

---

# Contents

<b>1</b>	<b>Do We Understand Classic Statistics?</b> . . . . .	1
1.1	Historical Introduction . . . . .	1
1.2	Test of Hypothesis . . . . .	4
1.2.1	The Procedure . . . . .	4
1.2.2	Common Misinterpretations . . . . .	7
1.3	Standard Errors and Confidence Intervals . . . . .	13
1.3.1	Definition of Standard Error and Confidence Interval . . . . .	13
1.3.2	Common Misinterpretations . . . . .	14
1.4	Bias and Risk of an Estimator . . . . .	16
1.4.1	Unbiased Estimators . . . . .	16
1.4.2	Common Misinterpretations . . . . .	16
1.5	Fixed and Random Effects . . . . .	18
1.5.1	Definition of ‘Fixed’ and ‘Random’ Effects . . . . .	18
1.5.2	Shrinkage of Random Effects Estimates . . . . .	19
1.5.3	Bias, Variance and Risk of an Estimator when the Effect is Fixed or Random . . . . .	20
1.5.4	Common Misinterpretations . . . . .	21
1.6	Likelihood . . . . .	22
1.6.1	Definition . . . . .	22
1.6.2	The Method of Maximum Likelihood . . . . .	24
1.6.3	Common Misinterpretations . . . . .	25
	Appendix 1.1 . . . . .	26
	Appendix 1.2 . . . . .	27
	Appendix 1.3 . . . . .	28
	Appendix 1.4 . . . . .	29
	References . . . . .	30
<b>2</b>	<b>The Bayesian Choice</b> . . . . .	33
2.1	Bayesian Inference . . . . .	33
2.1.1	The Foundations of Bayesian Inference . . . . .	33
2.1.2	Bayes Theorem . . . . .	34
2.1.3	Prior Information . . . . .	36
2.1.4	Probability Density . . . . .	40

2.2	Features of Bayesian Inference . . . . .	42
2.2.1	Point Estimates: Mean, Median and Mode . . . . .	42
2.2.2	Credibility Intervals . . . . .	44
2.2.3	Marginalisation . . . . .	49
2.3	Test of Hypothesis . . . . .	51
2.3.1	Model Choice . . . . .	51
2.3.2	Bayes Factors . . . . .	52
2.3.3	Model Averaging . . . . .	53
2.4	Common Misinterpretations . . . . .	54
2.5	Bayesian Inference in Practice . . . . .	57
2.6	Advantages of Bayesian Inference . . . . .	61
	Appendix 2.1 . . . . .	62
	Appendix 2.2 . . . . .	63
	Appendix 2.3 . . . . .	63
	References . . . . .	64
<b>3</b>	<b>Posterior Distributions . . . . .</b>	<b>67</b>
3.1	Notation . . . . .	67
3.2	Probability Density Function . . . . .	68
3.2.1	Definition . . . . .	68
3.2.2	Transformation of Random Variables . . . . .	69
3.3	Features of a Distribution . . . . .	71
3.3.1	Mean . . . . .	71
3.3.2	Median . . . . .	71
3.3.3	Mode . . . . .	72
3.3.4	Credibility Intervals . . . . .	72
3.4	Conditional Distributions . . . . .	72
3.4.1	Bayes Theorem . . . . .	72
3.4.2	Conditional Distribution of the Sample of a Normal Distribution . . . . .	73
3.4.3	Conditional Posterior Distribution of the Variance of a Normal Distribution . . . . .	73
3.4.4	Conditional Posterior Distribution of the Mean of a Normal Distribution . . . . .	75
3.5	Marginal Distributions . . . . .	76
3.5.1	Definition . . . . .	76
3.5.2	Marginal Posterior Distribution of the Variance of a Normal Distribution . . . . .	77
3.5.3	Marginal Posterior Distribution of the Mean of a Normal Distribution . . . . .	78
	Appendix 3.1 . . . . .	80
	Appendix 3.2 . . . . .	81
	Appendix 3.3 . . . . .	82
	Appendix 3.4 . . . . .	83
	Reference . . . . .	84

