

**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**

**UNIVERSITI SAINS MALAYSIA**

**2021**

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

by

**NUR SYAIRAH BINTI AB RANI**

**Thesis submitted in fulfilment of the requirements  
for the degree of  
Doctor of Philosophy**

**March 2021**

## ACKNOWLEDGMENTS

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, I praise and thank Allah SWT for all the strengths to be able to complete this thesis. A special dedication to my inspirational main supervisor, Assoc. Prof. Dr. Muzaimi Mustapha, who has always positively encouraged and guide me throughout this research journey; without your patience and excellent mentoring of me, I would falter to reach this final touch. To my co-supervisors, Dr Faruque Reza and Associate Prof Dr Wan Nudri Wan Daud, I thank you for your dedication and superb coaching during my PhD journey. Thank you goes to my family, especially to my lovely husband, Muhammad Ghazali Yahya, who is always by my side, your patience and prayers make meant a world to me. Special dedication also to both of my beloved daughters, Najjah and Nasuha with your gifts of endless smiles as my best comforts when things are challenging. To my beloved mother, Norma Ismail, your tremendous support for me from the beginning of this journey is something that I can never repay. Special thanks to my in-laws, who always pray and understand my research needs. Lastly, to members of my NeuroQuran team: Faizatul Aisyah, Mas Syazwanee, Dr. Mohammad Hakimi, Dr Ahmed Abdalla Kannan and Muhd Waqiyuddin; thanks a lot, for your tremendous contribution and cooperation. I also like to thank Ustaz Amiri Ab Ghani from Department Al-Quran and Hadith, Sultan Ismail Petra International Islamic College for the guidance in Qiraat and Quranic part. I also like to acknowledge Sheikh Hisham Al-Barri, an expert reciter in Qiraat and Tarannum from Iskandariah, Mesir for his contribution in Quranic recitation. It is not complete too without the help from Ustaz Wan Syarafi Wan Mustaffa as the Arabic translator during Quranic recording with Sheikh Hisham. A special thanks to everyone at the Department of Neurosciences: the staff and postgraduate students; and to other staff and friends in Universiti Sains Malaysia, Health Campus for all your kind support and prayers during my Ph.D. journey. Finally, thank you to Ministry of Higher Education (MyBrain 15) for the scholarship given and USM research grant supports (Fundamental Neuroscience– Neurobehaviour (BrainReward and Anti-Reward) (1002/CNEURO/910114) and Grant of Delineating Cerebral Correlates of the Qiraat and Tarannum of the Holy Quran from The Brain Frontal Theta Wave Signals (1001.PPSP.812189) for the support throughout the research. It means a lot to me.

## TABLE OF CONTENTS

<b>ACKNOWLEDGMENTS .....</b>	<b>ii</b>
<b>TABLE OF CONTENTS .....</b>	<b>iii</b>
<b>LIST OF TABLES .....</b>	<b>xiii</b>
<b>LIST OF FIGURES .....</b>	<b>xxii</b>
<b>LIST OF ABBREVIATIONS .....</b>	<b>xxxvi</b>
<b>ABSTRAK .....</b>	<b>xxxviii</b>
<b>ABSTRACT.....</b>	<b>xli</b>
<b>CHAPTER 1 INTRODUCTION.....</b>	<b>1</b>
1.1 Background .....	1
1.2 Problem statement and study rationale .....	4
1.3 Research Questions .....	7
1.4 Research hypotheses .....	8
1.4.1 General hypothesis .....	8
1.4.2 Alternative hypotheses .....	8
1.4.3 Null hypotheses .....	8
1.5 Objectives .....	8
1.5.1 General objective.....	8
1.5.2 Specific Objectives .....	9
1.6 Significance of study.....	9
<b>CHAPTER 2 LITERATURE REVIEW.....</b>	<b>11</b>
2.1 Music and the brain.....	11
2.1.1 Music and reward system in the brain .....	13
2.1.2 Music Therapy .....	15

2.2 Meditation practices .....	17
2.3 Islam and meditation .....	20
2.4 Melody and rhythm in Quranic recitation .....	28
2.4.1 Qiraat in Quranic Recitation .....	29
2.4.2 Tarannum in Quranic recitation .....	31
2.5 Theta Brainwave as the source candidate .....	33
2.6 FMT and frontal mental theta reflect the behaviour of cognitive functions .....	34
2.6.1 Frontal midline EEG (FMT) .....	34
2.6.2 Frontal mental MEG .....	37
2.7 Signal processing in MEG and EEG .....	38
2.8 MEG and EEG Multimodal Integration .....	41
2.9 Summary and conceptual framework .....	44
<b>CHAPTER 3 METHODOLOGY .....</b>	<b>46</b>
3.1 Study design .....	46
3.2 Ethical consideration .....	46
3.3 Study flow chart .....	47
3.4 Participants .....	48
3.4.1 Background of the subject .....	48
3.4.2 Sample size calculation .....	49
3.4.3 Subjects preparation .....	50
3.5 State Trait Anxiety Inventory (STAI) .....	51
3.5.1 Description and Application of STAI .....	52
3.5.2 STAI Adult Scoring .....	53
3.6 Stimuli design .....	53
3.6.1 Pre-resting state and post-resting state .....	54

3.6.2 Quranic verses stimuli .....	54
3.6.2(a) Quranic recitation version 1: Murattal Qiraat ‘Asim Riwayat Hafs (Murattal Qiraat Asim) .....	55
3.6.2(b) Quranic recitation version 2: Murattal Qiraat Abu ‘Amr Riwayat Al-Susiy (Murattal Susi) .....	56
3.6.3 Non-Quranic stimuli .....	56
3.6.4 Sequence of stimuli auditory presentation .....	57
3.7 EEG/MEG data acquisition.....	57
3.7.1 Impedance setting .....	58
3.7.2 MEG/EEG view in time series .....	59
3.7.3 The overview of data .....	60
3.8 The flow chart of the analysis pipeline .....	61
3.8.1 MNI coordinates .....	64
3.8.2 Setting for deep structures .....	64
3.8.3 Location and orientation constraints .....	65
3.9 Pre-processing of MEG and EEG .....	66
3.9.1 Zero-time setting .....	66
3.9.2 Bad channels detection and removal in EEG/MEG .....	67
3.9.3 Notch filter.....	68
3.9.4 TSSS for MEG data.....	69
3.9.5 Artefacts detection in pathology.....	70
3.9.6 External contamination.....	70
3.9.7 Internal artefacts .....	70
3.9.8 Other artefacts .....	71
3.9.9 Independent Component Analysis (ICA) and Signal Source Projection (SSP).....	72
3.9.10 Stationary test .....	73

