

Jan Sprenger

Stephan Hartmann

# Bayesian Philosophy of Science

Variations on a Theme by the  
Reverend Thomas Bayes

$$p(H|E) = p(H) \frac{p(E|H)}{p(E)}$$

**OXFORD**  
UNIVERSITY PRESS

# Contents

<b>First Author’s Preface</b>	<b>vii</b>
<b>Second Author’s Preface</b>	<b>xiii</b>
<b>List of Figures</b>	<b>xxi</b>
<b>List of Tables</b>	<b>xxiii</b>
<b>Book Overview</b>	<b>xxv</b>
<b>Theme: Bayesian Philosophy of Science</b>	<b>1</b>
Probability and Degrees of Belief . . . . .	4
Conditional Degrees of Belief and Bayes’ Theorem . . .	17
Conditionalization and Varieties of Bayesian Inference	21
Causal Bayesian Networks . . . . .	31
Variations on a Bayesian Theme . . . . .	35
<b>Variation 1: Confirmation and Induction</b>	<b>41</b>
1.1 Motivating Bayesian Confirmation Theory . . . . .	42
1.2 Confirmation as Firmness . . . . .	43
1.3 Confirmation as Increase in Firmness and the Paradoxes of Confirmation . . . . .	50
1.4 The Plurality of Bayesian Confirmation Measures . . .	55
1.5 Discussion . . . . .	61
Appendix: Proofs of the Theorems . . . . .	63
<b>Variation 2: The No Alternatives Argument</b>	<b>67</b>
2.1 Modeling the No Alternatives Argument . . . . .	68
2.2 Results . . . . .	74

2.3	Discussion . . . . .	75
	Appendix: Proofs of the Theorems . . . . .	78
<b>Variation 3: Scientific Realism and the No Miracles Argument</b>		<b>81</b>
3.1	The Bayesian No Miracles Argument . . . . .	82
3.2	Extending the No Miracles Argument to Stable Scientific Theories . . . . .	88
3.3	The Frequency-Based No Miracles Argument . . . . .	95
3.4	Discussion . . . . .	99
	Appendix: Proofs of the Theorems . . . . .	102
<b>Variation 4: Learning Conditional Evidence</b>		<b>107</b>
4.1	Divergence Minimization and Bayesian Conditionalization	110
4.2	Three Challenges for Minimizing Divergence . . . . .	113
4.3	Meeting the Challenges . . . . .	115
4.4	Learning Relative Frequencies: The Case of Judy Benjamin	121
4.5	Discussion . . . . .	123
	Appendix: Proofs of the Theorems . . . . .	126
<b>Variation 5: The Problem of Old Evidence</b>		<b>131</b>
5.1	The Dynamic Problem of Old Evidence: The Garber–Jeffrey–Niiniluoto Approach . . . . .	133
5.2	The Dynamic Problem of Old Evidence: Alternative Explanations . . . . .	138
5.3	The Static Problem of Old Evidence: A Counterfactual Perspective . . . . .	140
5.4	The Hybrid Problem of Old Evidence: Learning Explanatory Relationships . . . . .	143
5.5	Discussion . . . . .	147
	Appendix: Proofs of the Theorems . . . . .	150
<b>Variation 6: Causal Strength</b>		<b>155</b>
6.1	Interventions and Causal Bayesian Networks . . . . .	156
6.2	Probabilistic Measures of Causal Strength . . . . .	161
6.3	Causal Contribution and Actual Causal Strength . . . . .	171
6.4	Conclusion . . . . .	176
	Appendix: Proofs of the Theorems . . . . .	178

<b>Variation 7: Explanatory Power</b>	<b>185</b>
7.1 Causal Theories of Explanatory Power . . . . .	187
7.2 Statistical Relevance and Explanatory Power . . . . .	190
7.3 Representation Theorems for Measures of Explanatory Power . . . . .	192
7.4 Comparison of the Measures . . . . .	199
7.5 Discussion . . . . .	201
Appendix: Proofs of the Theorems . . . . .	204
<b>Variation 8: Intertheoretic Reduction</b>	<b>207</b>
8.1 The Generalized Nagel–Schaffner Model . . . . .	208
8.2 Reduction and Confirmation . . . . .	211
8.3 Why Accept a Purported Reduction? . . . . .	217
8.4 Discussion . . . . .	219
Appendix: Proofs of the Theorems . . . . .	222
<b>Variation 9: Hypothesis Tests and Corroboration</b>	<b>227</b>
9.1 Confirmation versus Corroboration . . . . .	232
9.2 Popper on Degree of Corroboration . . . . .	235
9.3 The Impossibility Results . . . . .	238
9.4 A New Explication of Corroboration . . . . .	245
9.5 Discussion . . . . .	251
Appendix: Proofs of the Theorems . . . . .	254
<b>Variation 10: Simplicity and Model Selection</b>	<b>261</b>
10.1 Simplicity in Model Selection . . . . .	263
10.2 The Akaike Information Criterion . . . . .	267
10.3 The Bayesian Information Criterion . . . . .	270
10.4 The Minimum Message Length Principle . . . . .	273
10.5 The Deviance Information Criterion . . . . .	277
10.6 Discussion . . . . .	280
Appendix: Sketch of the Derivation of the Akaike Infor- mation Criterion . . . . .	284
<b>Variation 11: Scientific Objectivity</b>	<b>287</b>
11.1 The Objections . . . . .	289
11.2 Convergence Theorems and Bayes Factors . . . . .	291
11.3 Frequentism and Scientific Objectivity . . . . .	293

11.4	Beyond Concordant, Value-Free and Procedural Objectivity . . . . .	298
11.5	Interactive and Convergent Objectivity . . . . .	300
11.6	Discussion . . . . .	307
<b>Variation 12: Models, Idealizations and Objective Chance</b>		<b>311</b>
12.1	The Equality and Chance–Credence Coordination . . .	313
12.2	The Suppositional Analysis . . . . .	316
12.3	Suppositional Prior Probabilities and the Trilemma Resolution . . . . .	319
12.4	Bayes' Theorem Revisited . . . . .	322
12.5	Conclusion . . . . .	324
<b>Conclusion: The Theme Revisited</b>		<b>327</b>
<b>Bibliography</b>		<b>339</b>
<b>Index</b>		<b>377</b>