





# **UNIVERSITI TEKNOLOGI MARA**

## **LEARNER'S BRAIN ELECTROENCEPHALOGRAM SUB-BANDS FOR KOLB'S LEARNING STYLE CLASSIFICATION**

05-4506832

Perpustakaan Tuanku Balnun pustaka.upsi.edu.my





Thesis submitted in fulfillment of the requirements for the degree of **Doctor of Philosophy** (Electrical Engineering)

**Faculty of Electrical Engineering** 









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ABSTRACT Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah

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Learning has been connected specifically to a human brain whereby brain's capacities such as thinking, short and long term memory are considered among the most critical modalities of learners. On the other hand, Learning Style (LS) had been widely accepted in education domain with the emergence of several LS models. Nevertheless, the models used only questionnaire-based Learning Style Inventory (LSI) in the LS determination process which exposed to inaccuracy. As such, this research proposes a new method whereby Electroencephalogram (EEG) signals are used hand-in-hand with the traditional LSI for Kolb's LS classification establishment. The research also aimed to determine the EEG sub-bands that could best classify the Kolb's LS and outline their characteristics. A total of 131 subjects were classified into their particular Kolb's LS of Diverger (n=33), Assimilator (n=36), Converger (n=32) or Accommodator (n=30) using the Kolb's Learning Style Inventory (KLSI) Workbook 3.1 by Haygroup®. Then, the subjects EEG signals were acquired using WaveRider Pro hardware and its accompanying software, Waveware. The EEG signals were recorded in the baseline condition of Open Eyes and Close Eyes at the frontal area of the scalp that divided to left and right position. For analysis, the signals were processed and generated as a Baseline Summative EEG (BSE) datasets. Statistical Analysis of SPSS 16 namely Descriptive Analysis, Normality Test, One-Way ANOVA and TwoStep Cluster Analysis were used to analyse the BSE. Beta Left, Beta Right, Alpha Left, Alpha Right, Theta Left, Theta Right, Delta Left and Delta Right in Open Eyes and Close Eyes were examined in term of its Means, Standard Deviation, Skewness and Kurtosis, Next, normal distribution of each subband was looked into using the Shapiro-Wilk test. The sub-bands were also tested using One-Way ANOVA for Means comparison between LS groups. Based on the ANOVA and Post-Hoc Tukey Honest Significant Difference (HSD) result, it has been found that the sub-bands of Theta Left and Delta Left in Open Eyes and Beta Left and Delta Left in Close Eyes were the best classifier for Kolb's LS. The output of TwoStep Cluster Analysis proved the selection was correct as LS were 100% classified by these sub-bands dependent to the particular Kolb's LS. On top of that, the research had established that the LS Accommodator is the best classified LS by the selected sub-bands. In a nutshell, the research has successfully pointed-out the best EEG sub-bands that could be utilized in Kolb's LS classification.

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	Page
<b>CONFIRMATION BY PANEL OF EXAMINERS</b>	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	V
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xix
LIST OF ABBREVIATIONS	XX

СН	APTER	ONE: INTRODUCTION		1
1.1	Researc	ch Background		1
$\binom{1}{1.3}^{2}$	Problem 5-4506832 Researc	n Statements pustaka.upsi.edu.my ch Objectives	PustakaTBainun	ptbupsi
1.4	Researc	ch Scope and limitation		3
1.5	Researc	h Contributions		4
1.6	Thesis (	Organization		5
CHA	APTER	<b>IWO: LITERATURE REVIEW</b>		7
2.1	Introdu	ction		7
2.2	Human	Brain		7
2.3	Brain St	tructures and Functions		9
2.4	Human	Brain's Neurophysiology		10
2.5	Researc	h on Human's Brain		12
	2.5.1	Experimental Ablation		13
	2.5.2	Brain Structure Visualization		14
	2.5.3	Assessing the Brain's Activity		17
	2.5.4	Inducing the Brain's Activity		21
	2.5.5	Genetic Manipulation		<b>2</b> 2
0	5-4506832	pustaka.upsi.edu.my F Perpustakaan Tuanku Bainun Kappus Sultan Abdul Jalil Shah	PustakaTBainun	ptbupsi

