APPENDIX **B**

Equations

Listed here are the computational equations used in this textbook. The page number refers to the page where the equation first appears.

Equation	Description	Equation First Occurs on Page:
$\sum_{i=1}^{N} X_i = X_1 + X_2 + X_3 + \cdots + X_N$	summation	27
$\text{cum } \% = \frac{\text{cum } f}{N} \times 100$	cumulative percentage	55
$\text{Percentile point} = X_L + (i/f_i)(\text{cum } f_p - \text{cum } f_L)$	equation for computing percentile point	58
$\text{Percentile rank} = \frac{\text{cum } f_L + (f_i/i)(X - X_L)}{N} \times 100$	equation for computing percentile rank	59
$\overline{X} = \frac{\Sigma X_i}{N}$	mean of a sample	81
$\mu = \frac{\Sigma X_i}{N}$	mean of a population of raw scores	81
$\overline{X}_{\text{overall}} = \frac{n_1\overline{X}_1 + n_2\overline{X}_2 + \cdots + n_k\overline{X}_k}{n_1 + n_2 + \cdots + n_k}$	overall mean of several groups	84
$\text{Mdn} = P_{50} = X_L + (i/f_i)(\text{cum } f_p - \text{cum } f_L)$	median of a distribution	85
$\text{Range} = \text{Highest score} - \text{Lowest score}$	range of a distribution	89
$X - \overline{X}$	deviation score for sample data	90
$X - \mu$	deviation score for population data	90
$\sigma = \sqrt{\frac{SS_{\text{pop}}}{N}} = \sqrt{\frac{\Sigma(X - \mu)^2}{N}}$	standard deviation of a population of raw scores	91
$s = \sqrt{\frac{SS}{N - 1}} = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N - 1}}$	standard deviation of a sample of raw scores	91

Equation	Description	Equation First Occurs on Page:
$SS = \Sigma X^2 - \frac{(\Sigma X)^2}{N}$	sum of squares	93
$s^2 = \frac{SS}{N-1}$	variance of a sample of raw scores	95
$\sigma^2 = \frac{SS_{\text{pop}}}{N}$	variance of a population of raw scores	95
$z = \frac{X - \mu}{\sigma}$	z score for population data	106
$z = \frac{X - \overline{X}}{s}$	z score for sample data	106
$X = \mu + \sigma z$	equation for finding a population raw score from its z score	114
$Y = bX + a$	equation of a straight line	125
$b = \text{Slope} = \frac{\Delta Y}{\Delta X} = \frac{Y_2 - Y_1}{X_2 - X_1}$	slope of a straight line	125
$r = \frac{\Sigma z_X z_Y}{N-1}$	computational equation for Pearson r using z scores	133
$r = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}}{\sqrt{\left[\Sigma X^2 - \frac{(\Sigma X)^2}{N}\right]\left[\Sigma Y^2 - \frac{(\Sigma Y)^2}{N}\right]}}$	computational equation for Pearson r	133
$r_s = 1 - \frac{6 \Sigma D_i^2}{N^3 - N}$	computational equation for Spearman rho	141
$Y' = b_Y X + a_Y$	linear regression equation for predicting Y given X	162
$b_Y = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}}{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}$	regression constant ***b*** for predicting Y given X, computational equation with raw scores	163
$a_Y = Y - b_Y \overline{X}$	regression constant ***a*** for predicting Y given X	163
$s_{Y\|X} = \sqrt{\frac{SS_Y - \frac{[\Sigma XY - (\Sigma X)(\Sigma Y)/N]^2}{SS_X}}{N-2}}$	computational equation for the standard error of estimate when predicting Y given X	170
