and external musical features (Akbar, 2009).

This study is significant as it explored the neural correlate of the different ways of reciting the Quran, namely *Murattal 'Asim*, *Murattal Susi* and *Tarannum Asli*, which had not been well-studied from the neuroscience perspective in previous studies. The different recitation styles could affect how the listeners' brains react and respond to it. These three different recitation styles have different tempos, rhythms and phonology that may affect the listeners differently. In addition, according to Sheikh Rifaat (d. 1950), a prominent and celebrated Quranic reciter from Egypt, every listener has a preferred recitation style they are exceptionally responsive to (Nelson, 1982). Besides, the reciting style is of utmost importance, especially to listeners who do not understand Arabic or are unfamiliar with the sound of Quranic recitation. They can only relate to the recitation's rhythm and vocalisation.

The simultaneous recording of M/EEG in this study also helps provide additional information in the source estimation of brainwaves as these modalities provide different sensitivities in capturing signals from the brain (Puce & Hämäläinen, 2017). Furthermore, increasing the number of electrodes/sensors, a minimum of 32

EEG electrodes (Brodbeck et al., 2011), is necessary to increase the spatial resolution localisation of the signal's source. Most previous studies on the rhythmic Quranic recitation applied low-density EEG (≤ 20 electrodes) considering artefacts involved during data acquisition.

This current study provides novel and scientifically sound evidence of the brain responses during rhythmic Quranic receptive listening, involving slow theta (4 – 7 Hz), medium alpha (8 – 13 Hz), and fast gamma (30 – 80 Hz) brainwaves as the neural substrate. To the best of our knowledge, this study is the first to determine theta, alpha and gamma brainwaves' role in the different styles of Quranic recitation.

In addition, exploring brain areas and their connectivity in processing the different Quranic recitation styles can provide more information on the neural representation of each style. As a result, the current study provides a potential new finding, the neural basis of which would guide its merit as a complementary therapy, not only as psycho-spiritual therapeutic therapy but also in cognitive function.

1.3 Research questions

The current study explored from the neuroscience context the neurobiology of the human brain responses during receptive listening to the different recitation styles of rhythmic Quranic recitations. The questions addressed by the study were as follows:

- 1) Do slow (theta), mid (alpha), and fast (gamma) brainwaves demonstrate the different effects of the rhythmic Quranic recitation?
- 2) What impacts do the differences in the rhythmic Quranic recitation styles have on the functional connectivity of the brain regions involved?
- 3) What are the source estimations for the different Quranic recitation styles for different frequency bands?
- 4) How does the brain perceive the different melodies from the Quranic recitations?
- 5) Do the different *Qiraat* show differences in neural representation?
- 6) Do the different tempos of Quran recitation show differences in neural representation?

1.4 Research hypothesis

This section describes the general hypothesis as well as the alternative and null hypotheses of this study.

1.4.1 General hypothesis

The targeted brainwaves, which are the theta, alpha and gamma brain signals provide the lead for the neural presentations associated with the receptive listening to the various rhythmic Quranic recitation styles, which are *Murattal 'Asim*, *Murattal Susi* and *Tarannum Asli*.

1.4.2 Alternative hypotheses

1. There are differences in the volume source estimation of the targeted brainwaves on the brain regions during passive listening to *Murattal 'Asim* rhythmic Quranic recitation between Muslim and non-Muslim groups in the MEG and EEG data.
2. There are differences in the volume source estimation of the targeted brainwaves on the brain regions during passive listening to *Murattal Susi* Quranic recitation between Muslim and non-Muslim groups in the MEG and EEG data.
3. There are differences in the volume source estimation of the targeted brainwaves on the brain regions during passive listening to *Tarannum Asli* Quranic recitation between Muslim and non-Muslim groups in the MEG and EEG data.
4. There are differences in functional connectivity (PLV) of the neural pathways for the targeted brainwaves during passive listening to *Murattal 'Asim* Quranic recitation in the MEG and EEG data.
5. There are differences in functional connectivity (PLV) of the neural pathways for the targeted brainwaves during passive listening to *Murattal Susi* Quranic recitation in the MEG and EEG data.
6. There are differences in functional connectivity (PLV) of the neural pathways for the targeted brainwaves during passive listening to *Tarannum Asli* Quranic recitation in the MEG and EEG data.