3.10 Processing analysis .....	73
3.11 Frontal channel.....	75
3.11.1 The EEG layout .....	77
3.11.2 The MEG layout .....	78
3.12 Region of interest.....	79
3.13 Source localisation of EEG and MEG .....	92
3.14 Statistical analysis .....	92
3.14.1 Pearson correlation .....	92
3.14.2 Two Way Mixed ANOVA .....	92
<b>CHAPTER 4 RESULTS.....</b>	<b>94</b>
4.1 Introduction.....	94
4.2 Demographic and psychological profiles.....	94
4.2.1 Psychological assessment.....	95
4.3 Resting state condition(EEG) .....	96
4.3.1 MRI-view .....	98
4.3.2 Sagittal view .....	99
4.3.3 Coronal view .....	100
4.3.4 Frequency band .....	101
4.4 Resting state condition (MEG) .....	102
4.4.1 MRI-view .....	103
4.4.2 Sagittal view .....	104
4.4.3 Coronal view .....	105
4.4.4 Frequency band .....	106
4.4.5 Summary of the EEG and MEG comparison in both groups for resting state.....	107

4.5 Frontal-middle theta EEG waves localization for Ayatul Kursi recitation styles in the dual faith group.....	107
4.5.1 Quran Recitation- Murattal Asim style .....	110
4.5.1(a) MRI-view.....	110
4.5.1(b) Sagittal view .....	111
4.5.1(c) Coronal view .....	112
4.5.1(d) Frequency band.....	113
4.5.2 Quranic recitation – Murattal Susi style .....	114
4.5.2(a) MRI-view.....	114
4.5.2(b) Sagittal view .....	115
4.5.2(c) Coronal view .....	116
4.5.2(d) Frequency band.....	117
4.5.3 Quranic recitation – Tarannum Asli style .....	118
4.5.3(a) MRI-view.....	118
4.5.3(b) Sagittal view .....	119
4.5.3(c) Coronal view .....	120
4.5.3(d) Frequency band.....	121
4.5.4 Quran Recitation – Hadr style .....	122
4.5.4(a) MRI-view.....	122
4.5.4(b) Sagittal view .....	123
4.5.4(c) Coronal view .....	124
4.5.4(d) Frequency band.....	125
4.5.5 Summary of the EEG findings in theta power source estimation in comparison all Quranic recitation styles .....	126
4.6 Frontal-mental theta MEG waves localization for Ayatul Kursi recitation styles in the dual faith group.....	127
4.6.1 Quranic Recitation – Murattal Asim style.....	129



4.6.1(a) MRI-view .....	129
4.6.1(b) Sagittal View .....	130
4.6.1(c) Coronal view .....	131
4.6.1(d) Frequency band.....	132
4.6.2 Quranic recitation – Murattal Susi style .....	133
4.6.2(a) MRI-view .....	133
4.6.2(b) Sagittal view .....	134
4.6.2(c) Coronal view .....	135
4.6.2(d) Frequency band.....	136
4.6.3 Quran recitation – Tarannum Asli style .....	136
4.6.3(a) MRI-view .....	136
4.6.3(b) Sagittal view .....	137
4.6.3(c) Coronal view .....	138
4.6.3(d) Frequency band.....	139
4.6.4 Quran Recitation – Hadr style .....	141
4.6.4(a) MRI-view .....	141
4.6.4(b) Sagittal view .....	142
4.6.4(c) Coronal view .....	143
4.6.4(d) Frequency band.....	144
4.6.5 Summary of the MEG findings in theta power source estimation in comparison all Quranic recitation styles .....	145
4.7 Correlation of the volume source among brain regions in FMT (EEG) and frontal-mental theta (MEG) for the different Quranic recitation styles with cerebral localisation .....	146
4.7.1 EEG Findings .....	147
4.7.1(a) Murattal Asim in Muslim group .....	147
4.7.1(b) Murattal Susi in Muslim group.....	149

4.7.1(c) Tarannum Asli in Muslim group .....	151
4.7.1(d) Hadr in Muslim group .....	153
4.7.1(e) Murattal Asim in non-Muslim group.....	155
4.7.1(f) Murattal Susi in non-Muslim group .....	157
4.7.1(g) Tarannum Asli in non-Muslim group .....	159
4.7.1(h) Hadr in non-Muslim group .....	161
4.7.2 MEG findings .....	163
4.7.2(a) Murattal Asim in Muslim group .....	163
4.7.2(b) Murattal Susi in Muslim group.....	165
4.7.2(c) Tarannum Asli in Muslim group .....	167
4.7.2(d) Hadr in Muslim group .....	169
4.7.2(e) Murattal Asim in non-Muslim group.....	171
4.7.2(f) Murattal Susi in non-Muslim group .....	173
4.7.2(g) Tarannum Asli in non-Muslim group.....	175
4.7.2(h) Hadr in non-Muslim group .....	177
4.8 Similarities and differences in the neural representation (theta power in EEG and MEG) between Quranic recitation styles and non-Quranic rhythm .....	180
4.8.1 Normality test .....	180
4.8.2 EEG Statistical Analysis within stimuli according to brain region .....	181
4.8.2(a) The EEG theta (mean) in stimuli and group .....	181
4.8.2(b) Brain region: ACCpreL .....	185
4.8.2(c) Brain region: ACCpreR .....	186
4.8.2(d) Brain region: ACCsubL.....	187
4.8.2(e) Brain region: ACCsubR.....	188
4.8.2(f) Brain region: ACCsupL .....	189
4.8.2(g) Brain region: ACCsupR.....	190

4.8.2(h) Brain region: AMYGL .....	191
4.8.2(i) Brain region: AMYGR .....	192
4.8.2(j) Brain region: MCCL.....	193
4.8.2(k) Brain region: MCCR .....	194
4.8.2(l) Brain region: PCCL.....	195
4.8.2(m) Brain region: PCCR.....	196
4.8.2(n) Brain region: PFCventmedL.....	197
4.8.2(o) Brain region: PFCventmedR .....	198
4.8.2(p) Brain region: FMGL.....	199
4.8.2(q) Brain region: FMGR.....	200
4.8.2(r) Brain region: SFGL.....	201
4.8.2(s) Brain region: SFGR .....	202
4.8.2(t) Brain region: SFGmedialL .....	203
4.8.2(u) Brain region: SFGmedialR .....	204
4.8.3 MEG Statistical Analysis within stimuli according to brain region.....	205
4.8.3(a) The MEG theta (mean) in stimuli and group.....	205
4.8.3(b) Brain region: ACCpreL .....	210
4.8.3(c) Brain region: ACCpreR .....	211
4.8.3(d) Brain region: ACCsubL.....	212
4.8.3(e) Brain region: ACCsubR.....	213
4.8.3(f) Brain region: ACCsupL .....	214
4.8.3(g) Brain region: ACCsupR.....	215
4.8.3(h) Brain region: AMYGL .....	216
4.8.3(i) Brain region: AMYGR .....	217
4.8.3(j) Brain region: MCCL.....	218