$b_Y = r\frac{s_Y}{s_X}$	equation relating r to the b_Y regression constant	173
$R^2 = \frac{r_{YX_1}^2 + r_{YX_2}^2 - 2r_{YX_1} r_{YX_2} r_{X_1X_2}}{1 - r_{X_1X_2}^2}$	equation for computing the squared multiple correlation	176

Equation	Description	Equation First Occurs on Page:
$p(A) = \dfrac{\text{Number of events classifiable as } A}{\text{Total number of possible events}}$	*a priori* probability	193
$p(A) = \dfrac{\text{Number of times } A \text{ has occurred}}{\text{Total number of occurrences}}$	*a posteriori* probability	194
$p(A \text{ or } B) = p(A) + p(B) - p(A \text{ and } B)$	addition rule for two events, general equation	196
$p(A \text{ or } B) = p(A) + p(B)$	addition rule when A and B are mutually exclusive	196
$p(A \text{ or } B \text{ or } C \text{ or } \ldots \text{ or } Z) = p(A) + p(B) + p(C) + \ldots + p(Z)$	addition rule with more than two mutually exclusive events	200
$p(A) + p(B) + p(C) + \ldots + p(Z) = 1.00$	when events are exhaustive and mutually exclusive	200
$P + Q = 1.00$	when two events are exhaustive and mutually exclusive	201
$p(A \text{ and } B) = p(A)p(B \vert A)$	multiplication rule with two events—general equation	201
$p(A \text{ and } B) = 0$	multiplication rule with mutually exclusive events	201
$p(A \text{ and } B) = p(A)p(B)$	multiplication rule with independent events	202
$p(A \text{ and } B \text{ and } C \text{ and } \ldots \text{ and } Z) = p(A)p(B)p(C) \ldots p(Z)$	multiplication rule with more than two independent events	206
$p(A \text{ and } B) = p(A)p(B \vert A)$	multiplication rule with dependent events	207
$p(A \text{ and } B \text{ and } C \text{ and } \ldots \text{ and } Z) = p(A)p(B \vert A)p(C \vert AB) \ldots p(Z \vert ABC \ldots)$	multiplication rule with more than two dependent events	210
$p(A) = \dfrac{\text{Area under curve corresponding to } A}{\text{Total area under curve}}$	probability of A with a continuous variable	214
$(P + Q)^N$	binomial expansion	229
Number of Q events $= N -$ Number of P events	relationship between number of Q events, number of P events, and N	235
$\mu = NP$	mean of the normal distribution approximated by the binomial distribution	239
$\sigma = \sqrt{NPQ}$	standard deviation of the normal distribution approximated by the binomial distribution	239
Beta $= 1 -$ Power	relationship between beta and power	285
$\mu_{\overline{X}} = \mu$	mean of the sampling distribution of the mean	305
$\sigma_{\overline{X}} = \dfrac{\sigma}{\sqrt{N}}$	standard deviation of the sampling distribution of the mean or standard error of the mean	305

Equation	Description	Equation First Occurs on Page:
$z_{\text{obt}} = \dfrac{\overline{X}_{\text{obt}} - \mu}{\sigma_{\overline{X}}}$	z transformation for $\overline{X}_{\text{obt}}$	312
$z_{\text{obt}} = \dfrac{\overline{X}_{\text{obt}} - \mu}{\sigma/\sqrt{N}}$	z transformation for $\overline{X}_{\text{obt}}$	315
$N = \left[\dfrac{\sigma(z_{\text{crit}} - z_{\text{obt}})}{\mu_{\text{real}} - \mu_{\text{null}}}\right]^2$	determining N for a specified power	321
$t_{\text{obt}} = \dfrac{\overline{X}_{\text{obt}} - \mu}{s/\sqrt{N}}$	equation for calculating the t statistic	328
