## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>ix</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xvii</td>
</tr>
<tr>
<td>Foreword by Richard L. Lewis</td>
<td>xx</td>
</tr>
<tr>
<td>Preface</td>
<td>xxiii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>xxiv</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Working Memory in Theories of Sentence Comprehension</td>
<td>2</td>
</tr>
<tr>
<td>1.2 Prediction in Sentence Processing</td>
<td>6</td>
</tr>
<tr>
<td>1.3 Working Memory and Prediction as Explanations for Processing Difficulty</td>
<td>7</td>
</tr>
<tr>
<td>1.4 Current Beliefs about Constraints on Sentence Comprehension</td>
<td>7</td>
</tr>
<tr>
<td>1.5 Some Gaps in the Sentence Processing Literature</td>
<td>8</td>
</tr>
<tr>
<td>1.5.1 The Relative Scarcity of Computationally Implemented Models</td>
<td>8</td>
</tr>
<tr>
<td>1.5.2 A Focus on Average Behaviour and Neglect of Individual-Level Differences</td>
<td>10</td>
</tr>
<tr>
<td>1.5.3 The Absence of High-Precision Studies</td>
<td>11</td>
</tr>
<tr>
<td>1.5.4 Unclear Desiderata for a Good Model Fit</td>
<td>11</td>
</tr>
<tr>
<td>1.6 The Goals of This Book</td>
<td>16</td>
</tr>
<tr>
<td>1.6.1 Providing Open Source Model Code</td>
<td>17</td>
</tr>
<tr>
<td>1.6.2 Modelling Average Effects as Well as Individual Differences</td>
<td>17</td>
</tr>
<tr>
<td>1.6.3 Developing a Set of Modelling and Empirical Benchmarks for Future Model Comparison</td>
<td>18</td>
</tr>
<tr>
<td>1.7 Looking Ahead</td>
<td>19</td>
</tr>
<tr>
<td>2 Dependencies in Sentence Comprehension</td>
<td>21</td>
</tr>
<tr>
<td>2.1 Memory Processes in Sentence Comprehension</td>
<td>21</td>
</tr>
<tr>
<td>2.2 Dependency Completion in Sentence Processing</td>
<td>23</td>
</tr>
<tr>
<td>2.3 Subject-Verb Non-Agreement Dependencies</td>
<td>26</td>
</tr>
<tr>
<td>2.4 Subject-Verb Number Agreement</td>
<td>31</td>
</tr>
<tr>
<td>2.5 Reflexives and Reciprocals</td>
<td>38</td>
</tr>
<tr>
<td>2.5.1 Individual-Level Effects in the Dillon et al. Design</td>
<td>44</td>
</tr>
<tr>
<td>2.5.2 A Sensitivity Analysis on the Ungrammatical Agreement and Reflexives Conditions Using Informative Priors</td>
<td>44</td>
</tr>
<tr>
<td>2.6 Concluding Remarks</td>
<td>47</td>
</tr>
<tr>
<td>3 The Core ACT-R-Based Model of Retrieval Processes</td>
<td>49</td>
</tr>
<tr>
<td>3.1 ACT-R</td>
<td>49</td>
</tr>
<tr>
<td>3.2 The Lewis and Vasishth (2005) Model</td>
<td>52</td>
</tr>
<tr>
<td>3.2.1 A Priori Predictions of the Model</td>
<td>54</td>
</tr>
</tbody>
</table>
## Table of Contents

### 3.2.2 Comparison of the LV05 Prediction Space with the Results of the Jäger et al. Meta-analysis

Page 60

### 3.3 A More Principled Approach to Parameter Estimation

- 3.3.1 Bayesian Parameter Estimation
  Page 64
- 3.3.2 Approximate Bayesian Computation
  Page 66

### 3.4 Concluding Remarks

Page 69

### 4 An Extension of the Core Model: Modelling Prominence and Multi-associative Cues

Page 71

- 4.1 Incorporating Prominence and Multi-associative Cues
  - 4.1.1 Item Prominence
    Page 74
  - 4.1.2 Multi-associative Cues
    Page 84
  - 4.1.3 Implementation of Item Prominence and Multi-associative Cues
    Page 89
  - 4.1.4 Multi-associative Cues
    Page 90
  - 4.1.5 Prominence
    Page 93