$\sim$	2.5.6	Summary	23
2.6	<sup>05</sup> Electroe	encephalogram	23 ptbupsi
	2.6.1	EEG History	24
2.7	EEG Ba	ands and Rhythm	26
2.8	Researc	h on EEG	28
	2.8.1	Neuromarketing	28
	2.8.2	Human Factors	29
	2.8.3	Social Interaction	29
	2.8.4	Psychology and Neuroscience	30
	2.8.5	Clinical and Psychiatric Studies	31
	2.8.6	Brain Computer Interfaces	32
2.9	Learning	g Theories	33
2.10	Experie	ntial Learning	36
2.11	Learning	g Style Models	39
	2.11.1	Dunn and Dunn Model	40
	2.11.2	Carl Jung and Myers Briggs Type Indicator	42
	2.11.3	Felder-Silverman Model	43
	<b>2.11.4</b>	Honey and Mumford Model	#46 ptbupsi
0	2.11.5	Kolb's Model	47
2.12	Rational	e on Kolb's LS Selection	49
2.13	EEG in 1	Education	51
2.14	Research	n Gap Analysis	54
СНА	PTER T	HREE: THEORETICAL BACKGROUND	55
3.1	Introduc	tion	<b>5</b> 5
3.2	EEG Fur	ndamentals	<b>5</b> 5
	3.2.1	EEG Production and Measurement	<b>5</b> 6
	3.2.2	EEG Artefacts	59
	3.2.3	EEG Pre-Processing	62
		3.2.3.1 Filter Design	62
		3.2.3.2 Filter Response	63
		3.2.3.3 Filter Type	65
		3.2.3.4 Cut-off Frequency	65
		3.2.3.5 Finite Impulse Response filter	66
	05-4506832	Perpustakaan Tuanku Bainun Perpustakaan Tuanku Bainun VustakaTBainun	ptbupsi

	05 4504000	3.2.3.6	Fourier Transform	67
$\bigcirc$	05-4506832	3.2.3.7	Fast Fourier Transform <sup>a Abdul</sup> Jalil Shah	68
3.3	Kolb's	Learning S	Style Inventory	71
3.4	Statistic	cal Analys	is	75
	3.4.1	Descript	ive Statistics	75
		3.4.1.1	Means ( <b>x</b> )	76
		3.4.1.2	Standard Deviation ( $\sigma$ )	76
		3.4.1.3	Skewness	77
		3.4.1.4	Kurtosis	78
	3.4.2	Normali	ty Test – Shapiro Wilk	79
	3.4.3	One-Wa	y Analysis of Variance	<b>8</b> 0
	3.4.4	Classific	ation - TwoStep Cluster Analysis	82
CH	APTER I	FOUR: R	ESEARCH METHODOLOGY	85
4.1	Introduc	ction		<b>8</b> 5
4.2	Experim	ent Arran	gement and Data Collection	<b>8</b> 6
	4.2.1	Subjects	and Demography	87
C	<b>4.2.2</b> 05-4506832	Learning <sup>pusta</sup> 4.2.2.1	Style Data Collection ka.upsi.edu.my Kampus Sultan Abdul Jalil Shah PustakaTBainun Online Questionnaire Using Google Docs	90 ptbupsi
		4.2.2.2	Online Kolb's LSI using Google docs	91
		4.2.2.3	Kolb's LSI Data processing	94
	4.2.3	EEG Dat	a Acquisition Experiment	99
		4.2.3.1	Location	99
		4.2.3.2	Apparatus – Waverider Pro	<b>9</b> 9
		4.2.3.3	WaveRider Pro Specifications and Components	101
		4.2.3.4	WaveWare	103
		4.2.3.5	WaveWare Processed Data Model	108
		4.2.3.6	WaveWare Export and Storage Capabilities	110
		4.2.3.7	Experiment Design	110
		4.2.3.8	WaveWare Configuration	112
		4.2.3.9	Baseline Summative EEG Processing	118
4.3	Statistica	al Analysis	3	121
	4.3.1	Descriptiv	ve Statistics	122
		4.3.1.1	Mean and Standard Deviation	122
C	05-4506832	pusta	ka.upsi.edu.my Ferpustakaan Tuanku Bainun PerpustakaTBainun	ptbupsi

