

# Contents

Certificate	iii
Declaration	v
Copyright Transfer Certificate	vii
Acknowledgments	ix
Preface	xi
Contents	xv
List of Figures	xix
List of Tables	xxi
Abbreviations	xxiii
Symbols	xxv
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 BRAIN ANATOMY OF LANGUAGE PROCESSING . . . . .	1
1.2 EXPERIMENTAL METHODS FOR LANGUAGE PROCESSING IN THE BRAIN . . . . .	4
1.2.1 HISTORICAL METHODS . . . . .	4
1.2.2 RECENT METHODS . . . . .	5
1.2.2.1 STATIC RECORDING . . . . .	5
1.2.2.2 DYNAMIC RECORDING: ELECTRICAL ACTIV- ITY . . . . .	7
1.2.3 NEURO-LINGUISTIC COMPUTATIONAL MODELS[1] . . .	7
1.2.3.1 STRUCTURED MODELS . . . . .	8
1.2.3.2 EMERGENT MODELS . . . . .	9
1.3 MATHEMATICAL METHODS . . . . .	10

1.4	RECENT RESEARCHES ON APHASIA AND DYSLEXIA . . . . .	11
1.5	MOTIVATION . . . . .	11
1.6	PROBLEM STATEMENT AND THESIS OBJECTIVES . . . . .	13
1.7	OUTLINE OF THE THESIS . . . . .	14
<b>2</b>	<b>THEORETICAL BACKGROUND AND LITERATURE REVIEW</b>	<b>17</b>
2.1	LANGUAGE ACQUISITIONS . . . . .	18
2.1.1	FIRST LANGUAGE ACQUISITION . . . . .	20
2.1.2	SECOND LANGUAGE ACQUISITION . . . . .	22
2.2	LANGUAGE COMPREHENSION . . . . .	26
2.3	<b>BILINGUALISM:</b> . . . . .	29
2.4	DATA ACQUISITION AND ANALYSIS TECHNIQUES . . . . .	37
2.5	DATA ANALYSIS . . . . .	40
2.5.1	STATISTICAL ANALYSIS METHODS . . . . .	40
2.5.1.1	THE UNIVARIATE METHODS . . . . .	40
2.5.1.2	MULTIVARIATE METHODS . . . . .	41
2.6	NEUROIMAGING SOFTWARE TOOLS . . . . .	41
2.7	READING AND WRITING IN THE BRAIN . . . . .	42
2.8	PERFORMANCE METRICS . . . . .	52
2.9	CONCLUSIONS . . . . .	54
<b>3</b>	<b>IDENTIFICATION OF NEURO-SEMANTIC REPRESENTATION OF CONCRETE NOUNS USING CASCADED FEATURE SELECTION</b>	<b>55</b>
3.1	INTRODUCTION . . . . .	56
3.2	METHODS AND MODELS . . . . .	57
3.2.1	DATASET DESCRIPTION . . . . .	57
3.2.2	MODEL DESCRIPTION . . . . .	58
3.3	RESULT ANALYSIS AND DISCUSSIONS . . . . .	68
3.4	CONCLUSIONS . . . . .	74
<b>4</b>	<b>SENTENCE POLARITY DETECTION</b>	<b>75</b>
4.1	INTRODUCTION . . . . .	76
4.2	METHODS AND MODELS . . . . .	79
4.2.1	DATA-SET DESCRIPTION . . . . .	79
4.2.2	MODEL . . . . .	81
4.2.2.1	fMRI DATA ACQUISITION . . . . .	81
4.2.2.2	PRE-PROCESSING . . . . .	82
4.2.2.3	DATA EXTRACTION FOR SENTENCE PROCESSING . . . . .	82
4.2.2.4	MEAN CALCULATION . . . . .	83
4.2.2.5	FEATURE SELECTIONS . . . . .	84