4.8.3(k) Brain region: MCCR .....	219
4.8.3(l) Brain region: PCCL.....	220
4.8.3(m) Brain region: PCCR.....	221
4.8.3(n) Brain region: PFCventmedL.....	222
4.8.3(o) Brain region: PFCventmedR .....	223
4.8.3(p) Brain region: FMGL.....	224
4.8.3(q) Brain region: FMGR.....	225
4.8.3(r) Brain region: SFGL.....	226
4.8.3(s) Brain region: SFGR .....	227
4.8.3(t) Brain region: SFGmedialL .....	228
4.8.3(u) Brain region: SFGmedialR .....	229
<b>CHAPTER 5 DISCUSSION .....</b>	<b>230</b>
5.1 Psychological Assessment .....	230
5.2 Frontal-middle theta EEG waves .....	232
5.2.1 Resting state EEG.....	233
5.2.2 Quran recitation - Murattal Asim .....	234
5.2.3 Quran recitation - Murattal Susi .....	235
5.2.4 Quran recitation - Tarannum Asli style .....	236
5.2.5 Quran recitation – Hadr style .....	237
5.3 Frontal-mental theta MEG waves .....	238
5.3.1 Resting State MEG .....	238
5.3.2 Quran Recitation – Murattal Asim Style .....	239
5.3.3 Quran Recitation – Murattal Susi Style.....	240
5.3.4 Quran Recitation – Tarannum Asli Style .....	241
5.3.5 Quran Recitation – Hadr Style .....	242

5.4 Correlation of frontal-middle EEG and MEG theta with cerebral localization .....	243
5.4.1(a) EEG findings.....	243
5.4.1(b) MEG findings .....	244
5.5 Neural representation comparisons between Quranic and non-Quranic rhythms .	248
5.5.1 Normality test on brain region.....	248
5.5.2 Mix ANOVA statistical analysis .....	248
5.5.2(a) EEG findings.....	248
5.5.2(b) MEG findings .....	250
5.6 Summary of the findings.....	251
5.6.1 The summary of the findings.....	252
5.6.2 The study implications .....	253
5.6.2(a) EEG and MEG research.....	253
5.6.2(b) Use of Advanced analysis.....	253
5.6.2(c) Melodic Quranic listening in Neurosciences perspective.....	253
<b>CHAPTER 6 CONCLUSION.....</b>	<b>254</b>
6.1 Limitation of the study.....	255
6.2 Future Recommendation.....	256
<b>REFERENCES.....</b>	<b>257</b>
<b>APPENDICES .....</b>	
<b>Appendix A: Ethical Approval .....</b>	
<b>Appendix B: State and Trait Anxiety Inventory License .....</b>	
<b>Appendix C: Data Collection Form .....</b>	
<b>Appendix D: Consent Form .....</b>	
<b>Appendix E. Normality test on all brain regions .....</b>	
<b>Appendix F. Publication .....</b>	

## LIST OF TABLES

	<b>Page</b>
Table 2.1      The summary of the effects from Quran recitation or listening from published literature (English medium).....	25
Table 2.2      The list of Imam Qurra' .....	30
Table 2.3      The melody description in Quran recitation .....	31
Table 3.1      The data overview of the data acquisition in simultaneously recording of EEG and MEG .....	60
Table 3.2      MEG and EEG frontal channel specifications .....	75
Table 4.1      The distribution of demographic variables .....	95
Table 4.2      The demographic data in age and job .....	95
Table 4.3      STAI score for all the subjects. (*: regarded as an outlier; the subject's MEG-EEG data was excluded from the subsequent theta wave analysis).....	96
Table 4.4      STAI profile comparison between dual faith group .....	96
Table 4.5      STAI profiles comparison between gender.....	96
Table 4.6      The main differences of theta power source localization in resting state (EEG and MEG) for Muslim and Non-Muslim groups in frontal area .....	107
Table 4.7The distribution of the strongest brain source localization over frontal region among Quran recitation in dual faith group EEG .....	126
Table 4.8      The distribution of the source estimation over frontal region among Quran recitation in dual faith group MEG .....	145

Table 4.9	Shows the Pearson correlation of theta power among brain regions during Murattal Asim recitation. All targeted brain regions showed strong significant correlations.....	147
Table 4.10	The significant Pearson correlation in EEG volume source estimation between brain regions for Murattal Susi in Muslim group .....	149
Table 4.11	The significant Pearson correlation in EEG volume source estimation between brain regions for Tarannum Asli in Muslim group .....	151
Table 4.12	The significant Pearson correlation in EEG volume source estimation between brain regions for Hadr in Muslim group .....	153
Table 4.13	The significant Pearson correlation in EEG volume source estimation between brain regions for Murattal Asim in Non-Muslim group .....	155
Table 4.14	The significant Pearson correlation in EEG volume source estimation between brain regions for Murattal Susi in Non-Muslim group .....	157
Table 4.15	The significant Pearson correlation in EEG volume source estimation between brain regions for Tarannum Asli in Non-Muslim group .....	159
Table 4.16	The significant Pearson correlation in EEG volume source estimation between brain regions for Hadr in Non-Muslim group ..	161
Table 4.17	The significant Pearson correlation in MEG volume source estimation between brain regions for Murattal Asim in Muslim group .....	163
Table 4.18	The significant Pearson correlation in MEG volume source estimation between brain regions for Murattal Susi in Muslim group .....	165

Table 4.19	The significant Pearson correlation in MEG volume source estimation between brain regions for Tarannum Asli in Muslim group .....	167
Table 4.20	The significant Pearson correlation in MEG volume source estimation between brain regions for Hadr in Muslim group ...	169
Table 4.21	The significant Pearson correlation in MEG volume source estimation between brain regions for Murattal Asim in non-Muslim group.....	171
Table 4.22	The significant Pearson correlation in MEG volume source estimation between brain regions for Murattal Susi in non-Muslim group.....	173
Table 4.23	The significant Pearson correlation in MEG volume source estimation between brain regions for Tarannum Asli in non-Muslim group.....	175
Table 4.24	The significant Pearson correlation in MEG volume source estimation between brain regions for Murattal Asim Hadr in Muslim group.....	177
Table 4.25	The summary of the Pearson Correlation Analysis in both EEG and MEG data for dual faith group according to Quranic recitation .....	179
Table 4.26	The descriptive analysis within stimuli.....	185
Table 4.27	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	185
Table 4.28	The descriptive analysis within stimuli.....	186
Table 4.29	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	186