1.5 Research objectives

This section explains the general objective of this study as well as the specific objectives.

1.5.1 General objective

The study aimed to investigate the theta, alpha and gamma brainwaves as the neural representations in the source estimation and functional connectivity (PLV) mapping of the neural pathways during passive listening of three different styles of *Ayatul Kursi* rhythmic Quranic recitation (*Murattal 'Asim*, *Murattal Susi* and *Tarannum Asli*) using 306-channels MEG and 61-channels EEG simultaneous recording in Muslim and non-Muslim groups.

1.5.2 Specific objectives

1. To determine the volume sources estimate of the targeted brainwaves as neural representations of *Murattal 'Asim* in both groups for the passive listening.
2. To identify the volume sources estimate of the targeted brainwaves as neural representations of *Murattal Susi* in both groups for the passive listening.
3. To determine the volume sources estimate of the targeted brainwaves as neural representations of *Tarannum Asli* in both groups for the passive listening.
4. To establish the functional connectivity (PLV) of the neural pathways in response to *Murattal 'Asim* passive listening for the targeted brainwaves in MEG and EEG data.
5. To evaluate the PLV of the neural pathways in response to *Murattal Susi* passive listening for the targeted brainwaves in MEG and EEG data.
6. To determine the PLV of the neural pathways in response to *Tarannum Asli* passive listening for the targeted brainwaves in MEG and EEG data.

1.6 Operational definition of the study keywords

Ayatul Kursi and Tajweed

Ayatul Kursi contains several verses that describe Allah's greatness and is the 255th verse of Chapter *Al-Baqarah* of the Quran. *Ayatul Kursi*, as guided by Prophet Muhammad (PBUH), is held in high regard by Muslims as a powerful verse in protecting themselves from evils (i.e., from their surroundings and/or within themselves), as well as having its healing effects. Muslims are taught to recite the Quran, including *Ayatul Kursi*, with *tajweed*. *Tajweed* is a set of recitation rules designed to regulate, codify, and preserve the nature of revelation and the accent of Quranic recitation as the word of God, as originally revealed to the Prophet (PBUH). These rules govern the Quranic recitation, distinguish it from all other text recitations, speeches, and musical forms and make the sound uniquely Al-Quran.

Theta, alpha and gamma neuronal oscillations

Human theta brainwaves can be found in cortical and subcortical areas, with an oscillation range of 4 – 7 Hz. Theta oscillations have been linked to various cognitive functions, including memory (Hsieh & Ranganath, 2014), encoding new information (Klimesch, 1999), making decisions (Cavanagh, Figueroa, Cohen, & Frank, 2011) and attention (Harris, Dux, Jones, & Mattingley, 2017).

Alpha oscillations (8 – 13 Hz) are thought to originate from the thalamus and cortex (Basar, Schurmann, Basar-Erogluc, & Karakas, 1997; Schurmann & Basar, 2001). The alpha oscillatory mechanism plays a role in the selective attention mechanism due to its inhibitory function (Payne & Sekuler, 2014).

Gamma brainwaves are neural oscillations that occur at 30 – 80 Hz (Buzsáki & Draguhn, 2004) and have the smallest amplitude compared to other types of

brainwaves. Gamma oscillations have also been linked to various cognitive functions, such as a general neural correlate of human attention and consciousness.

These brainwaves can be measured using the neuroimaging technique, namely EEG and MEG.

Simultaneous recording of M/EEG

The brain signals measured by MEG and EEG emerged from the same sources: the synchronised postsynaptic currents in and around apical dendritic pyramidal cells (Hämäläinen, Hari, Ilmoniemi, Knuutila, & Lounasmaa, 1993). Both of these modalities are primarily sensitive to cortical currents. Still, each method observes a slightly different aspect of brain activity due to differences in sensitivity to cortical current orientation and location (Puce & Hämäläinen, 2017).

