Contents

| Preface po | | | page xiii | |
|------------|---------------------------|---|-----------|--|
| I | Intui | Intuitive Definitions | | |
| 1 | Motivating Examples | | 3 | |
| 2 | Free Will and Determinism | | 5 | |
| | 2.1 | Can Free Choice Be Predicted? | 5 | |
| | 2.2 | Is the World Deterministic? | 6 | |
| | 2.3 | Is Free Will Observable? | 6 | |
| | 2.4 | The Problem of Free Will | 7 | |
| | 2.5 | A Rational Illusion | 10 | |
| | 2.6 | Free Will and the Decision Matrix | 12 | |
| 3 | The F | Principle of Indifference | 14 | |
| | 3.1 | Will a Canonical Space Help? | 14 | |
| | | 3.1.1 The Canonical State Space | 14 | |
| | | 3.1.2 Difficulties with a Uniform Prior on [0, 1] | 15 | |
| | | 3.1.3 Conclusion | 16 | |
| | 3.2 | What's Special about the Coin? | 17 | |
| | | 3.2.1 Symmetry | 17 | |
| | | 3.2.2 Smooth Beliefs | 18 | |
| 4 | 4 Relative Frequencies | | 20 | |
| | 4.1 | The Law of Large Numbers | 20 | |
| | 4.2 | The Problem of Induction | 21 | |
| | | 4.2.1 Hume's Critique | 21 | |
| | | 4.2.2 Goodman's Grue-Bleen Paradox | 22 | |
| | | 4.2.3 Kolmogorov Complexity and Its Dependence | | |
| | | of Language | 23 | |
| | | 4.2.4 Grue-Bleen Again | 26 | |
| | | 4.2.5 Evolutionary Explanations | 31 | |
| | 4.3 | Problems with the Frequentist Approach | 34 | |

| 5 | Subje | ective Probabilities | 37 |
|----|----------------------|--|----|
| | 5.1 | Linda the Bank Teller | 37 |
| | 5.2 | Pascal's Wager | 38 |
| | 5.3 | Classical versus Bayesian Statistics | 40 |
| | | 5.3.1 Basic Definitions | 40 |
| | | 5.3.2 The Gambler Fallacy | 41 |
| | | 5.3.3 Exchangeability | 42 |
| | | 5.3.4 Confidence Is Not Probability | 44 |
| | | 5.3.5 Classical Statistics Can Be Ridiculous | 45 |
| | | 5.3.6 Different Methods for Different Goals | 46 |
| II | Beha | avioral Definitions | 49 |
| 6 | A Ca | se Study | 51 |
| | 6.1 | A Characterization Theorem for Maximization | |
| | | of Utility | 51 |
| | 6.2 | Proof | 53 |
| | 6.3 | Interpretations | 55 |
| | | 6.3.1 A Few Definitions | 56 |
| | | 6.3.2 A Meta-Scientific Interpretation | 59 |
| | | 6.3.3 A Normative Interpretation | 62 |
| | | 6.3.4 A Descriptive Interpretation | 63 |
| | 6.4 | Limitations | 64 |
| | | 6.4.1 Semiorders | 65 |
| | | 6.4.2 Other Ways to Measure Utility | 71 |
| 7 | The Role of Theories | | 72 |
| | 7.1 | Theories Are Always Wrong | 72 |
| | 7.2 | Theories and Conceptual Frameworks | 74 |
| | 7.3 | Logical Positivism as a Metaphor | 76 |
| 8 | Von N | Neumann-Morgenstern's Theorem | 78 |
| | 8.1 | Background | 78 |
| | 8.2 | The Theorem | 79 |
| | 8.3 | Proofs | 83 |
| | | 8.3.1 The Algebraic Approach | 83 |
| | | 8.3.2 A Geometric Approach | 84 |
| | | 8.3.3 A Separation Argument | 85 |
| | 8.4 | The Three Interpretations | 86 |
| 9 | De Finetti's Theorem | | 89 |
| | 9.1 | Motivation | 89 |
| | 9.2 | The Theorem | 90 |
| | 9.3 | A Proof | 91 |
| | 9.4 | The Three Interpretations | 92 |