Table 4.30	The descriptive analysis among group for all stimuli .....	187
Table 4.31	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	187
Table 4.32	The descriptive analysis among group for all stimuli .....	188
Table 4.33	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	188
Table 4.34	The descriptive analysis among group for all stimuli .....	189
Table 4.35	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	189
Table 4.36	The descriptive analysis among group for all stimuli .....	190
Table 4.37	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	190
Table 4.38	The descriptive analysis among group for all stimuli .....	191
Table 4.39	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	191
Table 4.40	The descriptive analysis among group for all stimuli .....	192
Table 4.41	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	192
Table 4.42	The descriptive analysis among group for all stimuli .....	193
Table 4.43	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	193
Table 4.44	The descriptive analysis among group for all stimuli .....	194
Table 4.45	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	194

Table 4.46	The descriptive analysis among group for all stimuli .....	195
Table 4.47	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	195
Table 4.48	The descriptive analysis among group for all stimuli .....	196
Table 4.49	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	196
Table 4.50	The descriptive analysis among group for all stimuli .....	197
Table 4.51	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	197
Table 4.52	The descriptive analysis among group for all stimuli .....	198
Table 4.53	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	198
Table 4.54	The descriptive analysis among group for all stimuli .....	199
Table 4.55	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	199
Table 4.56	The descriptive analysis among group for all stimuli .....	200
Table 4.57	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	200
Table 4.58	The descriptive analysis among group for all stimuli .....	201
Table 4.59	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	201
Table 4.60	The descriptive analysis among group for all stimuli .....	202
Table 4.61	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	202

Table 4.62	The descriptive analysis among group for all stimuli .....	203
Table 4.63	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	203
Table 4.64	The descriptive analysis among group for all stimuli .....	204
Table 4.65	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	204
Table 4.66	The descriptive analysis among group for all stimuli .....	210
Table 4.67	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	210
Table 4.68	The descriptive analysis among group for all stimuli .....	211
Table 4.69	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	211
Table 4.70	The descriptive analysis among group for all stimuli .....	212
Table 4.71	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	212
Table 4.72	The descriptive analysis among group for all stimuli .....	213
Table 4.73	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	213
Table 4.74	The descriptive analysis among group for all stimuli .....	214
Table 4.75	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	214
Table 4.76	The descriptive analysis among group for all stimuli .....	215
Table 4.77	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	215

Table 4.78	The descriptive analysis among group for all stimuli .....	216
Table 4.79	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	216
Table 4.80	The descriptive analysis among group for all stimuli .....	217
Table 4.81	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	217
Table 4.82	The descriptive analysis among group for all stimuli .....	218
Table 4.83	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	218
Table 4.84	The descriptive analysis among group for all stimuli .....	219
Table 4.85	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	219
Table 4.86	The descriptive analysis among group for all stimuli .....	220
Table 4.87	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	220
Table 4.88	The descriptive analysis among group for all stimuli .....	221
Table 4.89	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	221
Table 4.90	The descriptive analysis among group for all stimuli .....	222
Table 4.91	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	222
Table 4.92	The descriptive analysis among group for all stimuli .....	223
Table 4.93	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group .....	223

Table 4.94	The descriptive analysis among group for all stimuli .....	224
Table 4.95	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	224
Table 4.96	The descriptive analysis among group for all stimuli .....	225
Table 4.97	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	225
Table 4.98	The descriptive analysis among group for all stimuli .....	226
Table 4.99	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	226
Table 4.100	The descriptive analysis among group for all stimuli .....	227
Table 4.101	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	227
Table 4.102	The descriptive analysis among group for all stimuli .....	228
Table 4.103	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	228
Table 4.104	The descriptive analysis among group for all stimuli .....	229
Table 4.105	Mix ANOVA analysis on theta brainwaves between group, within stimuli and interaction between stimuli across group.....	229
Table 5.1	The summary of the theta source estimation and General Linear Model analysis from simultaneously recordings of EEG/MEG during Quranic and non-Quranic recitation as shown by Figure 5.1 and Figure 5.2. ....	252

## LIST OF FIGURES

		<b>Page</b>
Figure 2.1	The graph shows the trends of studies related to music therapy between 1990 – 2020 (source: PubMed database).....	12
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).....	14
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 <i>et al.</i> (2019). ....	15
Figure 2.4	The trend of published studies related to meditation in scientific journals between 1990 – 2018 (source: PubMed database).....	18
Figure 2.5	Schematic view of brain responses during mindfulness meditation in specific brain regions. Adapted from Tang <i>et al.</i> (2015).....	20
Figure 2.6	Al-Baqarah (2:2) – This is the Book about which there is no doubt, a guidance for those conscious of Allah. ....	21
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. ....	22
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 <i>Kursi</i> extends over the heavens and the earth, and their preservation tires Him not. And He is the Highest, the Greatest.....	22
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.....	23
Figure 2.10	Quran recitations in <i>Qiraat</i> and <i>Tarannum</i> .....	32
Figure 2.11	The left figure shows the performance of spectra power for delta, theta, alpha and beta brainwaves during meditation state compared with resting state. Right figure indicates the distribution of brainwaves in three spotted brain areas (frontal, temporal-central, posterior). Figure is adapted from Lagopoulos <i>et al.</i> (2009) .....	33
Figure 2.12	Scalp topography maps representation of average theta power during the first four (4) second of planning (left), in control group (middle) and effect of planning (right). This image is adapted from Domic-Siede <i>et al.</i> (2019) .....	35
Figure 2.13	Source reconstruction of the brain shows specific activations in prefrontal areas for planning, and right-occipital and right-temporal activations for the control period. This image is adapted from Domic-Siede <i>et al.</i> (2019). .....	36
Figure 2.14	The frontal mental theta occurred in all subjects during arithmetic tasks. This figure is adapted from Ishii <i>et al.</i> (2014) .....	37
Figure 2.15	Neurophysiological events during MEG/EEG signal processing .....	38
Figure 2.16	The sphere diagram shows the relationship between the current in a dipole and magnetic field measured at the magnetometer; adapted from Jonathan How (2005). .....	39