MEG is only sensitive to tangentially oriented sources, but EEG can capture sources from both tangential and radial sources (Ahlfors, Han, Belliveau, & Hamalainen, 2010; Hämäläinen et al., 1993; Puce & Hämäläinen, 2017). As a result, the combination of both techniques, simultaneous M/EEG recording, is expected to yield more accurate results, in particular, to determine the source of theta, alpha and gamma activities during passive listening to Quranic recitations.

Functional Connectivity

The functional connectivity in this study is quantified through Phase Locking Value (PLV). Functional connectivity is the temporal correlation of the variations between different brain regions. The communication between the spatially segregated neuronal events plays a crucial role in complex cognitive processes.

Phase Locking Value (PLV)

Phase locking value (PLV) measures the phase synchrony between two time-series. A phase-locking analysis is especially well-suited for connectivity analysis because it measures neural signal temporal relationships independent of signal

amplitude (Schmidt, Ghuman, & Huppert, 2014). This method was analysed through open-source software, Brainstorm.

1.7 Summary

This introductory chapter has covered the key aspects of this study. These included the background of the research, problem statements and significance of the study, gaps in knowledge and the study objectives. As a continuation of this thesis, the next chapter reviews the previous literature relevant to the present study and the critical aspects pertinent to the objective of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Linguistic Miracle of Al-Quran

The word Quran is derived from the Arabic word, *qa-ra-a*, which means to read or to recite. Therefore, Quran as a verbal noun would mean ‘the recitation’ or ‘the reading’. It is the speech of Allah that was revealed in the Arabic language to Prophet Muhammad (PBUH) through the Angel Gabriel as a divine revelation and was revealed in stages over the course of 23 years (Yasir Qadhi, 1999). Al-Quran has been preserved over the years in its exact words and meanings, and no human being can produce something similar and parallel to the verse of Al-Quran. Allah guaranteed protection and preservation of Al-Quran from being corrupted;

“Indeed, it is We who sent down the Qur’an and indeed, We will be its guardian” (Al-Quran, 15:9), and He also pledged to explain it; “Then upon Us is its clarification [to you]” (Al-Quran, 75:19).

Al-Quran is strictly not poetry nor rhymed prose. It is the word of Allah that was revealed to be a guide to the Muslim believers. However, it is a fact that the rhyming system of Al-Quran is extraordinary, which incites many scholars to try to uncover it. In earlier Surahs, for example, Meccan Surahs, i.e. Surahs and verses revealed in Mecca before Hijrah, are short and concise (Yasir Qadhi, 1999). The main reason is to attract the Mecca people at that time to listen to the revelation and message from Prophet Muhammad (PBUH). This is because Arabs were known for their eloquence and poetic skill, and they considered brevity and shortness of the statement of a speech to be a fine discourse. They were also very fond of rhymed and rhythmical speech, which caused the poet to have a high rank in Arabic tribes, acting as spokesperson and communicator of news (Farahi, 2008; Quotah, 1995).

That is why, in the earlier phase of Al-Quran revelation to the Prophet Muhammad (PBUH), Al-Quran verses adopted the Arabs' favourite style of expression, which is in terse rhythmical prose, so that they are attracted to listen to the messages and revelation of Al-Quran from Prophet Muhammad (PBUH). The style of expression also differed from Surah to Surah, making Al-Quran's composition unique.

The rhythmic sound and literary value of Quranic verse had caused the Arab Meccans to accuse Prophet Muhammad of being a poet and sorcerer that tried to enchant them with the magical words of Al-Quran when they first heard the recitation of Al-Quran from Prophet (PBUH). This event has been reported in Al-Quran, Surah As-Saffat, verse 36;

And were saying, "Are we to leave our gods for a mad poet?" (Al-Quran, 37:36) Allah answered their question and stated that Prophet Muhammad is not a poet; "And We did not give Prophet Muhammad, knowledge of poetry, nor is it befitting for him. It is not but a message and a clear Qur'an" (Al-Quran, 36:69).

