## Contents

1. Concepts and Examples in Analysis of Variance

	John V	V. Tukey, Frederick Mosteller, and David C. Hoaglin	
	1A.	Interaction in ANOVA, 4	
	1B.	A Graphical Analysis of a Complex Experiment on the Hardness of Dental Gold, 9	
	1C.	An Election Example, 13	
	1D.	Why Main Effects and Interactions?, 19	
		Exercises, 21	
2.	to Ap	ses of Analyzing Data that Come in a Form Inviting Us oly Tools from the Analysis of Variance ick Mosteller and John W. Tukey	<b>2</b> 4
	2A.	Purposes Can Be Both Diverse and Unfamiliar, 25	
	2B.	A Quantitative Microcosm, 29	
	2C.	More Classic Purposes, 34	
	2D.	Causation, Experimentation, and Observation, 35	
	2E.	Summary, 37	
		Exercises, 38	
3.	Preliminary Examination of Data Frederick Mosteller and David C. Hoaglin		4(
	3A.	Editing, 40	
	3B.	Appreciating the Data, 42	
	3C.	Plots of the Data, 42	
	3D.	Boxplots, 44	
	3E.	Stem-and-Leaf Displays, 46	

1

xiv CONTENTS

4.	Types of Factors and Their Structural Layouts  Judith D. Singer		50
	4A. 4B. 4C. 4D. 4E.	Types of Factors, 51 Relationships Between Factors, 56 One-Way and Two-Way Layouts, 61 Three-Way and More-Way Layouts, 64 Summary, 68 Exercises, 69	
5.	Value-Splitting: Taking the Data Apart Christopher H. Schmid		72
	5A. 5B. 5C. 5D. 5E. 5F. 5G. 5H. 5I.	Forming Overlays, 73 Overlays for One-Way Data, 76 What the Residuals Tell Us, 82 Comparing Overlays: An ANOVA Table, 85 Designs with Two Crossed Factors, 90 Interaction and Replication, 97 Two-Factor Designs with Replication, 98 Two-Factor Data with Nesting, 104 Other Descriptions, 110 Summary, 111 Exercises, 111	
6.	Value Splitting Involving More Factors Katherine Taylor Halvorsen		114
	6A. 6B. 6C. 6D.	Three Crossed Factors, 114 Four Crossed Factors, 126 Latin Square Designs, 135 Summary, 141 Exercises, 142	
7.	Mean Squares, F Tests, and Estimates of Variance Frederick Mosteller, Anita Parunak, and John W. Tukey		146
	7A. 7B. 7C. 7D.	Formal Inferences: The $F$ Test, 146 Broadening the Base for the $F$ Test, 152 (Optional) Note on the Relation of the Pitman–Welch Work to an Ordinary $F$ Distribution, 155 Confidence Intervals for $\sigma^2$ Under Ideal Conditions, 158	

CONTENTS XV

Sensitivity to the Assumption of Normality, 160

7E.

		Exercises, 162	
8.	Graphical Display as an Aid to Analysis  John D. Emerson		165
	8 <b>A</b> .	An Overview of Graphical Methods for One-Way ANOVA, 166	
	8B.	Graphical Display for Two-Factor Data, 167	
	8C.	A Side-by-Side Plot Attuned to Mean Squares, 170	
	8D.	A Detailed Example: Percentage of Americans Who Have Never Married, 175	
	8E.	Patterns or Noise?, 181	
	8F.	Exploring Residuals Graphically, 186	
	8G.	Summary, 189	
		Exercises, 190	
9.	Comp	onents of Variance	193
	Consta	nce Brown and Frederick Mosteller	
	9A.	Structures Leading to Components in One-Way Analysis of Variance, 193	
	9B.	Example: Variance Components for Blood Pressure, 211	
	9C.	Alternative Methods for Estimating Variance Components, 213	
	9D.	Confidence Intervals for Variance Components, 215	
	9E.	Unbalanced Cases (Expected-Mean-Square Method), 227	
	9F.	Two-Way Tables, 231	
	9G.	Example: Nationalization of Electoral Forces, 240	
	9H.	Summary, 242	
		Exercises, 244	
10.	Which	Denominator?	252
	Thomas Blackwell, Constance Brown, and Frederick Mosteller		
	10A.	Analyzing the Structure, 252	
	10B.	The Sampling or Pigeonhole Model, 253	
	10C.	The Notion of "Above", 260	
	10D.	Three-Way Special Cases, 262	
	10E.	Constructing an Appropriate Error Term, 264	

xvi CONTENTS

		DNIENIS
10F.	Estimation of Variance Components in a Two-Way Analysis of Variance by Equating Average Values, 267	
10G.	An Alternative Model for Interaction in Two-Way Analysis of Variance, 273	
10H.	A Three-Way Example: Tumor Size, 276	
10I.	Examining the Effects in the Tumor Simulation Experiment, 282	
10 <b>J</b> .	The Two-Way Unbalanced Design, 283	
10K.	Summary, 290 Exercises, 291	
	Exercises, 291	
Assess	sing Changes	295
John V	V. Tukey, Frederick Mosteller, and Cleo Youtz	
11A.	Looking at Differences of Means Through Noise, 296	
11B.	Questions and Targets: Models of Two-Factor Situations, 296	
11C.	Relation to the Usual "Probability Models", 298	
11D.	Leaving Out or Pooling Noisy Estimates: The $F > 2$ Principle, 299	
11E.	A Hypothetical Example Illustrating Two-Factor Situations, 300	
11F.	Examples with Larger Factor A Effects, 306	
11G.	Sweeping the Common Term Down?, 308	
11H.	Looking at Two Factors with Replication, 308	
11I.	Replicated Cells: Pooling Interaction with Replication, 309	
11J.	Commentary on the Rule of 2, 317	
11 <b>K</b> .	More Complex Situations with an Example Having Four Factors, 318	
11L.	Displaying a Two-Way Packet, 328	
11M.	Taking the Example Further by Using What We Have Already Learned, 329	
11N.	Reasonableness of Fixed-Factor Analyses, 331	
	Exercises, 332	
Qualit	ative and Quantitative Confidence	336
	7. Tukey and David C. Hoaglin	220
12A.	An Election Example, 337	
12B.	Comparing Main Effects, 340	
12C.	Analyzing Two-Way Bordering	
	Tables Conditionally 350	

11.

12.

CON	ONTENTS		xvii
	12D. 12E.	Bicomparisons (Double Differences), 355 Comparing Nested Effects, 360	
	12F.	Summary, 362	
		Exercises, 363	
13.	Introd	uction to Transformation	365
	John D	. Emerson	
	13A.	Transformation in Everyday Experience, 366	
	13B.	Goals of Transformation, 367	
	13C.	Basic Concepts for Transformation, 369	
	13D.	Transformation in One-Way ANOVA, 373	
	13E.	Transformation in Two-Way ANOVA, 380	
	13F.	Transformation of Percentages and Proportions, 389	
	13G.	Summary, 397	
		Exercises, 398	
App	endix: 7	<b>Tables</b>	401
Inde	ex		425