Figure 2.17	The direction of magnetic field and the induced current can be described by referring to the right hand rule. Illustration from chegg.com ( <a href="https://www.chegg.com/learn/physics/introduction-to-physics/right-hand-rule">https://www.chegg.com/learn/physics/introduction-to-physics/right-hand-rule</a> ) .....	40
Figure 2.18	Localisation of brain signal sources from EEG/MEG – Bio-Imaging, Signal processing and Learning Lab (BISP) website.( <a href="https://bispl.weebly.com/neuro-imaging-and-analysis.html">https://bispl.weebly.com/neuro-imaging-and-analysis.html</a> ) .....	41
Figure 2.19	Volume conductor model in sagittal view. The yellow color represents the skin, red is the skull, CSF in light blue, white matter in light grey, grey matter in black. The picture adapted from Vorwerk <i>et al.</i> (2014). ....	42
Figure 2.20	The diagram of the source modeling in EEG and MEG. ....	43
Figure 2.21	The diagram of conceptual framework in music, meditation and Quranic recitation as an alternative and complementary therapy	45
Figure 3.1	The overall of the study flow chart .....	47
Figure 3.2	The central and noncentral distributions .....	49
Figure 3.3	The HPI fitting results to locate the position of the head within the probe to identify the signal sources relative to the head .....	50
Figure 3.4	The process of inserting gel into EEG channels .....	51
Figure 3.5	The placement of electrodes on participant's left ear for MEG reference.....	51
Figure 3.6	The process of Quranic recitation recording by Sheikh Hisyam Al-Barri at Audiology Room, School of Medical Sciences, Universiti Sains Malaysia, Kelantan in 2014.....	55



Figure 3.7	A schematic diagram of the stimuli presentation during MEG/EEG recording .....	57
Figure 3.8	(a) Shows the subject in EEG cap with four HPI coils, (b) Shows the subject in MEG room in dim light, (c) Shows the MEG/EEG data acquisition process.....	58
Figure 3.9	The impedances check for all the electrodes. Red bar indicated failed sensing, whilst acceptable for green and yellow bars. ....	59
Figure 3.10	MEG reading in time series during recording to identify any bad or noisy signal. ....	60
Figure 3.11	The overall analysis pipeline in EEG an MEG research.....	62
Figure 3.12	The anatomical protocol for EEG and MEG.....	63
Figure 3.13	EEG (a) and MEG (b) in zero-time setting began at 0s in time domain view .....	66
Figure 3.14	This figure shows the EEG topography before bad channel removal and bottom figure shows the topography of brain activity distribution after EE61 (bad) channels removal. Bottom figure shows the better of colour maps contain the brain signals compared to the blue colour showed the artefacts conquered the topography. ....	67
Figure 3.15	Top figure shows the MEG PSD graph in all frequency bands before applying any frequency filtering. The bottom figure shows the MEG PSD graph after the notch filter with 3Hz width for 50Hz, 100Hz, 150Hz, 200Hz, 250Hz, 300Hz.....	68
Figure 3.16	The arrow of the peak at every 50Hz inverts after notch-filter.....	69
Figure 3.17	Maxfiler with maxshield Neuromag Elekta applied for MEG raw data .....	69

Figure 3.18 Shows the artefacts detection during SSP method in cardiac activity.....	72
Figure 3.19 Shows the components of ICA during pathological artefacts elimination .....	73
Figure 3.20(a) The compute head model setting for source space (in this study used MRI volume). Overlapping spheres used for MEG whereas OpenMEEG BEM for EEG. (b) Template grid had chosen for group analysis .....	74
Figure 3.21(a) Inverse model setting for MEG, (b) inverse model setting for EEG.....	74
Figure 3.22 Layout for Waveguard EEG Cap 61-channel AntNeuro and the channels respective brain region (Adapted from Ab. Rani et al., 2016). .....	77
Figure 3.23 Layout for Whole head Elekta Neuromag 306-channels MEG system (102 magnetometers, 204 planar gradiometers). Lay-out taken from (Hu <i>et al.</i> , 2018) .....	78
Figure 3.24 The 170 brain areas in deep brains aal3.nii atlas to localize the source from the deep brain. ....	80
Figure 3.25 The location of ACCpreL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	82
Figure 3.26 The location of ACCpreR in source level (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	82
Figure 3.27 The location of ACCsubL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the	

	left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	83
Figure 3.28	The location of ACCsubR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view. ....	83
Figure 3.29	The location of ACCsupL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view. ....	84
Figure 3.30	The location of ACCsupR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view. ....	84
Figure 3.31	The location of AMYGL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	85
Figure 3.32	The location of AMYGR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view .....	85
Figure 3.33	The location of MCCL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	86
Figure 3.34	The location of MCCR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the	

left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view..... 86

Figure 3.35The location of PCCL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view..... 87

Figure 3.36The location of PCCR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view..... 87

Figure 3.37The location of PFCventmedL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view. .... 88

Figure 3.38The location of PFCventmedR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view ..... 88

Figure 3.39The location of FMGL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view..... 89

Figure 3.40The location of FMGR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view..... 89

Figure 3.41The location of SFGL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left

	internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	90
Figure 3.42	The location of SFGR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view.....	90
Figure 3.43	The location of SFGmedialL in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view .....	91
Figure 3.44	The location of SFGmedialR in source level. (A) is left external MRI-view, (B) is right external view, (C) is top MRI-view, (D) is the left internal MRI-view, (E) is the right internal MRI-view, (F) is the bottom MRI-view .....	91
Figure 4.1	EEG resting state setting for source localization using Brainstorm software .....	97
Figure 4.2	The average of theta source estimation in resting state EEG. Left panel (Muslim group), right panel (Non-Muslim group).....	98
Figure 4.3	Average of theta source estimation in sagittal view in resting state EEG. Top panel (Muslim group), bottom panel (Non-Muslim group). .....	99
Figure 4.4	The average of theta source localization in Murattal Asim recitation style. The amplitude setting for Non-Muslim group was 90%. Top panel (Muslim group), bottom panel (Non-Muslim group). .....	100
Figure 4.5	The average of source estimation in various frequency band for resting state EEG. Top panel (Muslim group), bottom panel (Non-Muslim group). .....	101