- 4.2 A Simulation of the Meta-analysis Studies
  - 4.2.1 Data
    Page 95
  - 4.2.2 Method
    Page 95
  - 4.2.3 Results
    Page 98

- 4.3 Discussion
  - 4.3.1 Distractor Prominence
    Page 107
  - 4.3.2 Multi-associative Cues
    Page 108

### Appendices

- 4.A Key Terms and Concepts
  Page 111
- 4.B List of Experiments Included in the Simulations
  Page 113
- 4.C Model Specifications
  Page 114

### 5 An Extension of the Core Model: Modelling the Interaction of Eye-Movement Control and Parsing

Page 116

- 5.1 The EMMA/ACT-R Reading Model
  Page 118
- 5.2 Replication of Salvucci (2001)
  - 5.2.1 Data
    Page 119
  - 5.2.2 Model
    Page 120
  - 5.2.3 Analysis
    Page 120
  - 5.2.4 Results
    Page 122
  - 5.2.5 Discussion
    Page 122

- 5.3 The Extended EMMA/ACT-R Model
  - 5.3.1 Surprisal
    Page 124

- 5.4 Simulations on the Potsdam Sentence Corpus
  - 5.4.1 Data
    Page 125
  - 5.4.2 Model
    Page 127
  - 5.4.3 Results
    Page 128
  - 5.4.4 Discussion
    Page 131

- 5.5 General Discussion
  - 5.5.1 Comparison with E-Z Reader
    Page 132
  - 5.5.2 Future Prospects
    Page 134
## Contents

### Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.A Root-Mean-Square Deviation</td>
<td>136</td>
</tr>
<tr>
<td>5.B Linear Regression Analysis</td>
<td>136</td>
</tr>
</tbody>
</table>

### 6 Reanalysis and Underspecification in Sentence Comprehension:

#### Modelling Eye Movements

6.1 Introduction 140

6.2 Modelling Reanalysis: Memory and Expectation Processes in Parsing

6.2.1 Memory and Expectation in Relative Clauses 141
6.2.2 Simulation: Modelling the Staub (2010) Data 143
6.2.3 Results 144
6.2.4 Discussion 145

6.3 Modelling Underspecification: The Adaptive Interaction between Parsing, Eye-Movement Control, and Working Memory Capacity

6.3.1 Good-Enough Parsing 148
6.3.2 Simulation: Modelling the von der Malsburg and Vasisht (2013) Experiment 153
6.3.3 Results 154
6.3.4 Discussion 157

6.4 General Discussion 160

### 7 Competing Accounts of Interference in Sentence Processing

7.1 The Direct-Access Model 161

7.2 Comparing the Predictive Performance of the Models

7.2.1 Inhibitory Interference 164
7.2.2 Relative Clauses in Chinese 167
7.2.3 Discussion 170

7.3 Encoding Interference in Agreement Attraction

7.3.1 An Evaluation of the Nairne Proposal 173
7.3.2 Model Comparison 174
7.3.3 Discussion 175

7.4 Summary 176

### 8 Modelling Sentence Comprehension Deficits in Aphasia

8.1 Theories and Models of Sentence Comprehension Deficits

8.1.1 Timing Deficit 178
8.1.2 Reduction in Memory 180
8.1.3 Intermittent Deficiency 181
8.1.4 Weakened Syntax 182
8.1.5 Slow Syntax 183
8.1.6 Lexical Integration Deficit 184
8.1.7 Lexical Access Deficits 184
8.1.8 A Comparison of Theories of Impaired Processing, and Their Relation to Theories of Unimpaired Processing 185

8.2 Modelling Individual-Level Differences

8.2.1 Mapping ACT-R Parameters to Sources of Deficits 189
8.2.2 Simulations 191
8.2.3 Results 192
8.2.4 Discussion 195
### Table of Contents

8.3 Competing Models of Retrieval in Aphasia 197  
8.3.1 Materials 197  
8.3.2 Results and Discussion 198  
8.4 Concluding Remarks 198  

9 Future Directions 200  
9.1 Developing Implemented Computational Models 200  
9.2 An Excessive Focus on Average Behaviour 200  
9.3 Creating Higher-Precision Benchmark Data-Sets for Model Evaluation and Comparison 201  
9.4 Developing Better Criteria for Evaluating Model Fit 202  
9.5 In Closing 202  

Bibliography 203  
Index 221