STATISTICS FOR SOCIAL SCIENCE

VOLUME: SPSS

CHAPTER: ANNOTATED OUTPUT

Abstract: This chapter is intended to facilitate the connection between standard introductory statistics concepts and their implementation in SPSS. It shows the output from various types of analyses, describes how to interpret the output, and shows the link between hand calculation formulas and SPSS output. Results derive from the examples in the other sections of this project.

Keywords: SPSS output, annotation, statistical interpretation

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This document is part of an online statistics sourcebook.

A browser-friendly viewing platform for the sourcebook is available:
https://cwendorf.github.io/Sourcebook

All data, syntax, and output files are available:
https://github.com/cwendorf/Sourcebook

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Frequencies (F

"N" provides the sample size for the entire data set. "Missing" refers to the number of entries that are blank, whereas "Valid" is the number of entries that are not blank.

Stat

Outcome		
N	Valid	8
	Missing	0
Mean		4.0000
Std. Deviation		3.11677
Variance		9.714
Percentiles	25	2.2500
	50	4.0000
	75	5.5000

The "Mean", "Standard Deviation", and "Variance" are all calculated as unbiased estimates of the respective population parameter. Here, the mean is determined as the average of the scores weighted by their frequencies:

$$M = \frac{\sum(fY)}{N} = \frac{(2 \times 0) + (1 \times 3) + (2 \times 4) + (1 \times 5) + (1 \times 7) + (1 \times 8)}{8} = 4$$

The "Variance" and "Std. Deviation" are both functions of the Sum of Squares (not shown in the output) of the scores in the frequency distribution:

$$SS = \sum f(Y - M)$$

$$SS = 2(0-4)^2 + 1(3-4)^2 + 2(4-4)^2 + 1(5-4)^2 + 1(7-4)^2 + 1(8-4)^2 = 68.000$$

The "Variance" (i.e., Mean Squares) and "Std. Deviation" are calculated as:

$$MS = \frac{SS}{(N-1)} = \frac{68}{7} = 9.714$$

$$SD = \sqrt{MS} = \sqrt{9.714} = 3.117$$

"Percentiles" provide the scores associated with particular percentile ranks. For example, the 50th percentile is the score in the following position:

$$Position = PR(N+1) = .50(8+1) = 4.5$$

Thus, the score at the 50th percentile is the 4.5th score in the frequency distribution – a score of 4. Similarly, a score of .75 is at the 25th percentile and a score of 6.5 is at the 75th percentile. Importantly, in some cases, the score values are non-integer interpolated values.

Outcome

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0.00	2	25.0	25.0	25.0
	3.00	1	12.5	12.5	37.5
	4.00	2	25.0	25.0	62.5
	5.00	1	12.5	12.5	75.0
	7.00	1	12.5	12.5	87.5
	9.00	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

The "Valid" column lists all of the actual scores in the entire data set. "Frequency" indicates the number of times that score exists. For example, the score 4 was listed 2 times.

The "Percent" column provides the percentage of cases for each possible score. For example, of the 8 scores in the entire data set, the score of 4 was listed 2 times and 2/8 is 25.0%.

The "Valid Percent" column provides the percentage of cases for each possible score divided by the total number of cases. Here, there were no missing scores, so the percent columns are equal.

"Cumulative Percent" is the sum of all percentages up to and including the row in question. For example, 62.5% of scores were a 4 or smaller. Similarly, 37.5% were a 3 or smaller.

Correlations (Bivariate)

These values of the statistics are identical to the values that would be provided by the "Frequencies" or "Descriptives" commands. See the earlier annotated output for details of how these are computed from frequency distributions. Note that they are calculated separately for each variable.