Figure 4.6	Brainstorm setting for MEG data in resting state. The amplitude was 92% and min size was 1.....	102
Figure 4.7	The average of theta source localization during resting state. Left panel (Muslim group), right panel (Non-Muslim group).....	103
Figure 4.8	The average of theta source localization during Quranic recitation in resting state. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	104
Figure 4.9	The average of theta source localization in Murattal Asim recitation style. The amplitude setting for both groups was 92%. Top panel (Muslim group), bottom panel (Non-Muslim group).	105
Figure 4.10	The average of source estimation in resting state recitation with all frequency band. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	106
Figure 4.11	EEG setting for source localization in Brainstorm software. ....	109
Figure 4.12	The average of theta source localization of Quranic recitation in Murattal Asim style. Left panel (Muslim group), right panel (Non-Muslim group).....	110
Figure 4.13	The average of the theta source localization during Quranic recitation in Murattal Asim style. Top panel (Muslim group), bottom panel (Non-Muslim group).....	111
Figure 4.14	The average of the theta source localization during Quranic recitation in Murattal Asim style. Top panel (Muslim group), bottom panel (Non-Muslim group).....	113
Figure 4.15	The average of the source localization during Quranic recitation in Murattal Asim will all frequency band. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	113

Figure 4.16	The average of the theta source localization during Quranic recitation in Murattal Susi style. The amplitude setting for Muslim group was 91%. Left panel (Muslim group), right panel (Non-Muslim group). ....	114
Figure 4.17	The average of the theta source localization during Quranic recitation in Murattal Susi style. The amplitude setting for Muslim group was 91%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	115
Figure 4.18	The average of the theta source localization during Quranic recitation in Murattal Susi style. The amplitude setting for Muslim group was 91%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	116
Figure 4.19	The average of the source localization during Quranic recitation in Murattal Susi style with all frequency band. The amplitude setting for Muslim group was 91%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	117
Figure 4.20	The average of the theta source localization during Quranic recitation in Tarannum Asli style. The amplitude setting for Non-Muslim average was 97%. Left panel (Muslim group), right panel (Non-Muslim group). ....	118
Figure 4.21	The average of the theta source localization during Quran recitation in Tarannum Asli style. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	119
Figure 4.22	The average of the theta source localization during Quran recitation in Tarannum Asli style. The amplitude setting for non-Muslim was 97%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	120

Figure 4.23	The average of the source localization during Quran recitation in Tarannaum Asli with all frequency band. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	121
Figure 4.24	The average of theta source localization during Quran recitation in Hadr style. The amplitude for Non-Muslim was 94%. Left panel (Muslim group), right panel (Non-Muslim group). ....	122
Figure 4.25	The average of theta source localization during Quran recitation in Hadr style. The amplitude for Non-Muslim was 94%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	123
Figure 4.26	The average of theta source localization during Quran recitation in Hadr style. The amplitude for Non-Muslim was 94%. Top panel (Muslim group), bottom panel (Non-Muslim group). ....	124
Figure 4.27	The average of source localization during Quran recitation in Hadr style with all frequency band. The amplitude for Non-Muslim was 94%. Top panel (Muslim group), bottom panel (Non-Muslim group).....	125
Figure 4.28	Brainstorm setting for view in source localization in MEG.....	128
Figure 4.29	These figures show the average of theta source localization from MRI-view in Murattal Asim recitation style. The amplitude setting for Non-Muslim group was 90%. Left (Muslim group), right (Non-Muslim group) .....	129
Figure 4.30	The average of theta source localization in Murattal Asim recitation style. The amplitude setting for Non-Muslim group was 90%. Top (Muslim group), bottom (Non-Muslim group).....	130
Figure 4.31	The average of theta source localization in Murattal Asim recitation style. The amplitude setting for Non-Muslim group was 90%. Top (Muslim group), bottom (Non-Muslim group).....	131



Figure 4.32	The average of theta source estimation in Murattal Asim recitation for all frequency band. The amplitude setting for Non-Muslim group was 90%. Top (Muslim group), bottom (Non-Muslim group).....	132
Figure 4.33	Theta source localization during Quranic recitation in Qiraat Susi style. The amplitude setting for both groups were 90%. Left (Muslim group), right (Non-Muslim group) .....	133
Figure 4.34	Theta source localization from Sagittal MRI-view, average 14 subjects in Muslim group during Quranic recitation in Qiraat Susi style. Top (Muslim group), bottom (Non-Muslim group).....	134
Figure 4.35	The average of theta source localization in Murattal Susi recitation style. The amplitude setting for both group were 90%. Top (Muslim group), bottom (Non-Muslim group).....	135
Figure 4.36	These figures show the average of source estimation in Murattal Susi recitation with all frequency band. Top (Muslim group), bottom (Non-Muslim group).....	136
Figure 4.37	These figures show theta source localization from MRI view during Quranic recitation in Tarannum Asli style. The amplitude setting for Non-Muslim group was 87%. Left (Muslim), right (Non-Muslim group) .....	137
Figure 4.38	These figures show the average of theta source localization during Quranic recitation in Tarannum Asli style. The amplitude setting for Non-Muslim group was 87%. Top (Muslim group), bottom (Non-Muslim group).....	138
Figure 4.39	The average of theta source localization in Tarannum Asli recitation style. The amplitude setting for Muslim was 87% and Non-Muslim group was 85%. Top (Muslim group), bottom (Non-Muslim group).....	139

Figure 4.40	These figures show the average of source estimation in Tarannum Asli recitation with all frequency band. The amplitude setting for Non-Muslim group was 87%. Top (Muslim), bottom (Non-Muslim group) .....	140
Figure 4.41	These figures show the average of theta source localization during Quranic recitation in Hadr style. The amplitude setting for Muslim was 87% and Non-Muslim group was 85%. Left (Muslim group), right (Non-Muslim group).....	141
Figure 4.42	These figures show the average of theta source localization during Quranic recitation in Hadr style. The both setting for amplitude were 90%. Top (Muslim group), bottom (Non-Muslim group).....	142
Figure 4.43	The average of theta source localization in Hadr recitation style. The amplitude setting for Muslim was 87% and Non-Muslim group was 85%. Top (Muslim group), bottom (Non-Muslim group).....	143
Figure 4.44	These figures show the average of source estimation in Hadr style recitation with all frequency band. The both setting for amplitude were 90%. Top (Muslim group), bottom (Non-Muslim group)	144
Figure 4.45	The ACC-pre left area showed the data was normal. ....	180
Figure 4.46	Graph (a-t) showed the mean distribution of EEG theta brainwave in 20 brain regions. Blue color representative of Muslim group while red color on behalf non-Muslim group. X-axis indicated the stimuli, 1 (resting state), 2 (monochord), 3 (Hare Krishna), 4(Arabic News), 5(Arabic Poem), 6(Murattal Asim), 7(Murattal Susi), 8(Tarannum Asli), 9 (Hadr), 10 post-resting state) .....	184
Figure 4.47	Graph (a-t) showed the mean distribution of MEG theta brainwave in 20 brain regions. Blue color representative of Muslim group while red color on behalf non-Muslim group. X-axis indicated the	

stimuli, 1 (resting state), 2 (Monochord), 3 (Hare Krishna),  
4(Arabic News), 5(Arabic Poem), 6(Murattal Asim), 7(Murattal  
Susi), 8(Tarannum Asli), 9 (Hadr), 10 post-resting state) ..... 209