	05 450 4000	4.3.1.2	Skewness and Kurtosis	123
0	05-44.38.22	Normali	ty Test Edu my Kampus Sultan Abdul Jalil Shah	123 ptbupsi
	4.3.3	One-Wa	y ANOVA	123
	4.3.4	Classific	ation	124
CHA	APTER I	IVE: RE	ESULTS AND DISCUSSION	125
5.1	Introduc	tion		125
5.2	Kolb's I	Learning S	tyle Classification	125
5.3	EEG An	alysis and	Results	126
	5.3.1	Baseline	Summative EEG Analysis	126
		5.3.1.1	Descriptive Analysis – Diverger in Open Eyes	126
		5.3.1.2	Descriptive Analysis – Assimilator in Open Eyes	128
		5.3.1.3	Descriptive Analysis – Converger in Open Eyes	130
		5.3.1.4	Descriptive Analysis – Accommodator in Open Eyes	132
		5.3.1.5	Summary of Descriptive Analysis in Open Eyes	134
		5.3.1.6	Descriptive Analysis – Diverger in Close Eyes	137
		5.3.1.7	Descriptive Analysis – Assimilator in Close Eyes	139
	05-4506832	5.3.1.8	Descriptive Analysis at Converger in Close Eyes	141 <sub>ptbupsi</sub>
$\bigcirc$		5.3.1.9	Descriptive Analysis – Accommodator in Close Eyes	143
		5.3.1.10	Summary of Descriptive Analysis in Close Eyes	145
		5.3.1.11	SW Normality Test – Diverger in Open Eyes	149
		5.3.1.12	SW Normality Test – Assimilator in Open Eyes	150
		5.3.1.13	SW Normality Test – Converger in Open Eyes	151
		5.3.1.14	SW Normality Test – Accommodator in Open Eyes	152
		5.3.1.15	Summary of Shapiro-Wilk in Open Eyes	153
		5.3.1.16	SW Normality Test – Diverger in Close Eyes	154
		5.3.1.17	SW Normality Test – Assimilator in Close Eyes	155
		5.3.1.18	SW Normality Test – Converger in Close Eyes	156
		5.3.1.19	SW Normality Test – Accommodator in Close Eyes	157
		5.3.1.20	Summary of Shapiro-Wilk in Close Eyes	158
		5.3.1.21	One-Way ANOVA for BSE Open Eyes	159
		5.3.1.22	One-Way ANOVA for BSE Close Eyes	162
		5.3.1.23	Summary of One-Way ANOVA	165
		5.3.1.24	LS Classification using Theta Left BSE in Open Eyes	166
C	05-4506832	yusta	ika.upsi.edu.my f Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah y PustakaTBainun	ptbupsi

ix

C	05-4506832	5.3.1.25 LS Classification using Delta Left BSE in Open Eyes pustaka.upsi.edu.my 5.3.1.26 Summary of Classification in Open Eyes	168 0 ptbupsi 171
		5.3.1.27 LS Classification using Beta Left BSE in Close Eyes	171
		5.3.1.28 LS Classification using Delta Left BSE in Close Eyes	174
		5.3.1.29 Summary of Classification in Close Eyes	177
	5.3.2	EEG Sub-Bands Profiling For Kolb's Ls	177
	5.3.3	Theta Left Open Eyes	177
	5.3.4	Delta Left Open Eyes	180
	5.3.5	Beta Left Close Eyes	183
	5.3.6	Delta Left Close Eyes	185
5.4	Summar	У	188
CH	APTER S	IX: CONCLUSION AND FUTURE WORK	189
6.1	Conclus	ion	189
6.2	Recomm	nendation and Future Work	<b>19</b> 0
REI	ERENC	CES	191
APF AU1	'ENDIC 05-4506832 <b>THOR'S</b>	Perpustakaan Tuanku Bainun PROFILE Perpustakaan Tuanku Bainun Vampus Sultan Abdul Jalil Shah	<b>236</b> <sub>ptbupsi</sub> 244







05-4506832 yustaka.upsi.edu.mLIST OF<sup>tt</sup>TABLES<sup>hun</sup> Kampus Sultan Abdul Jail Shah



Tables	Title	Page
Table 2.1	Comparison on Learning Theories Aspect	33
Table 2.2	Variables and factors in the Dunn and Dunn learning-styles	
	model	41
Table 3.1	Properties of selected window types for FIR filters	67
Table 3.2	Fourier Series Variable specifications	70
Table 4.1	Subjects' Demographic on Age and Gender	88
Table 4.2	List of range of WaveRider's channels gain	103
Table 4.3	Example of WaveRider's pre-programmed protocols	108
Table 4.4	WaveWare processing modes on FFT feeds	109
Table 4.5	WaveRider Pre-Calculated Digital Filter	109
Table 4.6 05-4506832	The WaveWare's General Graph Brainwave Categories pustaka.upsi.edu.my and description	ptbupsi 114
Table 4.7	List of General Graphics window Input Algorithm	116
Table 5.1	Subject's LS classification	125
Table 5.2	Test of Homogeneity of Variances for BSE data in Open	
	Eyes	160
Table 5.3	ANOVA summary of BSE in Open Eyes	161
Table 5.4	Tukey HSD Multiple Comparison for BSE in Open Eyes	162
Table 5.5	Test of Homogeneity of Variances for BSE data in Close	
	Eyes	163
Table 5.6	ANOVA summary of BSE in Close Eyes	164
Table 5.7	Tukey HSD Multiple Comparison for BSE in Close Eyes	165
Table 5.8	Cluster Centroids for Theta Left BSE in Open Eyes	166
Table 5.9	LS Cluster Classification for Theta Left BSE in Open Eyes	168



