

# CONTENTS

<b>Preface</b>	<b>xv</b>
<b>Illustration Credits</b>	<b>xix</b>
<b>1 Foundations of Experimental Design</b>	<b>1</b>
Introduction, 1	
What is Experimental Research? 2	
Design of Experiment and its Principles, 3	
Randomization, 3	
Replication, 4	
Blocking, 4	
Statistical Designs, 5	
Completely Randomized Design, 5	
Randomized Block Design, 6	
Matched Pairs Design, 8	
Latin Square designs, 8	
Factorial Experiment, 9	
Terminologies in Design of Experiment, 10	
Subject, 11	
Experimental Unit, 11	
Factor and Treatment, 11	
Criterion Variable, 12	
Variation and Variance, 12	
Experimental Error, 12	
External Validity, 13	

Internal Validity, 13	
Considerations in Designing an Experiment, 13	
Systematic Variance, 14	
Extraneous Variance, 14	
Randomization Method, 15	
Elimination Method, 15	
Matching Group Method, 15	
Adding Additional Independent Variable, 16	
Statistical Control, 16	
Error Variance, 17	
Exercise, 17	
Assignment, 18	
Bibliography, 18	

## **2 Analysis of Variance and Repeated Measures Design 21**

Introduction, 21	
Understanding Variance and Sum of Squares, 22	
One Way Analysis of Variance for Independent Measures Design, 24	
Assumptions, 24	
Illustration I, 25	
Partitioning of Total Variation in the Design, 26	
Computation, 26	
Explanation, 27	
Partitioning of SS and Degrees of Freedom, 27	
Computation, 27	
Results, 29	
Post-Hoc Analysis, 29	
Means Plot, 31	
Repeated Measures Design, 31	
When to Use Repeated Measures ANOVA, 32	
Assumptions, 32	
Solving Repeated Measures Design with One-Way ANOVA, 33	
Illustration II, 34	
Hypothesis Construction, 34	
Layout Design, 35	
One-Way Repeated Measures ANOVA Model, 36	
Computation in Repeated Measures Design with One-Way ANOVA, 36	
Explanation, 37	
Computation, 37	
Testing Sphericity Assumption, 39	
Correcting for Degrees of Freedom, 41	
Results, 43	
Pair-Wise Comparison of Means, 43	
Bonferroni Correction, 44	

Effect Size, 45	
Exercise, 46	
Assignment, 47	
Bibliography, 48	
<b>3 Testing Assumptions in Repeated Measures Design Using SPSS</b>	<b>51</b>
Introduction, 51	
First Step in Using SPSS, 52	
Assumptions, 54	
Testing Normality, 54	
Test of Normality, 57	
Q-Q Plot for Normality, 57	
Box-plot for Identifying Outliers, 57	
Testing Sphericity, 59	
Remedial Measures When Assumption Fails, 62	
Transforming Nonnormal Data into Normal, 62	
Choice of Design and Sphericity, 63	
Sample Size Determination, 64	
Important Terms, 64	
Confidence Interval, 64	
Confidence Level, 65	
Power of the Test, 66	
Sample Size Determination on the Basis of Cost, 67	
Sample Size Determination on the Basis of Accuracy Factor, 67	
Sample Size in Estimating Mean, 67	
Sample Size in Hypothesis Testing, 68	
Exercise, 68	
Assignment, 69	
Bibliography, 70	
<b>4 One-Way Repeated Measures Design</b>	<b>73</b>
Introduction to Design, 73	
Advantage of One-Way Repeated Measures Design, 74	
Weakness of Repeated Measures Design, 74	
Application, 74	
Layout Design, 75	
Case I: When the Levels of Within-Subjects Variable are Different Treatments, 75	
Case II: When the Levels of Within-Subjects Variable are Different Time Durations, 76	
Steps in Solving One-Way Repeated Measures Design, 77	
Illustration, 77	
Testing Assumptions, 77	
Layout Design, 78	
Distribution of Variation and Degrees of Freedom, 79	

Hypothesis Construction, 80	
Level of Significance, 80	
Solving One-Way Repeated Measures Design Using SPSS, 81	
SPSS Output and Interpretation, 83	
Descriptive Statistics, 83	
Testing Sphericity, 84	
Testing Significance of Within-Subjects Effect, 86	
How to Report the Findings, 88	
Inference, 88	
Exercise, 88	
Assignment, 89	
Bibliography, 90	

## **5 Two-Way Repeated Measures Design 91**

Introduction, 91	
Advantages of Using Two-Way Repeated Measures Design, 92	
Assumptions, 92	
Layout Design, 93	
Case I: When Levels of Within-Subjects Variable are Different Treatment, 93	
Case II: When the Levels of the Within-Subjects Variable are Different Time Durations, 94	
Application, 94	
Steps in Solving Two-Way Repeated Measures Design, 95	
Illustration, 97	
Layout Design, 97	
Distribution of Variation and Degrees of Freedom, 98	
Research Questions, 100	
Hypotheses Construction, 100	
Level of Significance, 101	
Solving Repeated Measures Design with Two-Way ANOVA Using SPSS, 101	
SPSS Output and Interpretation, 104	
Testing Assumptions, 105	
Data Type, 106	
Independence of Measurement, 106	
Normality, 106	
Sphericity, 106	
Descriptive Statistics, 106	
Testing Main Effect of Music (Within-Subjects), 106	
Pairwise Comparison of Marginal Means of Music Groups, 108	
Means Plot of Music, 108	
Testing Main Effect of Environment (Within-Subjects), 108	
Testing Significance of Interaction (Environment $\times$ Music), 108	
Type I Error for Simple Effect, 110	