<b>4</b>	<b>MCMC</b> . . . . .	85
4.1	Samples of Marginal Posterior Distributions . . . . .	86
4.1.1	Taking Samples of Marginal Posterior Distributions . . . . .	86
4.1.2	Making Inferences from Samples of Marginal Posterior Distributions . . . . .	87
4.2	Gibbs Sampling . . . . .	91
4.2.1	How It Works . . . . .	91
4.2.2	Why It Works . . . . .	92
4.2.3	When It Works . . . . .	94
4.2.4	Gibbs Sampling Features . . . . .	95
4.3	Other MCMC Methods . . . . .	98
4.3.1	Acceptance-Rejection . . . . .	98
4.3.2	Metropolis–Hastings . . . . .	100
	Appendix: Software for MCMC . . . . .	101
	References . . . . .	102
<b>5</b>	<b>The Baby Model</b> . . . . .	103
5.1	The Model . . . . .	103
5.2	Analytical Solutions . . . . .	104
5.2.1	Marginal Posterior Density Function of the Mean and Variance . . . . .	104
5.2.2	Joint Posterior Density Function of the Mean and Variance . . . . .	105
5.2.3	Inferences . . . . .	105
5.3	Working with MCMC . . . . .	109
5.3.1	The Process . . . . .	109
5.3.2	Using Flat Priors . . . . .	109
5.3.3	Using Vague Informative Priors . . . . .	112
5.3.4	Common Misinterpretations . . . . .	114
	Appendix 5.1 . . . . .	115
	Appendix 5.2 . . . . .	116
	Appendix 5.3 . . . . .	117
	References . . . . .	118
<b>6</b>	<b>The Linear Model: I. The ‘Fixed Effects’ Model</b> . . . . .	119
6.1	The ‘Fixed Effects’ Model . . . . .	119
6.1.1	The Model . . . . .	119
6.1.2	Example . . . . .	124
6.1.3	Common Misinterpretations . . . . .	125
6.2	Marginal Posterior Distributions via MCMC Using Flat Priors . . . . .	127
6.2.1	Joint Posterior Distribution . . . . .	127
6.2.2	Conditional Distributions . . . . .	128
6.2.3	Gibbs Sampling . . . . .	129

---

6.3	Marginal Posterior Distributions via MCMC Using Vague Informative Priors . . . . .	130
6.3.1	Vague Informative Priors . . . . .	130
6.3.2	Conditional Distributions . . . . .	131
6.4	Least Squares as a Bayesian Estimator . . . . .	132
Appendix 6.1	. . . . .	133
Appendix 6.2	. . . . .	134
References	. . . . .	135
<b>7</b>	<b>The Linear Model: II. The ‘Mixed’ Model . . . . .</b>	<b>137</b>
7.1	The Mixed Model with Repeated Records . . . . .	137
7.1.1	The Model . . . . .	137
7.1.2	Common Misinterpretations . . . . .	141
7.1.3	Marginal Posterior Distributions via MCMC . . . . .	142
7.1.4	Gibbs Sampling . . . . .	144
7.2	The Genetic Animal Model . . . . .	145
7.2.1	The Model . . . . .	145
7.2.2	Marginal Posterior Distributions via MCMC . . . . .	150
7.3	Bayesian Interpretation of BLUP and REML . . . . .	154
7.3.1	BLUP in a Frequentist Context . . . . .	154
7.3.2	BLUP in a Bayesian Context . . . . .	156
7.3.3	REML as a Bayesian Estimator . . . . .	158
7.4	The Multitrait Model . . . . .	158
7.4.1	The Model . . . . .	158
7.4.2	Data Augmentation . . . . .	160
7.4.3	More Complex Models . . . . .	163
Appendix 7.1	. . . . .	164
References	. . . . .	165
<b>8</b>	<b>A Scope of the Possibilities of Bayesian Inference + MCMC . . . . .</b>	<b>167</b>
8.1	Nested Models: Examples in Growth Curves . . . . .	168
8.1.1	The Model . . . . .	168
8.1.2	Marginal Posterior Distributions . . . . .	171
8.1.3	More Complex Models . . . . .	173
8.2	Modelling Residuals: Examples in Canalising Selection . . . . .	174
8.2.1	The Model . . . . .	175
8.2.2	Marginal Posterior Distributions . . . . .	176
8.2.3	More Complex Models . . . . .	177
8.3	Modelling Priors: Examples in Genomic Selection . . . . .	178
8.3.1	The Model . . . . .	179
8.3.2	RR-BLUP . . . . .	183
8.3.3	Bayes A . . . . .	185
8.3.4	Bayes B . . . . .	187
8.3.5	Bayes C and Bayes $C\pi$ . . . . .	188
8.3.6	Bayes L (Bayesian Lasso) . . . . .	188
8.3.7	Bayesian Alphabet in Practice . . . . .	189