Table 5.10 05-4506832	Cluster Centroids for Delta Left BSE in Open Eyes Pustaka.upsi.edu.my Ferpustakaan Fuanku Bahan Open Eyes Kampus Sultan Abdul Jalil Shah	ptbupsi
Table 5.11	LS Cluster Classification for Delta Left BSE in Open Eyes	170
Table 5.12	Cluster Centroids for Beta Left BSE in Close Eyes	172
Table 5.13	LS Cluster Classification for Beta Left BSE in Close Eyes	173
Table 5.14	Cluster Centroids for Delta Left BSE in Close Eyes	174
Table 5.15	LS Cluster Classification for Delta Left BSE in Close Eyes	176
Table 5.16	The information of EEG sub-bands selected for LS	185
	classification	177



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Figures	Title	Page
Figure 2.1	Brain's major parts - brainstem, cerebellum, and cerebral hemisphere	8
Figure 2.2	Neuron's fundamental structure	11
Figure 2.3	EEG of cortical field potentials for a net excitatory input to the apical dendritic tree of a typical pyramid cell	12
Figure 2.4	A stereotaxic instrument put-upon to infix an anode or a cannula into a particular part of an animal's brain	14
Figure 2.5	Computerized Tomography (CT) scanner	15
Figure 2.6	CT scans from a patient with a brain sore (Scan 2) caused by a harmed area	16
Figure 2.7	An MRI scan of a human brain	17
Figure 2.8	EEG Recording and sample wave output	18
Figure 2.92	MEG employed to a patient Sultan Abdul Jalil Shah	ptbupsi
Figure 2.10	Several Magnetic Resonance images acquired during PET	20
Figure 2.11	Brain areas "light-up" when performing certain tasks	20
Figure 2.12	Trans cranial magnetic stimulation	22
Figure 2.13	First recording of EEG signals made by Hans Berger	24
Figure 2.14	EEG band and rhythm	27
Figure 2.15	Kolb's Experiential Learning Cycle	37
Figure 2.16	MBTI dimensions model	43
Figure 2.17	Felder and Silverman Learning Style Index	44
Figure 2.18	Felder-Silverman bi-polar continuum constructs	45
Figure 2.19	Dimensions of Honey and Mumford's learning cycle	46
Figure 2.20	Kolb's four process of Learning Cycle	48



O5-4506832 Suttaka.upsi.edu.my f Perpustakaan Tuanku Bainun Krijius Sultan Abdul Jalil Shah SuttakaTBainun buby



Figure 2.21	Four areas of Cerebral cortexan Tuanku Bainun pustaka.upsi.edu.my Kampus Sultan Abdul Jalil Shah	ptbupsi
Figure 2.22	Educational Neuroscience as trans-disciplinary fields	52
Figure 3.1	Normal EEG Signal frequency spectrum	57
Figure 3.2	EEG standard 10-20 electrode placement system – Left View	58
Figure 3.3	EEG standard 10-20 electrode placement system – Top View	59
Figure 3.4	Various type of EEG artefacts	60
Figure 3.5	Corrected EEG Spectrum from artefacts	62
Figure 3.6	Time Domain versus Frequency Domain filter responses	64
Figure 3.7	Example low-pass (panels A–E) and high-pass (panels F– J) filter responses (Hamming windowed sync FIR)	66
Figure 3.8	Kolb's Learning Style	74
Figure 3.9	Types of Skewness distribution	78
Figure 3.10 05-4506832 Figure 4.1	Type of Kurtosis distribution pustaka.upsi.edu.my f Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah Summary of overall Research Process Flow	79 ptbupsi 86
Figure 4.2	Kolb's LSI grid chart	89
Figure 4.3	Google form registration and creation	92
Figure 4.4	Online Learning Style questionnaire homepage	93
Figure 4.5	Example of Online Learning Style questions	93
Figure 4.6	Online Learning Style questionnaire compliment and confirmation message	94
Figure 4.7	Subjects' feedback saved in Google Docs server	95
Figure 4.8	Subjects' responses data downloaded as MS Excel spreadsheet	96
Figure 4.9	CE, RO, AC and AE score	97
Figure 4.10	Kolb's LS cycle chart	97
Figure 4.11	Kolb's LS tabulation chart	98

