

EXPERTS IN UNCERTAINTY

**Opinion and Subjective Probability
in Science**

ROGER M. COOKE

New York Oxford
OXFORD UNIVERSITY PRESS
1991

Contents

Introduction, xi

PART I EXPERTS AND OPINIONS

1. Think Tanks and Oracles, 3
 - Background, 4
 - The RAND Corporation, 5
 - Herman Kahn, 6
 - Scenario analysis, 10
 - The Delphi method, 12
 - Conclusions: Toward a methodology for expert opinion, 17
2. Expert Opinion in Practice, 19
 - The Aerospace sector, 19
 - Military intelligence, 23
 - Probabilistic risk analysis, 27
 - Policy analysis, 41
3. Probabilistic Thinking, 47
 - Thinking, 47
 - Representing uncertainty in artificial intelligence, 50
 - Fuzziness, 59
 - Conclusion, 61
4. Heuristics and Biases, 63
 - Availability, 64
 - Anchoring, 65
 - Representativeness, 66
 - Control, 68
 - The base rate fallacy, 69
 - Overconfidence and calibration, 72
 - Conclusion, 78
5. Building rational consensus, 80
 - Rational consensus, 80
 - Principles, 81
 - Conclusion, 84

PART II SUBJECTIVE PROBABILITY

6. Savage's Normative Decision Theory, 87
 - The decision model, 88
 - The representation theorem, 91
 - Observation, 95
 - Supplement, 98
7. Relative Frequencies and Exchangeability, 108
 - The frequentist account of learning by experience, 109
 - Expected frequency, 110
 - Exchangeability, 110
 - De Finetti's finite representation theorem, 113
 - Supplement, 115
8. Elicitation and Scoring, 121
 - Elicitation, 122
 - Scoring, 125
 - Methodological problems, 133
 - Practical guidelines, 134
9. Scoring Rules for Evaluating and Weighing Assessments, 136
 - Improper scoring rules, 137
 - Scoring rules for individual variables, 138
 - Proper scoring rules for average probabilities, 141
 - Asymptotic properties, 145
 - A menu of weights, 147
 - Heuristics of weighing, 151
 - Supplement, 152
10. Two Experiments with Calibration and Entropy, 158
 - Calibration and knowledge; brief review of the literature, 158
 - The mechanical engineer experiment, 159
 - The managers experiment, 164
 - Conclusion, 168

PART III COMBINING EXPERT OPINIONS

11. Combining Expert Opinions; Review of the Literature, 171
 - Weighted combinations of probabilities, 171
 - Bayesian combinations, 176
 - Psychological scaling, 184
 - Conclusion, 186
12. The Classical Model, 187
 - Notation and definitions, 188
 - Basic model; uncertain events, 188
 - Basic model; continuous variables, 190
 - Variations and enhancements, 192
 - Issues, 194

- Measuring and optimizing performance; virtual weights, 195
 - Correlation, 196
 - Conclusions, 197
- 13. The Bayesian Model, 199
 - Basic theory, 200
 - Notations and definitions, 201
 - The Mendel-Sheridan model; assumptions, 202
 - Evaluation of model performance via bilinear loss functions, 206
 - A partially exchangeable Bayesian model, 207
 - Conclusions, 210
- 14. Psychological Scaling Models: Paired Comparisons, 211
 - Generic issues, 211
 - Significant preference for one expert, 212
 - Significant preference for the set of experts, 213
 - The Thurstone model, 214
 - The Bradley-Terry model, 217
 - The negative exponential lifetime model, 219
 - Relation to principles for expert opinion in science, 220
- 15. Applications, 221
 - Applications of the classical model, 221
 - The Royal Dutch Meteorological study, 227
 - Bayesian analysis, 230
 - Flange connections at a process plant—paired comparisons, 237
 - Flange connections at a process plant—the classical model, 241
 - Supplement, 246
- 16. Conclusions, 268
 - Part I, 268
 - Part II, 269
 - Part III, 270

- Appendix A. Mathematical Framework and Interpretation, 273
 - Mathematical framework, 273
 - Interpretation, 276
 - Conditional probability, independence, Bayes' theorem, 278
 - Expectation, moments, moment convergence, 279
 - Distributions, 280
 - Entropy, information, relative information, 282
- Appendix B. Standard normal, inverse normal, Chi square, coefficient of agreement, coefficient of concordance, 285
- References, 299
- Author Index, 315
- Subject Index, 319