$t_{\text{obt}} = \dfrac{\overline{X}_{\text{obt}} - \mu}{s_{\overline{X}}}$	equation for calculating the t statistic	328
$s_{\overline{X}} = \dfrac{s}{\sqrt{N}}$	estimated standard error of the mean	328
$\text{df} = N - 1$	degrees of freedom for t test (single sample)	331
$t_{\text{obt}} = \dfrac{\overline{X}_{\text{obt}} - \mu}{\sqrt{\dfrac{SS}{N(N-1)}}}$	equation for calculating the t statistic from raw scores	334
$d = \dfrac{\lvert\text{mean difference}\rvert}{\text{population standard deviation}}$	general equation for size of effect	339
$d = \dfrac{\lvert\overline{X}_{\text{obt}} - \mu\rvert}{\sigma}$	conceptual equation for size of effect, single sample t test	339
$\hat{d} = \dfrac{\lvert\overline{X}_{\text{obt}} - \mu\rvert}{s}$	computational equation for size of effect, single sample t test	340
$\mu_{\text{lower}} = \overline{X}_{\text{obt}} - s_{\overline{X}}t_{0.025}$	lower limit for the 95% confidence interval	342
$\mu_{\text{upper}} = \overline{X}_{\text{obt}} + s_{\overline{X}}t_{0.025}$	upper limit for the 95% confidence interval	342
$\mu_{\text{lower}} = \overline{X}_{\text{obt}} - s_{\overline{X}}t_{\text{crit}}$	general equation for the lower limit of the confidence interval	343
$\mu_{\text{upper}} = \overline{X}_{\text{obt}} + s_{\overline{X}}t_{\text{crit}}$	general equation for the upper limit of the confidence interval	343
$\mu_{\text{lower}} = \overline{X}_{\text{obt}} - s_{\overline{X}}t_{0.005}$	lower limit for the 99% confidence interval	344
$\mu_{\text{upper}} = \overline{X}_{\text{obt}} + s_{\overline{X}}t_{0.005}$	upper limit for the 99% confidence interval	344
$t_{\text{obt}} = \dfrac{r_{\text{obt}} - p}{s_r}$	t test for testing the significance of r	346

Equation	Description	Equation First Occurs on Page:
$t_{\text{obt}} = \dfrac{r_{\text{obt}}}{\sqrt{\dfrac{1 - r_{\text{obt}}^2}{N - 2}}}$	t test for testing the significance of r	346
$t_{\text{obt}} = \dfrac{\overline{D}_{\text{obt}} - \mu_D}{s_D/\sqrt{N}}$	t test for correlated groups	360
$t_{\text{obt}} = \dfrac{\overline{D}_{\text{obt}} - \mu_D}{\sqrt{\dfrac{SS_D}{N(N - 1)}}}$	t test for correlated groups	360
$SS_D = \Sigma D^2 - \dfrac{(\Sigma D)^2}{N}$	sum of squares of the difference scores	360
$d = \dfrac{\lvert\overline{D}_{\text{obt}}\rvert}{\sigma_D}$	conceptual equation for size of effect, correlated groups t test	364
$\hat{d} = \dfrac{\lvert\overline{D}_{\text{obt}}\rvert}{s_D}$	computational equation for size of effect, correlated groups t test	364
$\mu_{\overline{X}_1 - \overline{X}_2} = \mu_1 - \mu_2$	mean of the difference between sample means	368
$\sigma_{\overline{X}_1 - \overline{X}_2} = \sqrt{\sigma^2\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}$	standard deviation of the difference between sample means	368
$t_{\text{obt}} = \dfrac{(\overline{X}_1 - \overline{X}_2) - \mu_{\overline{X}_1 - \overline{X}_2}}{\sqrt{\left(\dfrac{SS_1 + SS_2}{n_1 + n_2 - 2}\right)\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}}$	computational equation for t_{obt}, independent groups design	371