O5-4506832 Spustaka.upsi.edu.my

Figure 4.12 05-4506832	WaveRider Pro hardware pustaka.upsi.edu.my Kampus Sultan Abdul Jalil Shah	4190 ptbupsi
Figure 4.13	Example of WaveRider electrodes affixed to body	101
Figure 4.14	WaveRider Pro's USB to serial port converter	102
Figure 4.15	WaveWare Main interface	103
Figure 4.16	WaveWare Strip Chart interface	104
Figure 4.17	WaveWare Fast Bars interface	105
Figure 4.18	WaveWare Slow Bars interface	106
Figure 4.19	WaveWare Spectrogram interface	106
Figure 4.20	WaveWare General Graphic Interface	107
Figure 4.21	EEG acquisition flowchart	111
Figure 4.22	WaveRider's electrodes placement	112
Figure 4.23	WaveWare configuration for EEG acquisition	113
Figure 4.24	General graph of Beta Left EEG signal recorded using	110
05-4506832 Figure 4.25	WaveWare configuration pustaka.upsi.edu.my General Graphics Option dialog box	ptbupsi 115
Figure 4.26	Brain menu General Graphics Interface and configuration	117
Figure 4.27	General Graphic window in input modes and control options	118
Figure 4.28	EEG archive to ASCII output option	119
Figure 4.29	EEG archive ASCII output	119
Figure 4.30	EEG ASCII data imported to MS Excel	120
Figure 4.31	EEG archive data in MS Excel format	120
Figure 5.1	BSE Mean and Standard Deviation for Diverger in Open Eyes	127
Figure 5.2	BSE Skewness and Kurtosis for Diverger in Open Eyes	128
Figure 5.3	BSE Mean and Standard Deviation for Assimilator in Open Eyes	129

Figure 5.4 05-4506832 Figure 5.5	BSE Skewness and Kurtosis for Assimilator in Open Eyes pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun BSE Mean and Standard Deviation for Converter in Open	130 ptbupsi
	Eyes	131
Figure 5.6	BSE Skewness and Kurtosis for Converger in Open Eyes	132
Figure 5.7	BSE Mean and Standard Deviation for Accommodator in Open Eyes	133
Figure 5.8	BSE Skewness and Kurtosis for Accommodator in Open Eyes	134
Figure 5.9	LS Mean comparison in Open Eyes by EEG bands	135
Figure 5.10	LS Skewness comparison in Open Eyes by EEG band	136
Figure 5.11	LS Kurtosis comparison in Open Eyes by EEG band	137
Figure 5.12	BSE Mean and Standard Deviation for Diverger in Close Eyes	138
Figure 5.13	BSE Skewness and Kurtosis for Diverger in Close Eyes	139
Figure 5.14 05-4506832 Figure 5.15	BSE Mean and Standard Deviation for Assimilator in Close Eyes pustaka.upsi.edu.my BSE Skewness and Kurtosis for Assimilator in Close Eyes	140 ptbupsi 141
Figure 5.16	BSE Mean and Standard Deviation for Converger in Close Eyes	142
Figure 5.17	BSE Skewness and Kurtosis for Converger in Close Eyes	143
Figure 5.18	BSE Mean and Standard Deviation for Accommodator in Close Eyes	144
Figure 5.19	BSE Skewness and Kurtosis for Accommodator in Close Eyes	145
Figure 5.20	LS Mean comparison in Close Eyes	146
Figure 5.21	LS Skewness comparison in Close Eyes	148
Figure 5.22	LS Kurtosis comparison in Close Eyes	149
Figure 5.23	Shapiro-Wilk Normality output for Diverger in Open Eyes	150
Figure 5.24	Shapiro-Wilk Normality output for Assimilator in Open Eyes	151
05-4506832	pustaka.upsi.edu.my	ptbupsi