Descriptive Statistics

	Mean	Std. Deviation	N
Outcome 1	2.0000	2.44949	4
Outcome 2	6.0000	2.44949	4

Correlations

		Outcome 1	Outcome 2
Outcome 1	Pearson Correlation	1	.500
	Sig. (2-tailed)		.500
	Sum of Squares and Cross-products	18.000	9.000
	Covariance	6.000	3.000
	N	4	4
Outcome 2	Pearson Correlation	.500	1
	Sig. (2-tailed)	.500	
	Sum of Squares and Cross-products	9.000	18.000
	Covariance	3.000	6.000
	N	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

These boxes represent the conjunction of both variables and therefore present the statistics relevant to the relationship between the two variables. (Thus, the boxes are redundant.)

This "Sum of Cross Products" (SCP) is not easily determined from the summary statistics of the output, but rather from the data (and the calculations are therefore not shown here).

The "Covariance" is a function of the Sum of Cross Products and the sample size:

$$COV = \frac{SCP}{(N-1)} = \frac{9.000}{(4-1)} = 3.000$$

The "Pearson Correlation" coefficient is a function of the covariance and the standard deviations of both variables:

$$r = \frac{COV}{(SD_X)(SD_Y)} = \frac{3.000}{(2.449)(2.449)} = .500$$

Though the statistic is not shown, *t* provides the standardized statistic for testing whether the correlation differs from zero:

$$t = \frac{r}{\sqrt{(1-r^2)/(N-2)}} = \frac{.500}{\sqrt{(1-.500^2)/(4-2)}} = .816$$

The *t* statistic follows a non-normal (studentized or *t*) distribution that depends on degrees of freedom. Here, $df = N - 2 = 4 - 2 = 2$. A *t* with 4 *df* that equals .816 has a two-tailed probability (*p*) of .500, which is not a statistically significant finding.

This box presents information about the first variable that can be derived from the "Std. Deviation" above. The "Covariance" here actually represents the estimated Variance (or Mean Squares) of the variable: $MS = SD^2 = 2.44949^2 = 6.000$. The "Sum of Squares" for this variable is then found (knowing that $SS = MS \times df$) to be equal to 18.000. Finally, note that, by definition, the variable is perfectly correlated with itself (r = 1.0).

This box presents information about the second variable that can be derived from the "Std. Deviation" above. The "Covariance" here actually represents the estimated Variance (or Mean Squares) of the variable: $MS = SD^2 = 2.44949^2 = 6.000$. The "Sum of Squares" for this variable is then found (knowing that $SS = MS \times df$) to be equal to 18.000. Finally, note that, by definition, the variable is perfectly correlated with itself (r = 1.0).

Explore (Descriptives and Confidence Intervals)

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Outcome	8	88.9%	1	11.1%	9	100.0%

The values of the descriptive statistics in this tables – like the "Mean", "Variance", and "Std. Deviation" – are identical to the values that would be provided by the "Frequencies" or "Descriptives" commands. See the earlier annotated output for details of how these are computed from frequency distributions.

Descriptives

			Statistic	Std. Error
Outcome	Mean		4.0000	1.10195
	95% Confidence Interval for Mean	Lower Bound	1.3943	
		Upper Bound	6.6057	
	5% Trimmed Mean		3.9444	
	Median		4.0000	
	Variance		9.714	
	Std. Deviation		3.11677	
	Minimum		.00	
	Maximum		9.00	
	Range		9.00	
	Interquartile Range		5.75	
	Skewness		.151	.752
	Kurtosis		-.467	1.481

The "Standard Error of the Mean" provides an estimate of how spread out the distribution of all possible random sample means would be. Here it's calculated as:

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{3.117}{\sqrt{8}} = 1.102$$

This section provides a confidence interval around (centered on) the "Mean." Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 7 *df*) that has a probability of .05 equals 2.365. As a result:

$$\begin{aligned} CI_M &= M \pm (t_{CRITICAL})(SE_M) \\ &= 4.000 \pm (2.365)(1.102) \end{aligned}$$

Thus, the researcher estimates that the true population mean difference is somewhere between 1.394 and 6.606 (knowing that the estimate could be incorrect).