Contents ix

| 10 | Savag | e's Theorem | 94 |
|----|----------------------|--|-----|
| | 10.1 | Background | 94 |
| | 10.2 | States, Outcomes, and Acts | 96 |
| | 10.3 | Axioms | 97 |
| | | 10.3.1 PI | 97 |
| | | 10.3.2 P2 | 97 |
| | | 10.3.3 Notation | 99 |
| | | 10.3.4 Null Events | 99 |
| | | 10.3.5 P3 | 100 |
| | | 10.3.6 P4 | 102 |
| | | 10.3.7 P5 | 102 |
| | | 10.3.8 P6 | 103 |
| | | 10.3.9 P7 | 104 |
| | 10.4 | The Result for a Finite Outcome Set | 105 |
| | | 10.4.1 Finitely Additive Measures | 105 |
| | | 10.4.2 Nonatomic Measures | 107 |
| | | 10.4.3 The Theorem | 108 |
| | 10.5 | The Case of a General Outcome Set | 108 |
| | 10.6 | Interpretations | 109 |
| | 10.7 | The Proof and Qualitative Probabilities | 110 |
| 11 | The D | efinition of States | 113 |
| | 11.1 | Causality | 113 |
| | | 11.1.1 Newcomb's Paradox | 113 |
| | | 11.1.2 States as Functions from Acts to Outcomes | 114 |
| | | 11.1.3 A Problem | 115 |
| | 11.2 | Hempel's Paradox of Confirmation | 116 |
| | | 11.2.1 Are All Ravens Black? | 116 |
| | | 11.2.2 A State-Space Formulation | 117 |
| | | 11.2.3 What Is a Confirmation? | 117 |
| | | 11.2.4 A Resolution | 118 |
| | | 11.2.5 Good's Variation | 118 |
| | | 11.2.6 What Do We Learn from This? | 119 |
| | 11.3 | Monty Hall Three-Door Game | 120 |
| 2 | A Critique of Savage | | 123 |
| | 12.1 | Criticizing Critiques | 123 |
| | | 12.1.1 An Example | 123 |
| | | 12.1.2 The General Lesson | 124 |
| | 12.2 | Critique of P3 and P4 | 125 |
| | | 12.2.1 Example | 125 |
| | | 12.2.2 Defense | 126 |
| | | 12.2.3 State-Dependent Utility | 127 |
| | | 12.2.4 The Definition of Subjective Probability | 128 |
| | | 12.2.5 When Is State Dependence Necessary? | 129 |

| x Contents |
|------------|
| |

| | 12.3 | Critique of P1 and P2 | 130 |
|----|--------------------------------|--|-----|
| | | 12.3.1 The Basic Problem | 130 |
| | | 12.3.2 Reasoned Choice versus Raw Preferences | 131 |
| | | 12.3.3 Schmeidler's Critique and Ellsberg's | |
| | | Paradox | 132 |
| | | 12.3.4 Observability of States | 136 |
| | | 12.3.5 Problems of Complexity | 137 |
| 13 | Objec | ctivity and Rationality | 138 |
| | 13.1 | Subjectivity and Objectivity | 138 |
| | 13.2 | Objective and Subjective Rationality | 139 |
| 14 | Ansc | ombe-Aumann's Theorem | 142 |
| Ш | Alte | ernative Behavioral Theories | 145 |
| 15 | Choq | uet Expected Utility | 147 |
| | | Schmeidler's Intuition | 147 |
| | 15.2 | | 149 |
| | | Comonotonicity | 150 |
| | 15.4 | Axioms and Result | 151 |
| 16 | Prospect Theory | | 154 |
| | | Background | 154 |
| | 16.2 | Gain-Loss Asymmetry | 154 |
| | | Distortion of Probabilities | 156 |
| | 16.4 | • | |
| | | Integration | 158 |
| 17 | Maxmin Expected Utility | | 160 |
| | 17.1 | Convex Games | 160 |
| | 17.2 | A Cognitive Interpretation of CEU | 161 |
| | 17.3 | | 163 |
| | 17.4 | Interpretation of MMEU | 163 |
| | 17.5 | Generalizations and Variations | 165 |
| | 17.6 | Bewley's Alternative Approach | 165 |
| | 17.7 | Combining Objective and Subjective Rationality | 166 |
| | 17.8 | Applications | 168 |
| IV | Cog | nitive Origins | 171 |
| 18 | Case-Based Qualitative Beliefs | | 173 |
| | 18.1 | | 173 |
| | 18.2 | Four Known Techniques | 175 |
| | 18.3 | The Combination Axiom in General Analogical | |
| | | Reasoning | 177 |
| | 18.4 | Violations of the Combination Axiom | 179 |

| 19 | Frequentism Revisited 18 | | 180 |
|------------|--------------------------|--|-----|
| | 19.1 | Similarity-Weighted Empirical Frequencies | 180 |
| | 19.2 | Intuition | 181 |
| | 19.3 | Axiomatization | 182 |
| | 19.4 | Empirical Similarity and Objective Probabilities | 184 |
| 20 | Future | Research | 188 |
| References | | | 191 |
| Index | | | 199 |