It is impossible for Prophet (PBUH) to write and compose the Al-Quran as he was illiterate. Hence, the unique and sophisticated composition of the Al-Quran is the words of God, revealed to Prophet (PBUH) as a guide for the believers. In addition, this sophisticated and unique composition of the Al-Quran is one factor making Al-Quran hard to be understood. Although the *mushaf*, or the book of Al-Quran can be physically accessible to all, people who are not familiar with the words of Al-Quran and even Muslims themselves find it hard to discern the composition of the Al-Quran. For years, people have criticised Al-Quran as being disconnected and incoherent because its 114 Surahs are not arranged in chronology or theme order (Cuypers, 2015). Instead, most topics are addressed with abrupt changes from one topic to another and then back again, even within the individual Surah.

Islamic scholars have addressed this issue with the work of Imam Fakhruddin Al-Razi (d. 1210), that showed interest in the subject of Quranic science. Quoted from him,

“The greater part of the Qur’anic intricacies and wisdom is buried in the fine arrangement and correspondence of the [surah and the verses of the] Qur’an” (Farahi, 2008).

Other Islamic scholars continued the work of Imam Al-Razi, and one of the scholars that further refined the Quranic science by introducing novel ideas such as coherence and interconnection between verses and Surah is Imam Hamid al-Din Farahi (d. 1930). The work of Imam Farahi is important to ensure that people who read Al-Quran can understand and ponder the message that the Al-Quran carried. Imam Farahi uses the term Nizam Al-Quran to include both types of coherence: thematic and structural (Farahi, 2008).

Not only had the work of Muslim scholars tried to uncover the miracle of the Al-Quran, but Western scholar also showed their interest in the Quranic science. For example, one of the ground-breaking works was done by Cuypers (2015) that showed Al-Quran is arranged according to the law of symmetry. Three types of symmetry that manifest in Al-Quran are, a) parallelism, where the structures take the form of AB/A'B', b) chiasm, where the structure takes the form of inverted parallelism (mirror composition), AB/B'A', and c) concentricism, where it is the same like chiasm, but it has a centre element, AB/C/B'A', hence also known as ring composition. This ring composition can be found for example in Surah Yusuf, Surah Al-Baqarah and also *Ayatul Kursi* (Cuypers, 2015).

2.2 Rhythmic Miracle of Al-Quran

The euphony and the musicality of the oral recitation of Al-Quran is made possible by the internal and external musical features that it comprises (Akbar, 2009).

The internal musical features can be divided into two levels. The first level is the text structure from the Al-Quran itself, such as a phonological character encompassing the composition and onomatopoeia, poetic and positional arrangement, end rhymes, coda and refrain. The second level of internal feature is the *Tajweed* system which forms the unique sound and rhythmic system of Quranic recitation. On the other hand, the external musical feature, as the third level, involves the recitation using melodic modes of Arabic songs in *mujawwad* style, for example, the *Tarannum Asli* style of recitation. Figure 2.1 illustrates the three levels of the euphony and musicality of Al-Quran oral recitation.

Furthermore, the internal musical features of Al-Quran make the sound of Al-Quran unique and inimitable, which is called *I'jaz Al-Quran*. The composition of the text character (Level 1) and the *Tajweed* system (Level 2) gives Al-Quran its divine identity. At the same time, the external musical feature (Level 3) is to decorate and embellish the sound of Al-Quran. Collectively, these levels imply that the element of Arabic songs represent an external factor and separate from Al-Quran. Its role is to be the additional ornament to the beautiful sound of Al-Quran. Hence, even without the embellishment, the sound of Al-Quran is unique and beautiful on its own (Akbar, 2009).