T-Test (One Sample)

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Outcome	8	4.0000	3.11677	1.10195

These values of the one-sample statistics are identical to the values that would be provided by the "Frequencies" or "Descriptives" commands. See the earlier annotated output for details of how these are computed from frequency distributions.

The "Standard Error of the Mean" provides an estimate of how spread out the distribution of all possible random sample means would be. Here it's calculated as:

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{3.117}{\sqrt{8}} = 1.102$$

One-Sample Test

	Test Value = 7					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Outcome	-2.722	7	.030	-3.00000	-5.6057	-.3943

The "Mean Difference" is the difference between the sample mean (*M* = 4) and the user-specified test value (*u* = 7). For the example, the sample had a mean one point higher than the test value. This raw effect size is important for both the significance test and the confidence interval.

The "t", "df", and "Sig." columns provide the results of the statistical significance test. First, *t* provides the standardized statistic for the mean difference:

$$t = \frac{M - \mu}{SE_M} = \frac{-3.000}{1.102} = -2.722$$

The *t* statistic follows a non-normal (studentized or *t*) distribution that depends on degrees of freedom. Here, *df* = *N* – 1 = 8 – 1 = 7. A *t* with 7 *df* that equals -2.722 has a two-tailed probability (*p*) of .030, a statistically significant finding.

This section provides a confidence interval around (centered on) the "Mean Difference." Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 7 *df*) that has a probability of .05 equals 2.365. As a result:

$$CI_{DIFF} = M_{DIFF} \pm (t_{CRITICAL})(SE_M) = -3.000 \pm (2.365)(1.102)$$

Thus, the researcher estimates that the true population mean difference is somewhere between -5.606 and -.394 (knowing that the estimate could be incorrect).

T-Test (Paired Samples)

These values of the group statistics are calculated separately for each variable.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Outcome 1	2.0000	4	2.44949	1.22474
	Outcome 2	6.0000	4	2.44949	1.22474

These are the standard errors for each variable calculated separately. For the first variable:

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{2.449}{\sqrt{4}} = 1.225$$

Notice that the standard errors are equal because the variables have the same standard deviation.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Outcome 1 & Outcome 2	4	.500	.500

This is the correlation between the scores of the two variables. This correlation is not easily determined from the summary statistics of the output, but rather from the data (and the calculations are therefore not shown here).

Though the statistic is not shown, *t* provides the standardized statistic for testing whether the correlation differs from zero:

$$t = \frac{r}{\sqrt{(1-r^2)/(N-2)}} = \frac{.500}{\sqrt{(1-.500^2)/(4-2)}} = .816$$

The *t* statistic follows a non-normal (studentized or *t*) distribution that depends on degrees of freedom. Here, *df* = *N* – 2 = 4 – 2 = 2. A *t* with 4 *df* that equals .816 has a two-tailed probability (*p*) of .500, which is not a statistically significant finding.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1	Outcome 1 - Outcome 2	-4.00000	2.44949	1.22474	-7.89768	-.10232	-3.266	3	.047

The "Paired Differences" statistics are determined by taking the differences of each person's pairs of scores on the two variables. Thus, the "Std. Deviation" of these is not determinable from the summary statistics. However, the "Mean" here is the difference between the two means provided above.

This confidence interval is centered on the "Mean" of the paired differences of the two variables. Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 3 *df*) that has a probability of .05 equals 3.182. As a result:

$$CI_D = M_D \pm (t_{CRITICAL})(SE_D)$$
$$CI_D = -4.000 \pm (3.182)(1.225)$$

Thus, the researcher estimates that the true population mean difference is somewhere between -7.898 and -.1023 (knowing that the estimate could be incorrect).

The "t", "df", and "Sig." columns provide the results of the statistical significance test. First, *t* provides the standardized statistic for the mean difference:

$$t = \frac{M_D}{SE_D} = \frac{-4.000}{1.225} = -3.266$$

The *t* statistic follows a non-normal (studentized or *t*) distribution that depends on degrees of freedom. Here, *df* = *N* – 1 = 4 – 1 = 3. A *t* with 3 *df* that equals -3.266 has a two-tailed probability (*p*) of .047, a statistically significant finding.