Figure 5.1 Schematic images that represent the source estimation (Muslims  
group) of FMT and frontal mental theta during Quranic recitation  
(Ayatul Kursi, 2:225) in different recitation styles. Green color  
(Murattal Asim style), light yellow color (Murattal Susi style),  
orange color (Tarannum Asli style), purple color (Hadr style).  
Left image indicates EEG data while right image indicates MEG  
data. .... 251

Figure 5.2 Schematic images that represent the source estimation (non-  
Muslims group) of FMT and frontal mental theta during Quranic  
recitation (Ayatul Kursi, 2:225) in different recitation styles.  
Green color (Murattal Asim style), light yellow color (Murattal  
Susi style), orange color (Tarannum Asli style), purple color  
(Hadr style). Left image indicates EEG data while right image  
indicates MEG data ..... 251

## LIST OF ABBREVIATIONS

AAL	Automated Anatomical Labelling Atlas 3
ACC	Anterior cingulate cortex
ACCpre	Anterior Cingulate Cortex pre-genua
ACCsub	Anterior Cingulate Cortex sub-genua
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 profil 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 dalam 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 EEG 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).

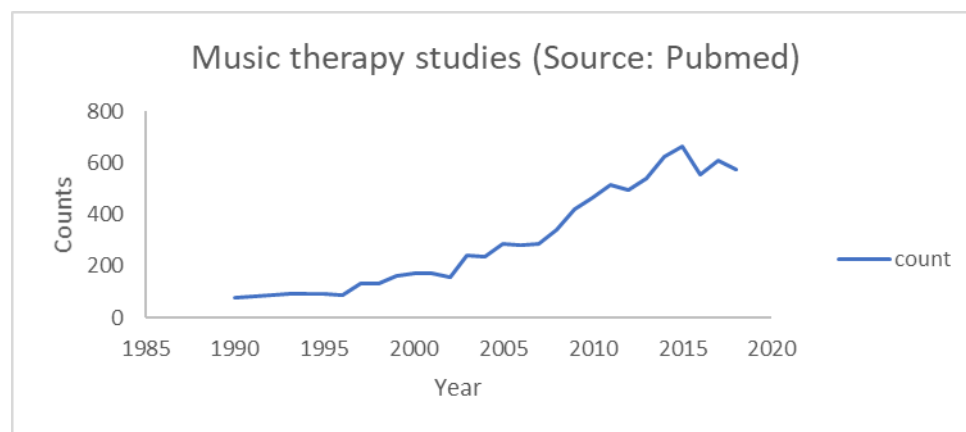


Figure 2.1 The graph shows the trends of studies related to music therapy between 1990 – 2020 (source: PubMed database)

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).



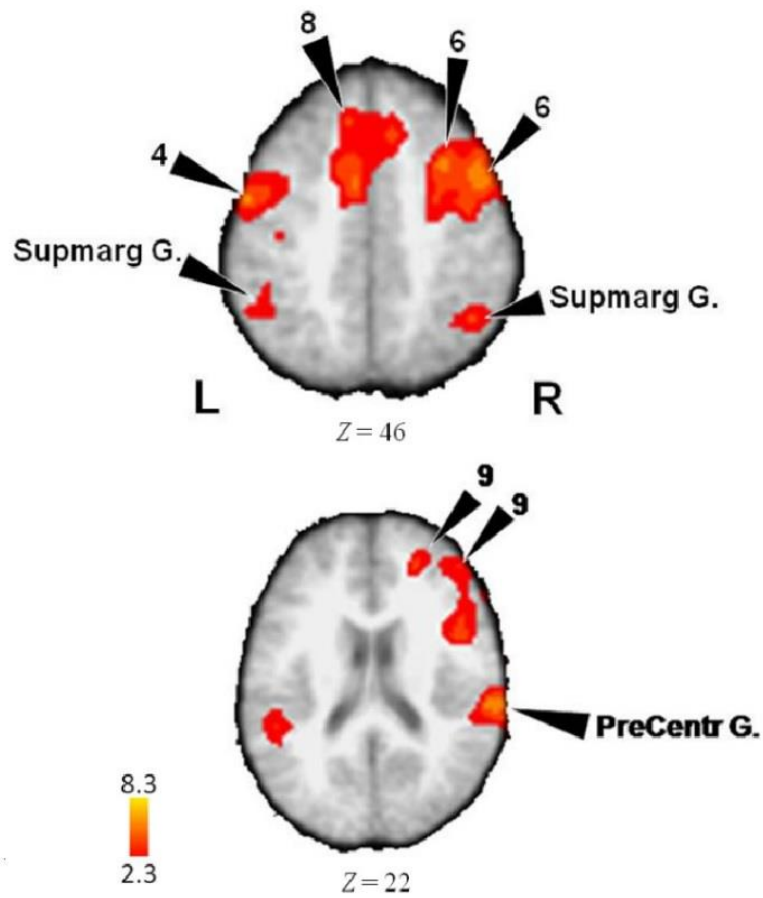


Figure 2.2 Activations in musical rhythm. Top image shows the activations of brain in supramarginal and medial frontal gyri, pre-central, and middle frontal areas. The colour scale represents the intensity of activations (in Z values). Bottom image shows the activations in inferior frontal, medial frontal, 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 Piazzolla) 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 bilateral superior frontal gyrus are linked to musical perception.