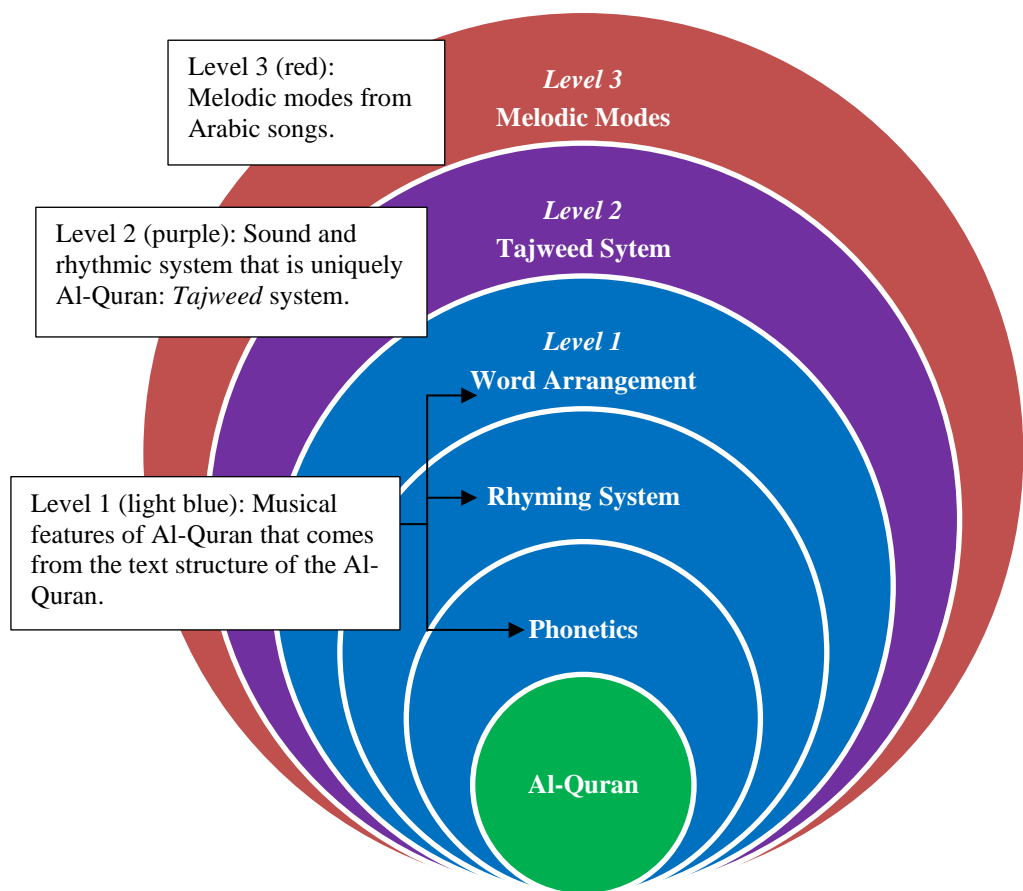


Figure 2.1: The three levels of euphony and musicality of Al-Quran recitation

2.3 The art of *Tajweed*

Tajweed is derived from the Arabic root ‘jawwada’, which means to make well, improve, or make good (Nasallah, 2016). The inextricable and comprehensive art or rules that regulate the correct oral pronunciation and enunciation of reciting the Al-Quran (Yasir Qadhi, 1999). Its function is to regulate, codify and preserve the nature of revelation and accent of Quranic recitation as the word of God as the original ways the Al-Quran was revealed to the Prophet (PBUH) (Nelson, 2001; Quotah, 1995).

Tajweed emphasises the importance of enunciating each phoneme from its point of articulation (*makhraj*) (see Figure 2.2). The phonological system of *tajweed* is unique to Quranic recitation, although there are few in spoken Arabic. The rules and

processes governed by *tajweed* include nasality, assimilation, extra-long vowels (madd), pharyngealisation, vowel epenthesis, pauses, and a certain sense of rhythm.

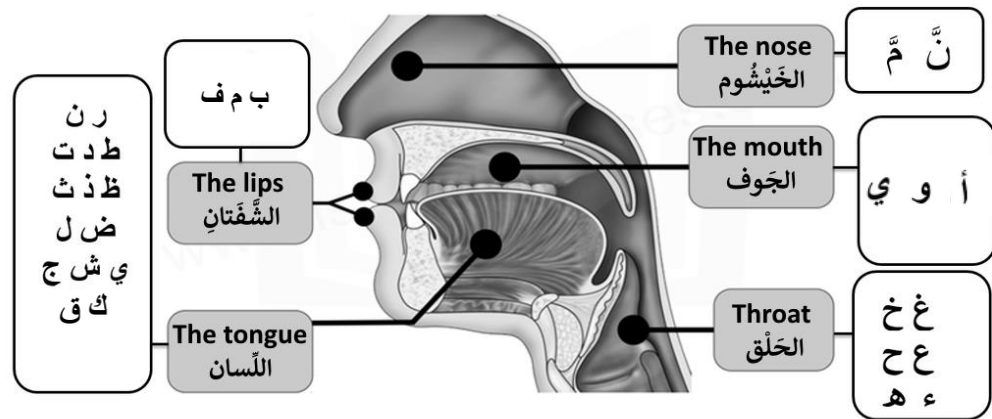


Figure 2.2: The five (5) main places of articulation (*makhraj*) of Arabic letters (Adapted from <https://en.al-dirassa.com/the-points-of-articulation-of-arabic-letters-tajweed-rules/>).