$t_{\text{obt}} = \dfrac{\overline{X}_1 - \overline{X}_2}{\sqrt{\left(\dfrac{SS_1 + SS_2}{n_1 + n_2 - 2}\right)\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}}$	computational equation for t_{obt} assuming the independent variable has no effect	371
$SS_1 = \Sigma X_1^2 - \dfrac{(\Sigma X_1)^2}{n_1}$	sum of squares for group x	373
$SS_2 = \Sigma X_2^2 - \dfrac{(\Sigma X_2)^2}{n_2}$	sum of squares for group x	373
$t_{\text{obt}} = \dfrac{\overline{X}_1 - \overline{X}_2}{\sqrt{\dfrac{SS_1 + SS_2}{n(n - 1)}}}$	computational equation for t_{obt} when $n_1 = n_2$	373
$d = \dfrac{\lvert\overline{X}_1 - \overline{X}_2\rvert}{\sigma}$	conceptual equation for size of effect, independent groups t test	377
$\hat{d} = \dfrac{\lvert\overline{X}_1 - \overline{X}_2\rvert}{\sqrt{s_W^2}}$	computational equation for size of effect, independent groups t test	377

Equation	Description	Equation First Occurs on Page:
$\mu_{\text{lower}} = (\overline{X}_1 - \overline{X}_2) - s_{\overline{X}_1 - \overline{X}_2} t_{0.025}$	lower limit for the 95% confidence interval for $\mu_{\overline{X}_1 - \overline{X}_2}$	383
$\mu_{\text{upper}} = (\overline{X}_1 - \overline{X}_2) + s_{\overline{X}_1 - \overline{X}_2} t_{0.025}$	upper limit for the 95% confidence interval for $\mu_{\overline{X}_1 - \overline{X}_2}$	383
$\mu_{\text{lower}} = (\overline{X}_1 - \overline{X}_2) - s_{\overline{X}_1 - \overline{X}_2} t_{0.005}$	lower limit for the 99% confidence interval for $\mu_{\overline{X}_1 - \overline{X}_2}$	385
$\mu_{\text{upper}} = (\overline{X}_1 - \overline{X}_2) + s_{\overline{X}_1 - \overline{X}_2} t_{0.005}$	upper limit for the 99% confidence interval for $\mu_{\overline{X}_1 - \overline{X}_2}$	385
$F = \dfrac{\text{Variance estimate 1 of } \sigma^2}{\text{Variance estimate 2 of } \sigma^2}$	basic definition of F	402
$F_{\text{obt}} = \dfrac{\text{Between-groups variance estimate}}{\text{Within-groups variance estimate}} = \dfrac{MS_{between}}{MS_{within}}$	F equation for the analysis of variance	406
$s_W{}^2 = \dfrac{SS_1 + SS_2}{(n_1 - 1) + (n_2 - 1)}$	t test, only 2 groups	407
$MS_{within} = s_W{}^2$	both are estimates of σ^2	407
$MS_{within} = \dfrac{SS_1 + SS_2 + SS_3 + \cdots + SS_k}{(n_1 - 1) + (n_2 - 1) + (n_3 - 1) + \cdots + (n_k - 1)}$	conceptual equation for MS_{within}	407
$MS_{within} = \dfrac{SS_1 + SS_2 + SS_3 + \cdots + SS_k}{N - k}$	simplified equation for MS_{within}	407
$MS_{within} = \dfrac{SS_{within}}{\text{df}_{within}}$	within-groups variance estimate	407
$SS_{within} = SS_1 + SS_2 + SS_3 + \cdot \cdot + SS_k$	within-groups sum of squares	407
$\text{df}_{within} = N - k$	within-groups degrees of freedom	407
$SS_{within} = \sum^{\text{all scores}} X^2 - \left[\dfrac{(\Sigma X_1)^2}{n_1} + \dfrac{(\Sigma X_2)^2}{n_2} + \dfrac{(\Sigma X_3)^2}{n_3} + \cdots + \dfrac{(\Sigma X_k)^2}{n_k}\right]$	computational equation for within-groups sum of squares	408