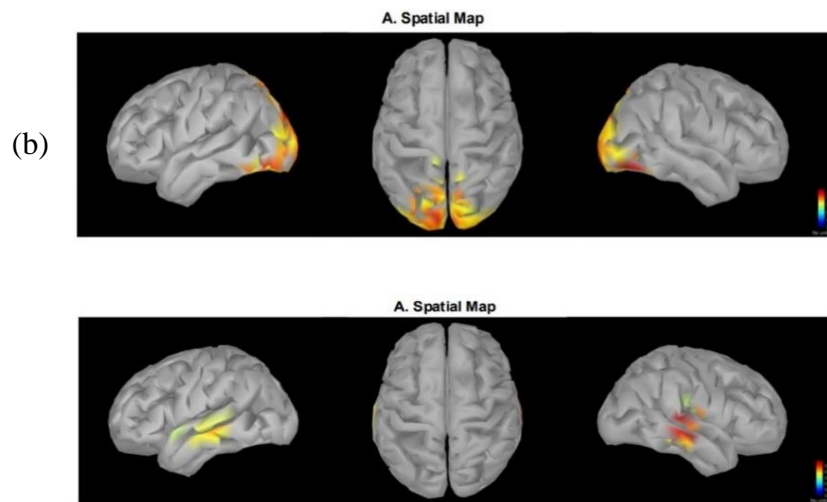


Figure 2.3 Source localization for alpha and beta bands. (a) Alpha frequency band during music listening. (b) Beta frequency band during music listening. Adapted from Carpentier *et al.* (2019).

### 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 Fachner *et 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).

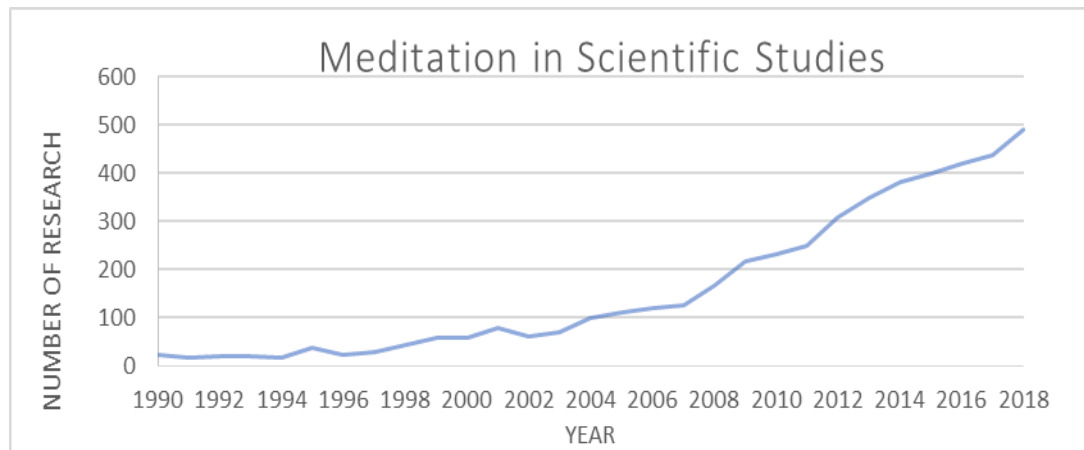


Figure 2.4 The trend of published studies related to meditation in scientific journals between 1990 – 2018 (source: PubMed database).

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.

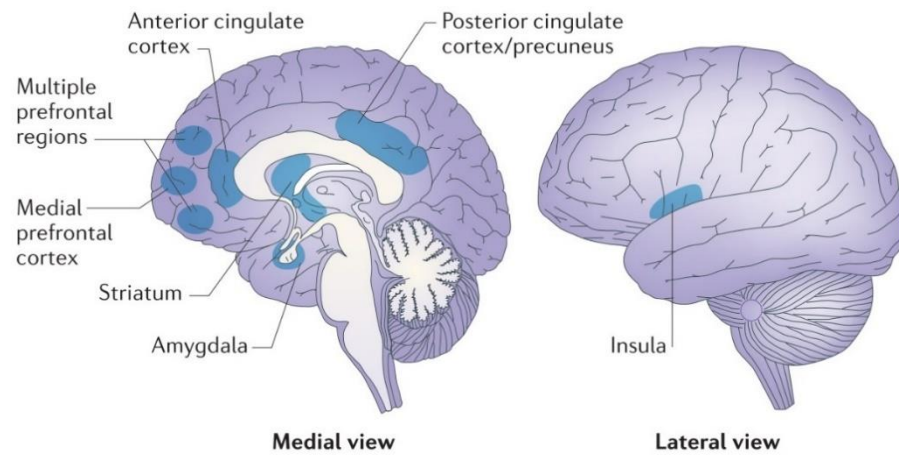


Figure 2.5 Schematic view of brain responses during mindfulness meditation in specific brain regions. Adapted from Tang *et al.* (2015).

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.

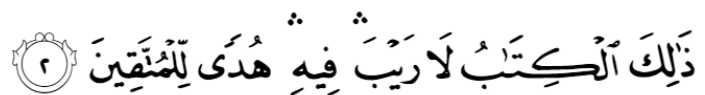


Figure 2.6 Al-Baqarah (2:2) – This is the Book about which there is no doubt, a guidance for those conscious of Allah.

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 الَّذِي أُنْزِلَ فِيهِ الْقُرْآنُ هُدًى لِّلنَّاسِ وَبَيِّنَاتٍ مِّنَ  
الْهُدَى وَالْفُرْقَانِ

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.

اللَّهُ لَا إِلَهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ لَا تَأْخُذُهُ سِنَّةٌ وَلَا نَوْمٌ لَهُ مَا فِي السَّمَوَاتِ وَمَا فِي  
الْأَرْضِ مَنْ ذَا الَّذِي يَشْفَعُ عِنْدَهُ إِلَّا بِإِذْنِهِ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ  
وَلَا يُحِيطُونَ بِشَيْءٍ مِّنْ عِلْمِهِ إِلَّا بِمَا شَاءَ وَسِعَ كُرْسِيُّهُ السَّمَوَاتِ وَالْأَرْضَ وَلَا  
يَئُودُهُ حِفْظُهُمَا وَهُوَ الْعَلِيُّ الْعَظِيمُ

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 chapter can be an alternative and complementary therapy for the believers.

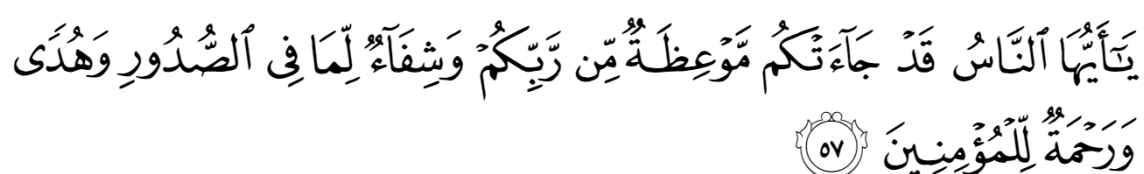


Figure 2.9 Yunus (10:57) – O mankind, there has to come to you an instruction (Al-Quran) from your Lord and healing for what is in the breasts and guidance and mercy for the believers.

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)