Muslims, when learning to read Al-Quran, are first exposed to and acquainted with these rules that comprised the fundamentals of Arabic alphabets and their origin, their phonetic sounds, different types of pauses and syllabic durations (Ahmad, 2005). These rules govern the Quranic recitation and set it forever apart from all other text recitations, speeches, and musical forms. In addition, as part of the Quran learning, it is mandatory for Muslims to learn about *tajweed* to recite the Al-Quran more fittingly, and according to the rules.

As the general art of vocal recitation, *tajweed* encompasses many traditions and types of oral recitations. The basic one is the *murattal* (sometimes called *tartil*) or measured and precise, usually less melodic cantillation. As the style of recitation most commonly used in prayer, personal devotion, and education, it has been and continues to be the fundamental form of Al-Quran recitation. While *Mujawwad*, at its most ornamented, incorporates more melodically modulated and musically cadenced forms of cantillation. The quality of voices and musical ability is more prominent in

mujawwad compared to the less modulated *murattal* form of recitation (Graham, 1993; Nelson, 2001).

Without *tajweed* as the basis of all recitations, the semantic content of the Quranic verse could have been distorted and differed from its actual meaning. If this happens, the reciter will not gain reward from the Quranic recitation as reciting according to *tajweed* and listening to Quranic recitation will be rewarded accordingly by Allah SWT. Interestingly, reciting Al-Quran with proper *tajweed* has been shown to increase heart rate variability (HRV) (Nayef & Wahab, 2018). HRV has been considered a surrogate parameter of the complex interaction between the brain and cardiovascular system (Ernst, 2017).

The relationship of Al-Quran and *tajweed* is a combination that cannot be separated in which *tajweed* is the internal musical feature that makes the sound of Al-Quran unique.

2.3.1 Qiraat as the technical discipline

With *tajweed*, there comes the rule of *qiraat*, a different text-system which classifies the different applications of the rules of *tajweed* (Dogan, 2014; Nelson, 2001; Yasir Qadhi, 1999). The word *qiraat*, which originated from the root ‘qa-ra-a’, according to Al-Sabuni can be defined as this;

“Qiraat is the school of thought (mazhab) in method of recitation of Al-Quran where the scholar of different school of thoughts (Imam Qurra’) prescribed different ways in reciting Al-Quran in terms of pronunciation and enunciation through the ways of Prophet (PBUH) recitation” (Al-Sabuni, 1985).

Qiraat is the knowledge of various readings and the modes of speed and tempo of recitation. The differences modes of tempo can be divided into three, which are *hadr* (fast tempo, usually use in memorising the Al-Quran), *tadwir* (medium tempo as usually incorporated during *salāt/prayer*) and *tahqiq* (slowest tempo usually used

during Tilawah Al-Quran, i.e. Quranic recitation competition, and also for teaching and learning purposes (Nasallah, 2016; Nelson, 2001).

Qiraat is the variants in words and elocutions of Quranic recitation and is the preserved verbalisation of the Quran as revealed to the Prophet Muhammad (PBUH) to the present day through oral transmission (Yasir Qadhi, 1999). These variants are typically synonymous words or differently voweled readings of the consonantal base text and represent divergent oral rather than written text (Graham, 1993). In general, *qiraat* is the body of knowledge about the different pronunciations and recitations of Al-Quran as the form of easiness that Allah SWT gave to His servants.

As the Arabic race as a whole had various tribes living in the Arabian Peninsula, for example Quraisy, Thaqif, Kinanah Yaman, Huzail, Khurasan and Tamim where each of the tribes spoke in different Arabic dialects and accent, this is one of the reasons for the recitation of Al-Quran feature seven *qiraat* (reading), whilst preserving its meaning.