$MS_{between} = \dfrac{n[(\overline{X}_1 - \overline{X}_G)^2 + (\overline{X}_2 - \overline{X}_G)^2 + (\overline{X}_3 - \overline{X}_G)^2 + \cdots + (\overline{X}_k - \overline{X}_G)^2]}{k - 1}$	conceptual equation for between-groups variance estimate	409
$MS_{between} = \dfrac{SS_{between}}{\text{df}_{between}}$	between-groups variance estimate	409
$SS_{between} = n[(\overline{X}_1 - \overline{X}_G)^2 + (\overline{X}_2 - \overline{X}_G)^2 + (\overline{X}_3 - \overline{X}_G)^2 + \cdots + (\overline{X}_3 - \overline{X}_G)^2$	between-groups sum of squares	409
$\text{df}_{between} = k - 1$	between-groups degrees of freedom	409
$SS_{between} = \left[\dfrac{(\Sigma X_1)^2}{n_1} + \dfrac{(\Sigma X_2)^2}{n_2} + \dfrac{(\Sigma X_3)^2}{n_3} + \cdots + \dfrac{(\Sigma X_k)^2}{n_k}\right] - \dfrac{\left(\sum^{\text{all scores}} X\right)^2}{N}$	computational equation for between-groups sum of squares	409
$SS_{total} = SS_{within} + SS_{between}$	equation for checking SS_{within} and $SS_{between}$	412

Equation	Description	Equation First Occurs on Page:
$SS_{total} = \sum^{\text{all scores}} X^2 - \frac{\left(\sum^{\text{all scores}} X\right)^2}{N}$	equation for calculating the total variability	412
$\hat{\omega}^2 = \frac{SS_{between} - (k-1)\,MS_{within}}{SS_{total} + MS_{within}}$	computational equation for estimating $\hat{\omega}^2$	419
$\eta^2 = \frac{SS_{between}}{SS_{total}}$	conceptual and computational equation for eta squared	420
$F_{\text{obt}} = \frac{MS_{between}}{\text{MS}_{within}} = \frac{n[(\overline{X}_1 - \overline{X}_G)^2 + (\overline{X}_2 - \overline{X}_G)^2 + (\overline{X}_3 - \overline{X}_G)^2]/2}{(SS_1 + SS_2 + SS_3)/(N-3)}$	F equation for three-group experiment	421
$t_{\text{obt}} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{within}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$	general equation for t equation for *planned* comparisons,	422
$t_{\text{obt}} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{2MS_{within}/n}}$	t equation for *planned* comparisons with equal n in the two groups	423
$Q_{\text{obt}} = \frac{\overline{X}_i - \overline{X}_j}{\sqrt{MS_{within}/n}}$	equation for calculating Q_{obt}	424
$SS_{between\,(groups\ i\ and\ j)} = \left[\frac{(\sum X_i)^2}{n_i} + \frac{(\sum X_j)^2}{n_j}\right] - \frac{\left(\sum^{\text{groups } i \text{ and } j} X\right)^2}{n_i + n_j}$	computational equation for $SS_{between\,(groups\ i\ and\ j)}$	426
$MS_{between\,(groups\ i\ and\ j)} = \frac{SS_{between\,(groups\ i\ and\ j)}}{\text{df}_{between\,(entire\ ANOVA)}}$	conceptual equation for $MS_{between\,(groups\ i\ and\ j)}$	426
$F_{Scheffé} = \frac{MS_{between\,(groups\ i\ and\ j)}}{MS_{between\,(entire\ ANOVA)}}$	equation for $F_{Scheffé}$	426
$F_{\text{crit}} = F_{\text{crit}\,(entire\ ANOVA)}$	F_{crit} for Scheffé test	426
$MS_{within-cells} = \frac{SS_{within-cells}}{\text{df}_{within-cells}}$	conceptual equation for equation for within-cells variance estimate	451
$SS_{within\text{-}cells} = SS_{11} + SS_{12} + \cdots + SS_{rc}$	conceptual equation for within-cells sum of squares	451