xvi

Figure 5.25	Shapiro-Wilk Normality stoutput Korin Converger in Appen Kampus Sultan Abdul Jalil Shah		
Figure 5.26	Shapiro-Wilk Normality output for Accommodator in Open Eyes	153	
Figure 5.27	Comparison of Shapiro-Wilk Normality test for LS in Open Eyes	154	
Figure 5.28	Shapiro-Wilk Normality output for Diverger in Close Eyes		
Figure 5.29	Shapiro-Wilk Normality output for Assimilator in Close Eyes	156	
Figure 5.30	Shapiro Wilk Normality output for Converger in Close Eyes	157	
Figure 5.31	Shapiro-Wilk Normality output for Accommodator in Close Eyes	158	
Figure 5.32	Comparison of Shapiro-Wilk result for LS in Close Eyes	159	
Figure 5.33	Cluster Means Variation for Theta Left BSE in Open Eye	167	
Figure 5.34	Clusterwise Importance for LS Classification of Theta Left		
05-4506832 Figure 5.35	Cluster Means Variation for Delta Left BSE in Open Eyes	168 ptbupsi 170	
Figure 5.36	Clusterwise Importance for LS Classification of Delta Left BSE in Open Eyes	171	
Figure 5.37	Cluster Means Variation for Beta Left BSE in Close Eyes	172	
Figure 5.38	Clusterwise Importance for LS Classification of Beta Left BSE in Close Eyes	173	
Figure 5.39	Cluster Means Variation for Delta Left EEG in Close Eyes	175	
Figure 5.40	Clusterwise Importance for LS Classification of Delta Left BSE in Close Eyes	176	
Figure 5.41	Theta Left Open Eyes BSE histogram for Diverger	178	
Figure 5.42	Theta Left Open Eyes BSE histogram for Assimilator	179	
Figure 5.43	Theta Left Open Eyes BSE histogram for Converger	179	
Figure 5.44	Theta Left Open Eyes BSE histogram for Accommodator	180	



Figure 5.45 05-4506832 Figure 5.46	Delta Left Open Eyes BSE histogram for Diverger pustaka.upsi.edu.my Delta Left Open Eyes BSE histogram for Assimilator	181 • ptbupsi 181
Figure 5.47	Delta Left Open Eyes BSE histogram for Converger	182
Figure 5.48	Delta Left Open Eyes BSE histogram for Accommodator	182
Figure 5.49	Beta Left Close Eyes BSE histogram for Diverger	183
Figure 5.50	Beta Left Close Eyes BSE histogram for Assimilator	184
Figure 5.51	Beta Left Close Eyes BSE histogram for Converger	184
Figure 5.52	Beta Left Close Eyes BSE histogram for Accommodator	185
Figure 5.53	Delta Left Close Eyes BSE histogram for Diverger	186
Figure 5.54	Delta Left Close Eyes BSE histogram for Assimilator	186
Figure 5.55	Delta Left Close Eyes BSE histogram for Converger	187
Figure 5.56	Delta Left Close Eyes BSE histogram for Accommodator	187





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### **Symbols**

δ	Delta band
θ	Theta band
α	Alpha band
β	Beta band
γ	Gamma band
$\mu V$	microvolt
Hz	Hertz
σ	Standard Deviation
Σ	Sigma
N 05-4506832	Number of subjects pustaka.upsi.edu.my f Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah Y PustakaTBainun Optbupsi
$\bar{x}$	Means
Но	Null Hypothesis
Ha	Alternative Hypothesis







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#### **Abbreviations**

AC	Abstract Conceptualization			
AE	Active Experimentation			
AIC	Akaike information criteria			
ANOVA	Analysis of Variances			
ASCII	American Standard Code for Information Interchange			
BCI	Brain Computer Interface			
BCI	Brain Computer Interface			
BIC	Bayesian information criteria			
BSE	Baseline Summative Electroencephalogram			
CE 05-4506832 CE	Concrete Experience pustaka.upsi.edu.my Close Eyes			
CNS	Central Nervous System			
СТ	Computerized Tomography			
DFT	Discrete Fourier Transform			
ECG	Electrocardiogram			
EEG	Electroencephalogram			
EMG	Electromyogram			
EOG	Electrooculogram			
FFT	Fast Fourier Transform			
FIR	Finite Impulse Response			
FMRi	Functional magnetic resonance imaging			
GSR	Galvanic Skin Resistance			
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HSD 05-4506832 KLSI	Honestly Significant Difference pustaka.upsi.edu.my Kolb's Learning Style Inventory	PustakaTBainun	ptbupsi
LS	Learning Style		
MEG	Magnetoencephalography		
MRI	Magnetic Resonance Imaging		
OE	Open Eyes		
PET	Positron Emission Tomography		
PSD	Power Spectrum Density		
RAS	Reticular Activating System		
RO	Reflective Observation		
SD	Standard Deviation		
SPSS	Statistical Package for the Social Sciences		
SW	Shapiro-Wilk		
<b>TMS</b> 06832	Transcranial magnetic stimulation Abdul Jalil Shah	PustakaTBainun	ptbupsi
URL	Uniform Resource Locator		