This shows that the revelation of Al-Quran in the Arabic language through different *qiraat* is the ultimate grace and wisdom from Allah SWT to the followers of Prophet Muhammad (PBUH). In Surah Al-Hujurat, verse 13, Allah had stated:

“O mankind, indeed We have created you from male and female and made you peoples and tribes that you may know one another. Indeed, the most noble of you in the sight of Allah is the most righteous of you. Indeed, Allah is Knowing and Acquainted” (Al-Quran, 49:13)

From this verse, it is recognised that Allah SWT had created different tribes with different distinguishing traits that are known to each of the tribes. Thus, this is the reason for the wisdom of Al-Quran being revealed in different *qiraat*. It is to ease and facilitate the different tribes to learn the language and sound of Al-Quran as the ways of Prophet Muhammad (PBUH) (Sobki, Yusof, & Yusof, 2017).

Narrated Ibn ‘Abbas:

Prophet Muhammad (PBUH) said, “Jibril read the Qur’an to me in one way (i.e. dialect) and I continued asking him to read it in different ways till he read it in seven ahruf (different ways)” (Sahih Bukhari, Book of Virtues of the Qur’an, Vol. 6, Book 61, Hadith 513).

Prophet Muhammad thought his companions (*sahabah*) about the recitation of the Al-Quran as the ways he received the revelation from Angel Jibril, which are in seven different ways (*ahruf*). However, it should be noted that the relationship between the acknowledged variant readings of Al-Quran, which is the *qiraat* to the seven *ahruf* is rather a subject of much discussion and debate in Islamic world. Most scholars agree that the seven *ahruf* does not refer to the seven *qiraat* but the basis of the variant of the *qiraat* come from the phonetic materials of the seven *ahruf* hence the variant in readings and recitations of the Al-Quran (Yasir Qadhi, 1999).

The Prophet’s companions continued the teaching of Al-Quran, i.e., *sahabahs* (generation of people who live and learn directly from Prophet Muhammad (PBUH)) to the *tabi’in* (generation of people after the death of Prophet) who settled all over the Arabian Peninsula. The effort of *sahabahs* in spreading the knowledge of Al-Quran is being continued by *tabi’in* that gained the knowledge through *mutawatir* (transmission that has numerous independent chains of transmitters) hence preventing the possibility of the knowledge from being corrupted.

Through the *mutawatir* method, there are seven *mutawatir qiraat* and three *masyhur qiraat* (*masyhur*: slightly less wide transmission compared to *mutawatir* but deemed adequate to prevent any error). Each *qiraat* was named accordingly to the Imam Qurra’, who was the leader and authoritative reader for the particular *qiraat* (Sulaiman, 2011). There was ten (10) famous Imam Qurra’, and one of them was Abu Bakr ‘Asim bin Bahdalah Abi al-Najud al-Kufi al-Hannat al-Asadi (-127H) thus, the *qiraat* is named *Qiraat ‘Asim*. Each *qiraat* is conserved and preserved by the two Imam Qurra students, and they are called *Rawi* or “Transmitter”. They are responsible for

spreading the knowledge of *qiraat* that they learned from the Imam. The readings from the two students can be secondarily traced back to the Imam Qurra' and are called as *Riwayah*.

For example, in *Qiraat 'Asim*, the two *riwayahs* are from Imam Hafs and Imam Shu'ba as the two students of Imam Qurra' 'Asim. Nowadays, *Qiraat 'Asim* through the *riwayah* of Hafs (*Qiraat: Hafs 'an 'Asim*) is the most popular, with ninety-five per cent (95%) of Muslims around the world, including in Malaysia, use it (Yasir Qadhi, 1999). Figure 2.3 describes the transmission of the reading (*sanad*) that can be traced back to Prophet Muhammad PBUH.

In our study we use two different *qiraat* which are *Qiraat 'Asim riwayah Hafs* (referred to as *Murattal 'Asim*) and *Qiraat Abu 'Amr riwayah Susi* (referred to as *Murattal Susi*). *Qiraat Abu 'Amr* got its name from Imam Abu 'Amr Zabban bin al-'Alla bin 'Ammar bin al-'Uryan al-Mazini al Tamimi al-Basri (68H-154H). Imam Abu 'Amr had two students who acted as *rawi*: Ad-Duriyy and Susi. *Qiraat Abu 'Amr* is mainly used by Muslims in African region (Yasir Qadhi, 1999).

