

Contents

1	Setting the Stage: Computation in Cognitive Science	1
1.1	Introduction	1
1.2	What is Cognitive Science?.....	7
1.3	The Present Thesis in the Landscape of Previous Work	9
1.4	Formalisms of Computability versus Accounts of Concrete Computation	12
1.5	A Tripartite Division: The Semantic, Causal and Functional Views of Computation	15
1.5.1	Representation, Mental Representations and Computational Representations	15
1.5.2	The Semantic View of Computation	22
1.5.3	The Causal View of Computation	23
1.5.4	The Functional View of Computation	25
1.6	The Plan of Attack	26
	References	28
 2	 An Analysis of the Adequacy Criteria for Evaluating Accounts of Computation	 33
2.1	Introduction	33
2.2	Smith's Tripartite Adequacy Criteria	34
2.2.1	The Empirical Criterion	35
2.2.2	The Conceptual Criterion	35
2.2.3	The Cognitive Criterion	36
2.2.4	Asking Too Much and Too Little	37
2.3	Piccinini's Sexpartite Adequacy Criteria	40
2.3.1	The Empirical Criterion	41
2.3.2	The Objectivity Criterion	41
2.3.3	The Explanation Criterion	41
2.3.4	The Right Things Compute Criterion	42
2.3.5	The Miscomputation Criterion	42
2.3.6	The Taxonomy Criterion	43
2.3.7	An Adequate Alternative	43

2.4	Von Neumann's Tripartite Adequacy Criteria	48
2.4.1	The Precision and Reliability Criterion	48
2.4.2	The Single Error Criterion.....	49
2.4.3	The Analogue – Digital Distinction Criterion	49
2.4.4	A Comparison with Previous Criteria	50
2.5	Implementation Theory Bridging Computability and Concrete Computation.....	51
2.5.1	The Implementation Adequacy Criterion.....	51
2.5.2	The Empirical Criterion and the Cognitive Criterion Revisited.....	52
2.6	Recommended Sexpartite Adequacy Criteria.....	53
	References	55
3	Starting at the Beginning: Turing's Account Examined.....	57
3.1	Turing Machines from Mathematical and Physical Perspectives	57
3.2	The Key Requirements According to Turing's Account.....	65
3.3	Turing's Account Evaluated.....	68
3.4	Concluding Remarks: Digitality, Determinism and Systems	71
	References	76
4	The Triviality "Account" Examined.....	79
4.1	Introduction.....	79
4.2	The Searle-Triviality Thesis.....	80
4.3	The Putnam-Triviality Theorem.....	81
4.4	The Key Requirements for a System to Perform Digital Computation.....	84
4.5	Trivialisation of Computation Blocked	86
	References	94
5	Semantic Accounts of Computation Examined	97
5.1	The PSS Account	98
5.1.1	Introduction	98
5.1.2	The Key Requirements Implied by the PSS Account.....	100
5.1.3	The PSS Account Evaluated.....	104
5.2	The FSM Account	107
5.2.1	Introduction	107
5.2.2	The Key Requirements Implied by the FSM Account	110
5.2.3	The FSM Account Evaluated	114
5.3	A Reconstruction of Smith's Participatory Account	118
5.3.1	Introduction	118
5.3.2	The Key Requirements Implied by Smith's Participatory Account	119
5.3.3	Smith's Participatory Account Evaluated	122

5.4 Arguments for the Semantic View of Computation Criticised..... 125

References 131

6 Computation as Information Processing 133

6.1 Introduction 133

6.2 Semantic Information, Non-semantic Information and Data 134

6.2.1 Shannon Information as a Non-semantic Conception
of Information 135

6.2.2 Algorithmic Information as a Non-semantic Conception
of Information 136

6.2.3 Semantic Conceptions of Information..... 137

6.3 Features of the Resulting IP Accounts Based on the Different
Conceptions of Information 141

6.3.1 A Possible Objection 141

6.3.2 Features of the Resulting IP Accounts Based on
Non-semantic Information 142

6.3.3 Features of the Resulting IP Accounts Based on Semantic
Information..... 145

6.4 The Key Requirements Implied by the Resulting IP Account 146

6.5 Problems for the Resulting IP Accounts 153

6.5.1 Problems for IP Accounts Based on SI or AI..... 153

6.5.2 Problems for an IP Account Based on Factual
Information..... 155

6.6 The Instructional Information Processing (IIP) Account 157

6.6.1 An Outline of the IIP Account 158

6.6.2 The IIP Account Evaluated 160

6.7 Concluding Remarks 163

References 164

7 Causal and Functional Accounts of Computation Examined..... 167

7.1 The Gandy-Sieg Account 167

7.1.1 Introduction 167

7.1.2 The Key Requirements Implied by the
Gandy-Sieg Account 169

7.1.3 The Gandy-Sieg Account Evaluated 171

7.2 The Algorithm Execution Account 175

7.2.1 Introduction 175

7.2.2 The Key Requirements Implied by the Algorithm
Execution Account 176

7.2.3 The Algorithm Execution Account Evaluated..... 179

7.3 The Mechanistic Account..... 185

7.3.1 Introduction 185

7.3.2	The Key Requirements Implied by the Mechanistic Account	186
7.3.3	The Mechanistic Account Evaluated	188
7.4	Concluding Remarks	193
	References	193
8	Computation Revisited in the Context of Cognitive Science	197
8.1	A Limited Representational Character of Digital Computation	197
8.2	Avoiding Ambiguity about Computation	202
8.3	The Explanatory Role of Computation in Cognitive Science	207
8.3.1	Computationalism and Computation Simpliciter	208
8.3.1.1	Classicism and Symbolic Computation	208
8.3.1.2	Broad Construals of Computationalism and Digital Computation	209
8.3.2	Connectionism and Sub-symbolic Computation	211
8.3.3	Computational Neuroscience and Neural Computation	213
8.3.4	Extreme Dynamicism and the Non-computational Shift	215
8.3.5	Mechanistic versus Non-mechanistic Explanatory Frameworks	217
8.4	Computation and Cognition – Concluding Remarks	223
	References	226