T-Test (Independent Samples)

These values of the group statistics are calculated separately for each group. They are not identical to the values obtained from analyzing the variable as a whole.

Group Statistics

	Lab Group	N	Mean	Std. Deviation	Std. Error Mean
Outcome	Level 1	4	2.0000	2.44949	1.22474
	Level 2	4	6.0000	2.44949	1.22474

These are the standard errors for each mean separately.

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{2.449}{\sqrt{4}} = 1.225$$

Notice that the standard errors are equal because both groups have the same standard deviation and sample size.

"Levene's Test" determines whether the variability from the two groups is significantly different. If this were significant, one might consider using the t-test for unequal variances.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Outcome	Equal variances assumed	.000	1.000	-2.309	6	.060	-4.00000	1.73205	-8.23818	.23818
	Equal variances not assumed			-2.309	6.000	.060	-4.00000	1.73205	-8.23818	.23818

The "t", "df", and "Sig." columns provide the results of the statistical significance test. First, *t* provides the standardized statistic for the mean difference:

$$t = \frac{M_1 - M_2}{SE_{DIFF}}$$

$$t = \frac{-4.000}{1.732} = -2.309$$

The *t* statistic follows a non-normal (studentized or *t*) distribution that depends on degrees of freedom. Here, *df* = N – 2 = 8 – 2 = 6. A *t* with 6 df that equals -2.309 has a two-tailed probability (*p*) of .060, a finding that is not statistically significant.

The "Mean Difference" is the difference between the two group means. For the example, group one's mean was 4 points lower.

The "Standard Error of the Difference" is a function of the two groups' individual standard errors. When sample sizes are equal:

$$SE_{DIFF} = \sqrt{SE_1^2 + SE_2^2}$$

$$SE_{DIFF} = \sqrt{1.225^2 + 1.225^2} = 1.732$$

This value is important for both the significance test and the confidence interval. [Importantly, the computation of the standard error of the difference is more complex for unequal sample sizes.]

This section provides a confidence interval around (centered on) the "Mean Difference." Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 6 *df*) that has a probability of .05 equals 2.447. As a result:

$$CI_{DIFF} = M_{DIFF} \pm (t_{CRITICAL})(SE_{DIFF})$$

$$CI_{DIFF} = -4 \pm (2.447)(1.732)$$

Thus, the researcher estimates that the true population mean difference is somewhere between -8.238 and 0.238 (knowing that the estimate could be incorrect).

Oneway (One

These values of the group statistics are calculated separately for each group. They are not identical to the values obtained from analyzing the variable as a whole.

These are the standard errors for each mean separately. For example, for the first group.

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{2.449}{\sqrt{4}} = 1.225$$

Outcome

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Level 1	4	2.0000	2.44949	1.22474	-1.8977	5.8977	.00	5.00
Level 2	4	6.0000	2.44949	1.22474	2.1023	9.8977	4.00	9.00
Level 3	4	7.0000	2.44949	1.22474	3.1023	10.8977	4.00	9.00
Total	12	5.0000	3.16228	.91287	2.9908	7.0092	.00	9.00

"Minimum" and "Maximum" values are the lowest and highest scores in each group.

These "Total" values are all calculated for the set of data as a whole (i.e., not separately for each group). Because the mean and standard deviation are the same for each of the group values, the SE and CI will also be the same:

$$SE_M = \frac{SD}{\sqrt{N}} = \frac{3.162}{\sqrt{12}} = 0.913$$

$$CI_M = M \pm (t_{CRITICAL})(SE_M) = 5.000 \pm (2.179)(0.913)$$

Thus, the researcher estimates that the true population grand (or overall) mean is somewhere between 2.991 and 7.009 (knowing it may not).