xxi



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**INTRODUCTION** 

#### 1.1 Research Background

Human momentous limitless capacity with regards to learning is ostensibly the single factor that lifts their position in the rank of world's occupant [1]. Hence, it is understandable why emergence research field such as Artificial Intelligence considered human as the proficient example of how to design a learning capable artificial organism rather than being programmed directly by the field specialists [2]. Most credible references allude learning as an adjustment in behaviour that is because of experience. This is basically an extremely essential practical meaning of learning in that learning is viewed as a capacity that maps experience onto behaviour. In short, learning is characterized as an impact of experience on behaviour [3]. On the other hand, it has been contended that learners have an extensive variety of capacities crosswise over various sorts of intelligence and they are more joyful when they utilize them [4, 5]. So, Individual differences seem to play an important role in learning brought capacity researchers for the last two decades that carry the centre naturally to the term "Learning Style" (LS) [6, 7].

The "Learning Style" is comprehensively utilized in the literature to refer to learners' categorization outline depending essentially on their cognitive and mental attributes when occupied with learning exercises. Learning Style had been defined as the favoured technique of comprehending and dealing on information while scholars also depicted LS as the composite of trademark subjective, feeling, and physiological elements that serve as moderately steady markers of how a learner sees, collaborates with, and reacts to the learning environment [8, 9]. It had been underlined that LS is ever-vital in educational field of research particularly in Educational Psychology [10],[11]. A great deal of investigation had open a Pandora box which indicated the significant of LS with diverse parts of instructing and learning for example learning accomplishment [12], learning style inclination in distinctive races [13] and in differing higher training courses [12, 14-16]. Likewise, there is an explicit confirmation that learners will come to be more spurred to study by knowing progressively about their own qualities and shortcomings. Then again, if instructors





could react to learners' requirements, the educating and learning process will be more bupsi adequate and resulting in better learners' accomplishment [17]. Henceforth, there is a catalyst needed to give a careful consideration to learners' LS by method of gripping them in the education and learning process.

Over the last three decades, various learning style models have been proposed whereas the exact number of 71 models had been reviewed extensively by researcher which found that information of learning styles can be utilized to build the mindfulness of learners and mentors about their qualities and shortcomings as learners [18]. As such, it had been inferred that every one of the favourable circumstances guaranteed for metacognition can be picked up by urging all learners to wind up proficient about their own learning and that of others [19]. In the LS research domain, several top models such as Dunn & Dunn [20], Car Jung and Myers Briggs Type Indicator [21], Felder-Silverman's Learning [22], Honey and Mumford [23] and Kolb's [24] model were discussed as literature and ultimately, the Kolb's LS model is preferred as the main and focal point of the study. It has been found that the model has been utilized and assessed as a part of learning circumstances. As far as the LS research is concerned, questionnaires were the major instrument used by the models to acquire the learners' LS [25-27]. Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

On the other hand, the emergence of Electroencephalogram (EEG) as worthwhile proven technology to probe humans' potential attributes had been phenomenal in supporting the learning-related research including LS [28-30]. As a current trend, EEG technology has a tremendous capacity dimension to investigate the learners' LS using biological signature which could enhance the findings accuracy and reliability [31]. In this research, an advanced EEG brain signals processing of learners which held specified Kolb's LS is conducted to correspond between the two areas. As such this study could be envisioned as a merge between the education and neuroscience domains where the findings were beneficial to both aspects [32-35].

#### **1.2 Problem Statements**

LS is a distinguish attributes which could help educators, teachers or lecturers to understand their learners better. On top of that, learners also could fetch advantages of knowing their own LS to enhance their learning process. Unfortunately, most of the LS model including Kolb's model is using questionnaire based instrument which

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recognized as Learning Style Inventory (LSI) to probe and find out the learner's LS. 05-4506832 Pustaka.upsi.edu.my Pustakaan upsi.edu.my Pustakaan upsi.

#### 1.3 Research Objectives

The main objective of the thesis is to analyse and determine the most significant and best EEG sub-band in classifying the subjects LS corresponding to the Kolb's 05-4506832 (S) pustaka.upsi.edu.my Learning Style Inventory (KLSI). To achieve this objective, the following subobjectives were applied:

- i. To specify the learner's LS and to obtain their brain signals features using Kolb's Learning Style Inventory (KLSI) and EEG technology respectively.
- ii. To determine the EEG sub-band that could best classify the Kolb's LS.
- iii. To outline the characteristics of EEG sub-band that best classify the Kolb' LS.