4.2.2.6	CLASSIFICATION . . . . .	87
4.3	RESULT ANALYSIS AND DISCUSSION . . . . .	91
4.4	CONCLUSIONS . . . . .	104
<b>5</b>	<b>IDENTIFICATION OF EMOTIONS AND MOOD OF READER'S DURING STORY READING</b>	<b>105</b>
5.1	INTRODUCTION . . . . .	105
5.2	METHODS AND MODELS . . . . .	106
5.2.1	DATASET DESCRIPTION . . . . .	106
5.2.2	EXTRACTING TOKEN LEVEL fMRI VECTORS . . . . .	107
5.2.3	IDENTIFICATION OF EMOTIONS IN THE STORY . . . . .	109
5.3	RESULT ANALYSIS AND DISCUSSION . . . . .	116
5.3.0.1	MOOD IDENTIFICATION . . . . .	116
5.4	CONCLUSIONS . . . . .	118
<b>6</b>	<b>CONCLUSION AND FUTURE WORK</b>	<b>119</b>
6.1	CONCLUSIONS . . . . .	119
6.2	FUTURE WORKS . . . . .	122
	<b>BIBLIOGRAPHY</b>	<b>123</b>
<b>A</b>	<b>LIST OF PUBLICATIONS</b>	<b>155</b>



# List of Figures

1.1	Brain anatomy for language processing [2]	3
3.1	Data acquisition scheme	58
3.2	Proposed Model	60
3.3	Spatial Realignment	61
3.4	Normalisation	62
3.5	Principal Component Analysis	66
3.6	LDA	68
3.7	Feature selection Accuracy Result	69
3.8	Classification Result	70
3.9	Result for 12 Class problem	71
3.10	Efficiency of cascaded feature selection	72
4.1	Trial Representation	80
4.2	Proposed Model	81
4.3	CFS Feature Selection	88
4.4	Multilayer Perceptron	89
4.5	Statistical distribution and Graphical representations of selected features	93
4.6	Comparative analysis (Overall average of six subjects)	96
4.7	Average of the result obtained for all subjects)	99
4.8	Average of results for all subjects	100
4.9	Comparative result analysis on Star-Plus Dataset	104
5.1	Token Level fMRI vector [289]	108
5.2	Gaussian Distribution	108
5.3	Gumbel Distribution	109
5.4	Result Random Forest	118
5.5	Result Random MLP	118



# List of Tables

1.1	Trends in Neurolinguistics Research . . . . .	3
1.2	Recent Research on Aphasia and Dyslexia . . . . .	12
2.1	Recent Research on Language Acquisition . . . . .	34
2.2	Review of Language comprehension in the brain . . . . .	36
2.3	Tools for Neuro-data analysis . . . . .	42
2.4	Performance Measure . . . . .	52
3.1	Concrete nouns and its categories . . . . .	59
3.2	<b>Confusion Matrix</b> . . . . .	73
3.3	Confusion Matrix 12 Class . . . . .	73
4.1	Number of voxels in each anatomical region of the brain . . . . .	92
4.2	Region-wise number of selected features . . . . .	94
4.3	Result analysis table for all six subjects CFS subset evaluator . . . . .	95
4.4	Filtered Subset Evaluator . . . . .	95
4.5	Info-gain . . . . .	95
4.6	Confusion matrix of all subject . . . . .	96
4.7	Result obtained without feature selection from all subjects . . . . .	97
4.8	Comparative analysis of average performance measures . . . . .	98
4.9	Result obtained for all Subjects k-NN . . . . .	98
4.10	Confusion Matrix . . . . .	99
4.11	Confusion Matrix . . . . .	101
4.12	The classification result . . . . .	101
4.13	Error Analysis . . . . .	102
4.14	Statistical Analysis of Results . . . . .	102
4.15	Pairwise comparisons and p-value . . . . .	103
4.16	Result of Rotation Forest with Varying feature set . . . . .	103
5.1	<b>Emotion Classification</b> . . . . .	110
5.2	<b>Emotion Classification</b> . . . . .	112
5.3	<b>Emotion Areas in Brain</b> . . . . .	115
5.4	Confusion Matrix . . . . .	117
5.5	Result Analysis . . . . .	117