This section provides a confidence interval around (centered on) each mean separately. Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 3 *df*) that has a probability of .05 equals 3.182. For example, for the first group:

$$CI_M = M \pm (t_{CRITICAL})(SE_M) = 2.000 \pm (3.182)(1.225)$$

Thus, the researcher estimates that the true population mean is somewhere between -1.898 and 5.898 (knowing it may not).

ANOVA

Outcome

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.000	2	28.000	4.667	.041
Within Groups	54.000	9	6.000		
Total	110.000	11			

"Mean Squares" are estimates of the variance for each source. For each in turn:

$$MS_{BETWEEN} = \frac{SS_{BETWEEN}}{df_{BETWEEN}} = \frac{56.000}{2} = 28.000$$

$$MS_{WTIHIN} = \frac{SS_{WITHIN}}{df_{WITHIN}} = \frac{54.000}{9} = 6.000$$

"Within Groups" statistics are a function of the group variabilities. Because SS for each group is calculable (*SS = SD² x df*):

$$SS_{WITHIN} = SS_1 + SS_2 + SS_3$$
$$SS_{WITHIN} = 18 + 18 + 18 = 54.0$$
$$df_{WITHIN} = df_1 + df_2 + df_3 = 9$$

"Between Groups" statistics are a function of the group means and sample sizes:

$$SS_{BETWEEN} = \sum n_{GROUP}(M_{GROUP} - M_{TOTAL})^2$$
$$SS_{BETWEEN} = 4(2-5)^2 + 4(6-5)^2 + 4(7-5)^2$$
$$SS_{BETWEEN} = 56.000$$
$$df_{BETWEEN} = \#groups - 1 = 2$$

The "F" statistic is a ratio of the between and within group variance estimates:

$$F = \frac{MS_{BETWEEN}}{MS_{WITHIN}} = \frac{28.000}{6.000} = 4.667$$

An *F* with 2 and 9 *df* that equals 4.667 has a two-tailed probability (*p*) of .041, a statistically significant finding.

Post Hoc Tests (OneWay ANOVA)

Tukey's HSD procedure is appropriate for post-hoc pairwise comparisons between groups. The output lists all possible pairwise comparisons, including those that are redundant.

The "Sig." column provides the probability of the HSD statistic (which is not listed). The HSD statistic is a function of the "Mean Difference" and the "Std. Error". For the first comparison in the example:

$$HSD = \frac{M_1 - M_2}{SE_{DIFF}} = \frac{-4.000}{1.732} = 2.309$$

An HSD of 2.309 (with 2 df_{BETWEEN} and 9 df_{WITHIN} like in the ANOVA source table) has a two-tailed probability (p) of .106, which is not a statistically significant finding.

Dependent Variable: Outcome
Tukey HSD

(I) Factor	(J) Factor	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Level 1	Level 2	-4.00000	1.73205	.106	-8.8359	.8359
	Level 3	-5.00000*	1.73205	.043	-9.8359	-.1641
Level 2	Level 1	4.00000	1.73205	.106	-.8359	8.8359
	Level 3	-1.00000	1.73205	.835	-5.8359	3.8359
Level 3	Level 1	5.00000*	1.73205	.043	.1641	9.8359
	Level 2	1.00000	1.73205	.835	-3.8359	5.8359

* The mean difference is significant at the .05 level.

This section provides confidence intervals around (centered on) the "Mean Differences." Calculation requires the appropriate critical value. Specifically, the HSD statistic (with 2 df_{BETWEEN} and 9 df_{WITHIN}) that has a probability of .05 equals 3.068. For the first comparison in the example:

$$CI_{DIFF} = M_{DIFF} \pm (HSD_{CRITICAL})(SE_{DIFF})$$
$$CI_{DIFF} = -4.000 \pm (2.792)(1.732)$$

Thus, the estimates that the true population mean difference is somewhere between -8.836 and 0.836 (knowing that the estimate could be incorrect).

