
Contents

Foreword	ix
Preface	xi
List of Figures	xiii
List of Tables	xv
1 Introduction and Overview	1
2 Nonparametric Tests for the Location Problem	5
2.1 The Fisher–Pitman Permutation Test	5
2.1.1 Example	8
2.1.2 Implementation in SAS	11
2.1.3 Approximate Permutation Test	12
2.2 The Wilcoxon Rank Sum Test	14
2.2.1 Implementation in SAS	18
2.3 The Test of Baumgartner, Weiss, and Schindler	21
2.3.1 Implementation in SAS	25
2.4 Comparison of the Three Tests	29
2.5 One-Sided Alternatives	33
2.6 Adaptive Tests and Maximum Tests	35
2.7 Ties	43
2.7.1 Example	48
2.7.2 Pseudo-Precision	49
2.8 Further Tests	50
2.9 Sample Size Calculation	52
2.10 Concluding Remarks	53
3 Tests in the Case of Heteroscedasticity	55
3.1 Location-Scale Tests	59
3.1.1 The Lepage Test	61
3.1.2 Example	62
3.1.3 Implementation in SAS	63
3.1.4 Weighted and Modified Location-Scale Tests	64
3.1.5 The Cucconi test	66
3.1.6 Implementation in SAS	68

3.2	The Nonparametric Behrens–Fisher Problem	68
3.2.1	A Permutation Test with the Brunner–Munzel Statistic	71
3.2.2	Example	72
3.3	Bootstrap Tests	73
3.3.1	The SAS Procedure MULTTEST	74
3.3.2	A Bootstrap Test for the Behrens–Fisher Problem . .	77
3.3.3	The D.O Test, A Combination of Permutation Test and Bootstrap	81
3.3.4	Which Test Can Be Recommended for the Behrens– Fisher Problem?	84
3.4	Tests for a Difference in Variability	87
3.4.1	Example and Implementation in SAS	91
3.5	Concluding Remarks	91
4	Tests for the General Alternative	93
4.1	The (Kolmogorov–)Smirnov Test	93
4.1.1	Example and Implementation in SAS	94
4.2	Further Tests	96
5	Ordered Categorical and Discrete Numerical Data	99
5.1	Tests for Comparing Multinomial Distributions	99
5.2	The Exact χ^2 Test	101
5.2.1	Implementation in SAS	105
5.3	Comparison of the Tests	106
6	The Conservatism of Permutation Tests	109
6.1	Disadvantages of Bootstrap and Permutation Tests	109
6.2	Approaches to Reduce the Conservatism	110
7	Further Examples for the Comparison of Two Groups	115
7.1	A Difference in Location	115
7.2	A Clinical Trial	117
7.3	Heteroscedasticity	119
7.4	Discrete Numerical Data	120
7.5	Case-Control Data	121
8	One-Sample Tests and Tests for Paired Data	125
8.1	The Sign Test	126
8.1.1	Implementation in SAS	128
8.2	The Wilcoxon Signed Rank Test	130
8.2.1	Comparison between the Sign Test and the Wilcoxon Signed Rank Test	132
8.3	A Permutation Test with Original Observations	133
8.3.1	Implementation in SAS	133
8.4	One-Sample Bootstrap Tests	134
8.5	The McNemar Test	137

8.5.1	Implementation in SAS	138
9	Tests for More than Two Groups	139
9.1	The Kruskal–Wallis Test and the Permutation F Test	139
9.1.1	Implementation in SAS	141
9.2	Trend Tests	143
9.2.1	Implementation in SAS	146
9.2.2	Comparison of the Jonckheere–Terpstra Test with Other Tests	147
9.2.3	Tests for Umbrella Alternatives	148
9.3	Tests for Multiple Dependent Groups	150
9.3.1	Implementation in SAS	152
10	Independence and Correlation	155
10.1	The χ^2 Test	155
10.2	The Likelihood-Ratio Test	157
10.3	Correlation Coefficients	158
10.3.1	Implementation in SAS	161
11	Stratified Studies and Combination of p-Values	165
11.1	The Van Elteren Test	165
11.1.1	Example	166
11.2	Combination Tests	167
11.2.1	Example	169
11.3	A Combination Test for Discrete Test Statistics	170
12	Nonstandard Situations and Complex Designs	175
12.1	A Contingency Table with Empty Cells	176
12.2	Composite Test Statistics	178
12.2.1	Example	179
13	Estimation and Confidence Intervals	181
13.1	One-Sample Situation	181
13.2	Two-Sample Situation	183
13.3	Bootstrap and Jackknife	185
Appendix		189
A.1	Level of Measurement	189
A.2	Statistical Tests	190
A.3	Multiple Testing	191
A.4	Nonparametric Tests in R	194
Bibliography		203
Index		227