$SS_{within-cells} = \sum^{\text{all scores}} X^2 - \left[\frac{\left(\sum^{\text{cell } 11} X\right)^2 + \left(\sum^{\text{cell } 12} X\right)^2 + \cdots + \left(\sum^{\text{cell } rc} X\right)^2}{n_{\text{cell}}}\right]$	computational equation for within-cells sum of squares	452
$\text{df}_{within\text{-}cells} = rc(n-1)$	within-cells degrees of freedom	452
$MS_{rows} = \frac{SS_{rows}}{\text{df}_{rows}}$	conceptual equation for the row variance estimate	452
$SS_{rows} = n_{row}[(\overline{X}_{\text{row }1} - \overline{X}_G)^2 + (\overline{X}_{row\ 2} - \overline{X}_G)^2 + \cdots + (\overline{X}_{row\ r} - \overline{X}_G)^2]$	conceptual equation for the row sum of squares	453

Equation	Description	Equation First Occurs on Page:
$\mathrm{df}_{rows} = r - 1$	row degrees of freedom	453
$SS_{rows} = \left[\dfrac{\left(\sum\limits^{\text{row 1}} X\right)^2 + \left(\sum\limits^{\text{row 2}} X\right)^2 + \cdots + \left(\sum\limits^{\text{row } r} X\right)^2}{n_{\text{row}}}\right] - \dfrac{\left(\sum\limits^{\text{all scores}} X\right)^2}{N}$	computational equation for the row sum of squares	453
$MS_{columns} = \dfrac{SS_{columns}}{\mathrm{df}_{columns}}$	column variance estimate	454
$SS_{columns} = n_{column}\left[(\overline{X}_{column\ 1} - \overline{X}_G)^2 + (\overline{X}_{column\ 2} - \overline{X}_G)^2 + \cdots + (\overline{X}_{column\ c} - \overline{X}_G)^2\right]$	conceptual equation for the column sum of squares	454
$\mathrm{df}_{columns} = c - 1$	column degrees of freedom	454
$SS_{columns} = \left[\dfrac{\left(\sum\limits^{\text{column 1}} X\right)^2 + \left(\sum\limits^{\text{column 2}} X\right)^2 + \cdots + \left(\sum\limits^{\text{column } c} X\right)^2}{n_{column}}\right] - \dfrac{\left(\sum\limits^{\text{all scores}} X\right)^2}{N}$	computational equation for the column sum of squares	454
$MS_{interaction} = \dfrac{SS_{interaction}}{\mathrm{df}_{interaction}}$	interaction variance estimate	455
$SS_{interaction} = n_{cell}\left[(\overline{X}_{\text{cell }11} - \overline{X}_G)^2 + (\overline{X}_{\text{cell }12} - \overline{X}_G)^2 + \cdots + (\overline{X}_{\text{cell }rc} - \overline{X}_G)^2\right] - SS_{rows} - SS_{columns}$	conceptual equation for the interaction sum of squares	455
$SS_{interaction} = \left[\dfrac{\left(\sum\limits^{\text{cell 11}} X\right)^2 + \left(\sum\limits^{\text{cell 12}} X\right)^2 + \cdots + \left(\sum\limits^{\text{cell } rc} X\right)^2}{n_{\text{cell}}}\right] - \dfrac{\left(\sum\limits^{\text{all scores}} X\right)^2}{N} - SS_{rows} - SS_{columns}$	computational equation for the interaction sum of squares	455
$\mathrm{df}_{interaction} = (r - 1)(c - 1)$	interaction degrees of freedom	455
$\chi^2_{\text{obt}} = \sum \dfrac{(f_o - f_e)^2}{f_e}$	equation for calculating χ^2_{obt}	485
$U_{\text{obt}} = n_1 n_2 + \dfrac{n_1(n_1 + 1)}{2} - R_1$	general equation for calculating U_{obt} or U'_{obt}	503
$U_{\text{obt}} = n_1 n_2 + \dfrac{n_2(n_2 + 1)}{2} - R_2$	general equation for calculating U_{obt} or U'_{obt}	503
$H_{\text{obt}} = \left[\dfrac{12}{N(N + 1)}\right]\left[\sum\limits_{i=1}^{k} \dfrac{(R_i)^2}{n_i}\right] - 3(N + 1)$	*equation for computing H_{obt}*	509