"Mean Difference (I-J)" is the difference between the means for the "I" and "J" groups. Even though half of the listed comparisons are redundant, the mean differences will have the opposite signs because of subtraction order. This will also change the signs of the associated confidence intervals.

These "Standard Errors" are for the difference between the two group means. The values are a function of the MS_{WITHIN} (from the ANOVA) and the sample sizes:

$$SE_{DIFF} = \sqrt{\left(\frac{MS_{WITHIN}}{n_{GROUP}}\right) + \left(\frac{MS_{WITHIN}}{n_{GROUP}}\right)}$$

$$SE_{DIFF} = \sqrt{\left(\frac{6.000}{4}\right) + \left(\frac{6.000}{4}\right)} = 1.732$$

In this case, because all groups are of the same size, the standard error for each comparison is the same.

Homogeneous Subsets

Tukey HSD

Factor	N	Subset for alpha = .05 1	2
Level 1	4	2.0000	
Level 2	4	6.0000	6.0000
Level 3	4		7.0000
Sig.		.106	.835

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

"Homogeneous Subsets" provide groupings for the means. Means within the same subset are not significantly different from each other (note the "Sig." value at the bottom of the column for the subset). This offers a useful summary of the comparisons as analyzed above.

General Linear Model (Repeated Measures ANOVA)
(Note that some aspects of this output have been deleted and rearranged for the sake of presentation!)

Within-Subjects Factors

Measure: MEASURE_1

Factor	Dependent Variable
1	Outcome 1
2	Outcome 2

This provides a description of the variable levels (i.e., columns in the data set) that are linked by being separate instances of the dependent variable.

Descriptive Statistics

	Mean	Std. Deviation	N
Outcome 1	2.0000	2.44949	4
Outcome 2	6.0000	2.44949	4

These values of the descriptive statistics are calculated separately for each level or condition of the within-subjects factor. They are identical to what would be obtained if the "Frequencies" or "Descriptives" procedure had been used separately for each.

Because sample sizes are equal, a grand mean can be determined by averaging these two level means:

$$M_{TOTAL} = (M_{LEVEL} + M_{LEVEL})/2 = (2.000 + 6.000)/2 = 4.000$$

Estimated Marginal Means

Factor

Measure: MEASURE_1

Factor	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2.000	1.225	-1.898	5.898
2	6.000	1.225	2.102	9.898

This section provides a confidence interval around (centered on) each condition's mean separately. Calculation requires the appropriate critical value. Specifically, the *t* statistic (with 3 *df*) that has a probability of .05 equals 3.182. For example, for the first time:

$$CI_M = M \pm (t_{CRITICAL})(SE_M) = 4.000 \pm (3.182)(1.225)$$

Thus, the researcher estimates that the true population mean for the measure for the Outcome 1 is somewhere between -1.898 and 5.898 (knowing that the estimate could be incorrect).

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	128.000	1	128.000	14.222	.033
Error	27.000	3	9.000		

The “Between-Subjects Intercept” here refers to the average score of the participants in the study and the significance test determines whether that average is different from zero. This is often not an informative test.

“Between-Subjects Error” refers to the average differences across the participants of the study. This Sum of Squares is not easily determined from the summary statistics output, but rather from the data (and the calculations are therefore not shown here). However:

$$df_{SUBJECTS} = \#subjects - 1 = 3$$

The “Mean Square” is the usual ratio of the Sum of Squares to the degrees of freedom.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Factor	Sphericity Assumed	32.000	1	32.000	10.667	.047
	Greenhouse-Geisser	32.000	1.000	32.000	10.667	.047
	Huynh-Feldt	32.000	1.000	32.000	10.667	.047
	Lower-bound	32.000	1.000	32.000	10.667	.047
Error(time)	Sphericity Assumed	9.000	3	3.000		
	Greenhouse-Geisser	9.000	3.000	3.000		
	Huynh-Feldt	9.000	3.000	3.000		
	Lower-bound	9.000	3.000	3.000		