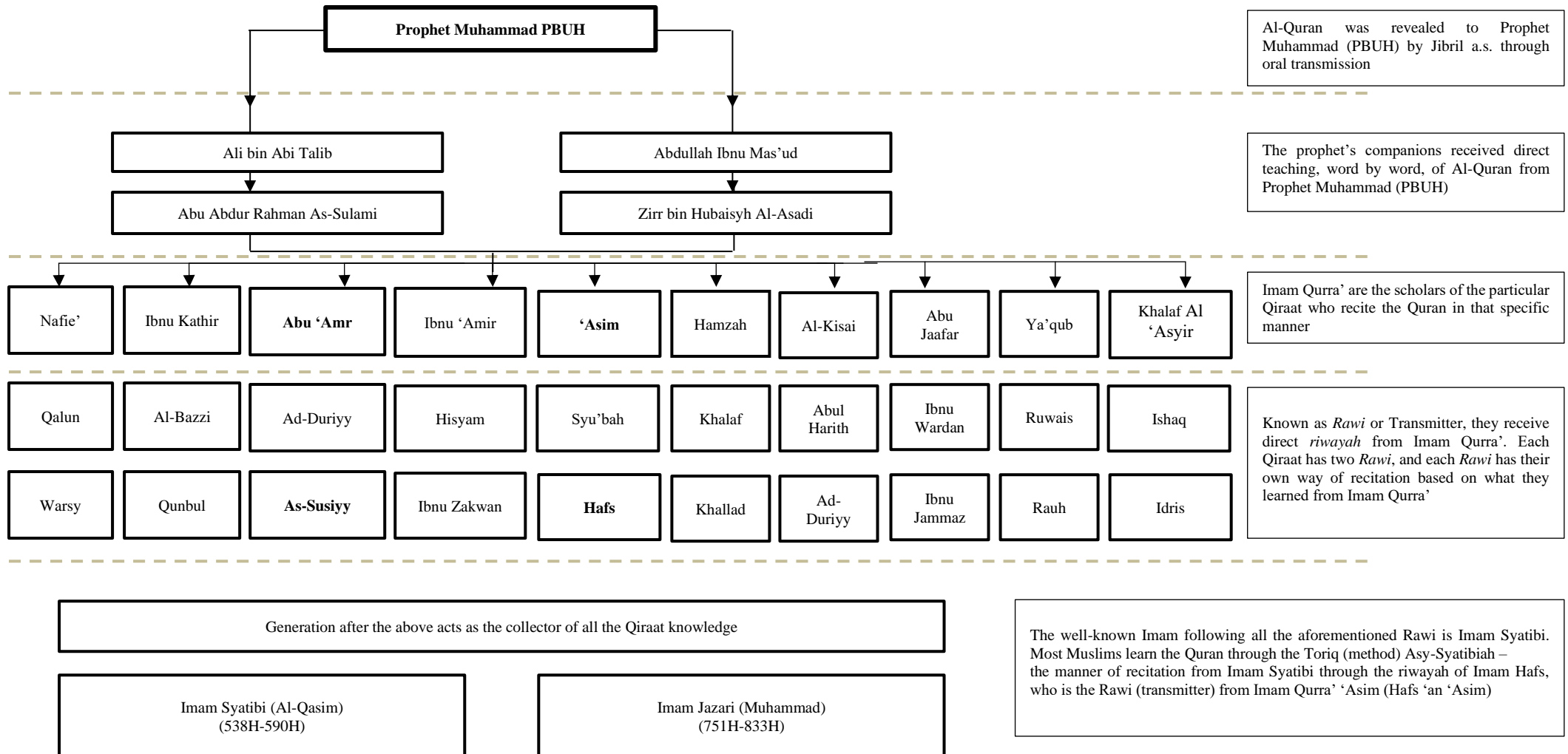


Figure 2.3: Description of sanad of Qiraat