Appendix 8.1 . . . . .	190
References . . . . .	191
<b>9 Prior Information . . . . .</b>	<b>193</b>
9.1 Exact Prior Information . . . . .	193
9.1.1 Prior Information . . . . .	193
9.1.2 Posterior Probabilities with Exact Prior Information . . . . .	195
9.1.3 Influence of Prior Information in Posterior Probabilities . . . . .	197
9.2 Vague Prior Information . . . . .	198
9.2.1 A Vague Definition of Vague Prior Information . . . . .	198
9.2.2 Examples of the Use of Vague Prior Information . . . . .	200
9.3 No Prior Information . . . . .	203
9.3.1 Flat Priors . . . . .	204
9.3.2 Jeffreys Prior . . . . .	205
9.3.3 Bernardo’s ‘Reference’ Priors . . . . .	206
9.4 Improper Priors . . . . .	207
9.5 The Achilles Heel of Bayesian Inference . . . . .	208
Appendix 9.1 . . . . .	209
Appendix 9.2 . . . . .	210
References . . . . .	210
<b>10 Model Selection . . . . .</b>	<b>213</b>
10.1 Model Selection . . . . .	213
10.1.1 The Purpose of Model Selection . . . . .	213
10.1.2 Fitting Data vs Predicting New Records . . . . .	217
10.1.3 Common Misinterpretations . . . . .	218
10.2 Hypothesis Tests . . . . .	221
10.2.1 Likelihood Ratio Test and Other Frequentist Tests . . . . .	221
10.2.2 Bayesian Model Choice . . . . .	223
10.3 The Concept of Information . . . . .	226
10.3.1 Fisher’s Information . . . . .	227
10.3.2 Shannon Information and Entropy . . . . .	231
10.3.3 Kullback–Leibler Information . . . . .	232
10.4 Model Selection Criteria . . . . .	233
10.4.1 Akaike Information Criterion (AIC) . . . . .	233
10.4.2 Deviance Information Criterion (DIC) . . . . .	237
10.4.3 Bayesian Information Criterion (BIC) . . . . .	239
10.4.4 Model Choice in Practice . . . . .	241
Appendix 10.1 . . . . .	242
Appendix 10.2 . . . . .	243
Appendix 10.3 . . . . .	244
Appendix 10.4 . . . . .	245
References . . . . .	246

**Appendix: The Bayesian Perspective—Three New Dialogues Between Hylas and Philonous** . . . . . 247

**References** . . . . . 265

**Index** . . . . . 271



<http://www.springer.com/978-3-319-54273-7>

Bayesian Data Analysis for Animal Scientists

The Basics

BLASCO, A.

2017, XVIII, 275 p. 62 illus., 57 illus. in color., Hardcover

ISBN: 978-3-319-54273-7