#### 1.4 Research Scope and limitation

The research scope is set to the following, consorting to the experimental protocol which approved by the Research Ethics Committee of the University, Ethics No.600-RMI (5/1/6):





The study was administered to the Software Engineering undergraduate pustaka.upsi.edu.my I Kampus Sultan Abdul Jalil Shah students of Universiti Pendidikan Sultan Idris (UPSI), Tanjong Malim and Electrical Engineering undergraduate students of Universiti Teknologi MARA (UiTM), Shah Alam.

- Two types of baseline brain states were probed during the brain signals acquisition which indicated as in Open Eyes (OE) and Close Eyes (CE) conditionality.
- Electrodes placements on the scalp for EEG data recording were using bipolar type arrangements, placed at the prefrontal area Fp1 (left hemisphere) and Fp2 (right hemispheres complying with the International 10-20 systems).
- iv. EEG data acquisition tools used in the research is WaveRider with a frequency of 128 Hz which is the maximum frequency offered by the hardware. By using this frequency, detail PSD data points on each subject are cleanly captured and subsequently being used in the Baseline Summative EEG (BSE) calculation that form the core EEG dataset in this research.

O 05-4906832 All circuit design, filtering and coding were executed in WaveWare ptbupsi

#### 1.5 Research Contributions

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This study shows a novel approach in applying a biological marker in the form of brain signal for Kolb's LS classification. This research had demonstrated that LSI in questionnaire-type instrument and brain signals could be employed hand-by-hand in the LS classification effort. Analysis on the brain signal sub-bands of Beta, Alpha, Theta and Delta for each particular Kolb's LS has led to a differentiation between signals based on their pattern, properties and characteristics. In addition, this research entails a significant contribution by presenting the best EEG brain signal sub-bands for the Kolb's LS classification. On top of that, the effort to probe further on the best selected sub-bands in order to understand and confirm on its properties also considered as one of the research's contribution.



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#### 1.6 Thesis Organization 05-4506832 pustaka.upsi.edu.my

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This thesis is prepared in six (6) chapters. The content of each chapter is briefed as follows:

Chapter 1 introduces the background of the research which touches on the LS and EEG aspects. Subsequently statement of the problem, research objectives, scope and contributions are outlined. Thesis organization is prepared as the final section in this chapter.

Chapter 2 is about the review of the related literatures of the research. It covers mainly on human brain, EEG, Learning and LS. First, fundamental of human brain structures and function is discussed. Then, its neurophysiology aspect is covered thoroughly which lead to the explanation on several primary research domains that involved human brain. After that, the relevancy and importance of EEG in brain research is being touched. This report covers the latest trend of current EEG research. Next, the aspect of Learning Theories and then scoped to LS is discussed.

Chapter 3 explains the theoretical aspects that were used in the research. It involves mainly three big components of: EEG, Kolb's LSI and Statistical Analysis. For EEG part, theoretical aspects of EEG are discussed thoroughly. This discussion 05-4506832 (a) pustaka.upsi.edu.my includes the history of EEG, EEG generation and measurement, EEG artefacts and pre-processing. The chapter covers on the theoretical basis of Kolb' Learning Style Inventory (KLSI) including its history and experiential learning concepts. Finally, the theoretical aspects of Statistical Analysis employed in the research are discussed.

Chapter 4 explains on the methodologies that being employed in the research. The methodologies cover mainly on Experiment and Data collection part and Statistical Analysis part. For the first part, LS data collection and EEG signal acquisition procedure are discussed in details. Then explanation includes the online administration of Kolb's LSI to subjects and the off-line processing of EEG dataset in order to produce the BSE power which is the EEG dataset utilized in the research.

Chapter 5 presents and discusses the result obtained in the research. It is divided into three main parts which are finding and discussion on the subjects Kolb's LS determination using questionnaire, Statistical Analysis of the BSE and Kolb's LS classification. The EEG sub-bands which acting as the best classifier for Kolb's LS are determined in this chapter. Chapter 5 ends with the reporting on the determined EEG sub-bands profiling.

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Finally, Chapter 6 presents the conclusions of the research. Some potential 05-4506832 pustaka.upsi.edu.my Furgustakaan Iuanku Bainun future works are recommended at the end of this chapter.





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