- Simple Effect of Environment (Within-Subjects), 110
- Simple Effect of Music (Within-Subjects), 116
- How to Report the Findings, 120
  - Assumptions, 120
  - Testing Main Effects, 120
  - Testing Simple Effects, 121
- Inference, 121
- Exercise, 122
- Assignment, 122
- Bibliography, 124

## 6 Two-Way Mixed Design

125

- Introduction, 125
- Advantages of Two-Way Mixed Design, 127
- Assumptions, 127
- Application, 128
- Layout Design, 129
  - Case I: When Levels of the Within-Subjects Factor are Different Treatment, 129
  - Case II: When Levels of the Within-Subjects Factor are Different Time Durations, 130
- Steps in Solving Mixed Design with Two-Way ANOVA, 131
- Illustration, 132
  - Layout Design, 132
  - Distribution of Variation and Degrees of Freedom, 134
  - Research Questions, 135
  - Hypothesis Construction, 136
  - Level of Significance, 136
  - Solving Mixed Design with Two-Way ANOVA using SPSS, 137
  - SPSS Outputs and Interpretation, 140
  - Testing Assumptions, 141
    - Assumption of Normality, 141
    - Homogeneity of Variance Covariance Matrices, 142
    - Homogeneity of Variance, 142
    - Sphericity Assumption, 142
  - Descriptive Statistics, 143
  - Testing Main Effect of Movie (within-Subjects), 144
    - Pair-Wise Comparison of Marginal Means of Movie Groups, 144
    - Means Plot of Movie, 145
  - Testing Main Effect of Age (between-Subjects), 145
    - Pair-Wise Comparison of Marginal Means of Age Groups, 146
    - Means Plot of Age, 146
  - Testing Significance of Interaction (Movie  $\times$  Age), 147
    - Simple Effect of Movie (within-Subjects), 147
    - Simple Effect of Age (between-Subjects), 151

How to Report the Findings, 155
Assumptions, 155
Testing Main Effects, 156
Testing Simple Effects, 156
Inference, 157
Exercise, 157
Assignment, 158
Bibliography, 159

## **7 One-Way Repeated Measures MANOVA**

**161**

Introduction, 161
When to Use Repeated Measures MANOVA? 162
Why to Use Repeated Measures MANOVA? 162
Assumptions, 163
Application, 164
Layout Design, 165
Case I: When Levels of Within-Subjects Factor are Different Treatment, 165
Case II: When Levels of Within-Subjects Factor are Different Time Durations, 166
Steps in Solving One-Way Repeated Measures MANOVA, 166
Illustration, 167
Layout Design, 167
Research Questions, 168
Hypotheses Construction, 168
Level of Significance, 170
Solving One-Way Repeated Measures MANOVA Design with SPSS, 170
SPSS Output and Interpretation, 173
Descriptive Statistics, 174
Testing Assumptions, 174
Testing Correlation, 174
Testing Normality, 176
Testing Outliers, 176
Multivariate Testing, 178
Univariate Testing, 181
Testing Sphericity, 181
Pair-Wise Comparison of Marginal Means, 181
Means Plot of Maths, 181
Means Plot of English, 182
Means Plot of Reasoning, 182
How to Report the Findings, 183
Assumptions, 183
Testing Multivariate Effect, 183
Testing Univariate Effect, 184

Inference, 184  
 Exercise, 184  
 Assignment, 185  
 Bibliography, 187

## **8 Mixed Design with Two-Way MANOVA**

**189**

Introduction, 189  
 What Happens in MANOVA Experiment, 190  
 Assumptions, 191  
   Multivariate Analysis, 191  
   Univariate Analysis, 192  
 Layout Design, 192  
   Case I: When the Levels of Within-Subjects Factor are Different Treatment, 192  
   Case II: When the Levels of the Within-Subjects Factor are Different Time Durations, 193  
 Application, 193  
 Steps in Solving Mixed Design with Two-Way MANOVA, 194  
 Illustration, 196  
   Layout Design, 196  
   Research Questions, 198  
   Hypotheses Construction, 198  
   Level of Significance, 200  
   Solving Mixed Design with Two-Way MANOVA Using SPSS, 200  
   SPSS Output and Interpretation, 204  
     Multivariate Outcome, 205  
     Main Effect of Each Dependent Variable, 205  
     Simple Effect of Each Dependent Variable, 205  
   Testing Assumptions, 205  
     Data Type, 205  
     Testing Correlations, 206  
     Testing Normality, 207  
     Testing Outliers, 210  
     Homogeneity of Variances, 211  
     Homogeneity of Variance Covariance Matrices, 211  
     Sphericity Assumption for Within-Subjects Conditions, 211  
   Multivariate Testing, 211  
   Univariate Testing, 213  
     Main Effect of Between-Subjects Factor (Sex), 215  
     Main Effect of Within-Subjects Factor (Chocolate), 215  
     Level of Significance for Simple Effect, 219  
     Simple Effect on Taste, 219  
     Simple Effect on Crunchiness, 226  
     Simple Effect on Flavor, 230  
     Means Plots (Sex  $\times$  Chocolate), 232

How to Report Findings, 234	
Assumptions, 234	
Multivariate Effects, 236	
Univariate Main Effects, 236	
Univariate Simple Effects, 237	
Inference, 237	
Exercise, 238	
Assignment, 238	
Bibliography, 240	
<b>Appendix</b>	<b>243</b>
<b>Index</b>	<b>255</b>