Statistics for the Behavioural Sciences

An Introduction

Riccardo Russo

Contents

	Preface Acknowledgements	xi xiv
1	Introduction and basic concepts Why is statistics useful in the behavioural sciences? I Measurement scales 6 Descriptive and inferential statistics 9 What is an experiment? 10	1
2	Descriptive statistics Organising raw data 14 Frequency distributions and histograms 14 Grouped data 15 Stem-and-leaf diagrams 17 Summarising data 20 Measures of central tendency: mode, median, and mean 21 Advantages and disadvantages of mode, median, and mean 23 A useful digression on the Σ notation 26 Measures of dispersion (or variability) 27 Further on the mean, variance, and standard deviation of frequency distributions 33 How to calculate the combined mean and the combined variance of several samples 35 Properties of estimators 36 Mean and variance of linearly transformed data 38	14
3	Introduction to probability Why are some notions of probability useful? 42 Some preliminary definitions and the concept of probability 43 Venn diagrams and probability 44 The addition rule and the multiplication rule of probability 47 Probability trees 49 Conditional probability 50 Independence and conditional probability 53 Bayes's theorem 54	42

4	Probability distributions and the binomial distribution Introduction 57	57
	Probability distributions 58	
	Calculating the mean (µ) of a probability distribution 60	
	Calculating the variance (σ^2) and the standard deviation (σ) of a probability distribution 62	
	Orderings (or permutations) 63	
	Combinations 66	
	The binomial distribution 66	
	Mean and variance of the binomial distribution 70	
	How to use the binomial distribution in testing hypotheses 70	
	The sign test 75	
	Further on the binomial distribution and its use in hypothesis testing 76	
5	Continuous random variables and the normal distribution Introduction 78	78
	Continuous random variables and their distribution 78 The normal distribution 81	
	The standard normal distribution 84	
	Hypothesis testing and the normal distribution 87	
	Type I and Type II errors 89	
	One-tailed and two-tailed statistical tests 93	
•	Using the normal distribution as an approximation of the	
	binomial distribution 95	
6	The chi-square distribution and the analysis of categorical data	100
	Introduction 100	
	The chi-square (χ^2) distribution 100	
	The Pearson's chi-square test 101	
	The Pearson's χ^2 goodness of fit test 103	
	Further on the goodness of fit test 107	
	Assumptions underlying the use of Pearson's χ^2 test 108	
	Pearson's χ^2 test and the analysis of 2×2 contingency tables 110	
	Further on the degrees of freedom and the calculation of the expected	
	frequencies for any contingency table 113	
	The analysis of $R \times C$ contingency tables 114	
	One- and two-tailed tests 115	
	How to measure the strength of the association between variables in a contingency table 116	
	A fundamental conceptual equation in data analysis: Magnitude of a	
	significance test = Size of the effect \times Size of the study 119	
	An important note on the inclusion of nonoccurrences	
	in contingency tables 120	
7	Statistical tests on proportions	123
	Introduction 123	
	Statistical tests on the proportion of successes in a sample 123	

	Confidence intervals for population proportions 124 Statistical tests on the difference between the proportions of successes from two independent samples 127 Confidence intervals for the difference between two independent population proportions 129 Statistical tests on the difference between nonindependent proportions of successes (McNemar test) 130	
8	Sampling distribution of the mean and its use in hypothesis testing Introduction 134	134
	The sampling distribution of the mean and the Central Limit Theorem 134	
	Testing hypotheses about means when σ is known 136	
	Testing hypotheses about means when σ is unknown: the Student's	
	t-distribution and the one-sample t-test 137	
	Two-sided confidence intervals for a population mean 141	
9	Comparing a pair of means: the matched- and the independent-samples <i>t</i> -test	146
	Introduction 146	
	The matched-samples t-test 146	
	Confidence intervals for a population mean 149	
	Counterbalancing 150	
	The sampling distribution of the difference between pairs of means and the independent-samples t-test 151	
	An application of the independent-samples t-test 155	
	Confidence intervals for the difference between two population means 157 The robustness of the independent-samples t-test 158	
	Ceiling and floor effects 162	
	Matched-samples or independent-samples t-test: which of these two tests should be used? 164	
	A fundamental conceptual equation in data analysis: Magnitude of a significance test = Size of the effect \times Size of the study 165	
10	Nonparametric statistical tests	168
	Introduction 168	
	The Wilcoxon matched-pairs signed-ranks test 168	
	The Wilcoxon rank-sum test 172	
11	Correlation	176
	Introduction 176	
	Linear relationships between two continuous variables 176	
	More on linear relationships between two variables 178	
	The covariance between two variables 181	
	The Pearson product-moment correlation coefficient r 183	
	Hypothesis testing on the Pearson correlation coefficient r 184 Confidence intervals for the Pearson correlation coefficient 185	
	t onnagace intervals for the reation Coffelation Coefficient (a.)	

	Testing the significance of the difference between two independent Pearson correlation coefficients r 187	-
	Testing the significance of the difference between two nonindependent Pearson correlation coefficients r 188	
	Partial correlation 190	
	Factors affecting the Pearson correlation coefficient r 192	
	The point biserial correlation \mathbf{r}_{pb} 194	
	The Spearman Rank correlation coefficient 198	
	Kendall's coefficient of concordance W 200	
12	Regression	202
	Introduction 202	
	The regression line 202	
	Linear regression and correlation 207	
	Hypothesis testing on the slope b 207	
	Confidence intervals for the population regression slope \(\beta \) 209	
	Further on the relationship between linear regression and Pearson's r: r ² as a measure of effect size 210	
	Further on the error of prediction 211	
	Why the term regression? 212	
13	Introduction to power analysis	214
	Introduction 214	
	Effect size and power 215	
	Factors affecting the power of a statistical test 215	
	Power calculations for the one-sample t-test 219	
	Power calculations for the independent-samples t-test 222	
	Power calculations for the matched-samples t-test 223	
	Power calculation for correlation coefficients 225	
	Power calculation for the difference between two independent Pearson's correlation coefficients r 227	
	Power calculation for a single proportion 228	
	Power calculation for the difference between two independent proportions 229	
	Appendix	231
	References	231
	Index	239