The statistics for the effect (or change) on the “Factor” are functions of the means of the levels or conditions and the sample sizes:

$$SS_{EFFECT} = \sum n_{LEVEL}(M_{LEVEL} - M_{TOTAL})^2$$
$$SS_{EFFECT} = 4(2.0 - 4.0)^2 + 4(6.0 - 4.0)^2$$
$$SS_{EFFECT} = 32.000$$
$$df_{EFFECT} = \#levels - 1 = 1$$

The “Mean Square” is the usual ratio of the Sum of Squares to the degrees of freedom.

$$MS_{EFFECT} = \frac{SS_{EFFECT}}{df_{EFFECT}} = \frac{32.000}{1} = 32.000$$

The “F” statistic is a ratio of the effect and within-subjects error variance estimates:

$$F = \frac{MS_{EFFECT}}{MS_{ERROR}} = \frac{32.000}{3.000} = 10.667$$

An *F* with 1 and 3 *df* that equals 10.667 has a two-tailed probability of .047, a statistically significant finding.

These rows provide statistics adjusted for the “Sphericity” test (not shown). Because that test showed no violation of the assumption, these statistics show the exact same results as those in which sphericity is assumed.

The “Within-Subjects Error” is a function of variabilities of the separate levels or conditions of the factor and the “between-subjects error” given above. Because SS for each level can be determined ($SS = SD^2 \times df$, which equals 18.000 for each of the two outcomes):

$$SS_{ERROR} = SS_1 + SS_2 - SS_{SUBJECTS}$$
$$SS_{ERROR} = 18.000 + 18.000 - 27.000 = 9.000$$
$$df_{ERROR} = df_1 + df_2 - df_{SUBJECTS} = 3 + 3 - 3 = 3.000$$

The “Mean Square” is the usual ratio of the Sum of Squares to the degrees of freedom.

Univariate Analysis of Variance (Factorial ANOVA)

Descriptive Statistics

Dependent Variable: Outcome

FactorA	FactorB	Mean	Std. Deviation	N
Level 1	Level 1	2.0000	2.44949	4
	Level 2	7.0000	2.44949	4
	Total	4.5000	3.50510	8
Level 2	Level 1	6.0000	2.44949	4
	Level 2	5.0000	2.44949	4
	Total	5.5000	2.32993	8
Total	Level 1	4.0000	3.11677	8
	Level 2	6.0000	2.50713	8
	Total	5.0000	2.92119	16

These descriptive statistics are calculated separately for each condition as defined by the factors. They are not identical to the values obtained from analyzing the variable as a whole.

These descriptive statistics are calculated separately for each factor. They represent the marginal means of one factor collapsing across the levels of the other factor. They are not identical to the values obtained from analyzing the variable as a whole.

These descriptive statistics represent the grand (or overall) values obtained from analyzing the variable as a whole. They are identical to what would be obtained if the "Frequencies" or "Descriptives" procedure had been used.

Dependent Variable: Outcome

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	56.000[a]	3	18.667	3.111	.067
Intercept	400.000	1	400.000	66.667	.000
Factor A	4.000	1	4.000	.667	.430
Factor B	16.000	1	16.000	2.667	.128
Factor A * Factor B	36.000	1	36.000	6.000	.031
Error	72.000	12	6.000		
Total	528.000	16			
Corrected Total	128.000	15			

a. R Squared = .438 (Adjusted R Squared = .297)

The "Intercept" statistics are generally not informative.

The "Corrected Model" statistics reflect the overall between-group variability. They are a function of the group means and sample sizes.

$$SS_{MODEL} = \sum n_{GROUP}(M_{GROUP} - M_{TOTAL})^2$$
$$SS_{MODEL} = 4(2.000 - 5.000)^2 + 4(7.000 - 5.000)^2 + 4(6.000 - 5.000)^2 + 4(5.000 - 5.000)^2$$
$$SS_{MODEL} = 56.000$$
$$df_{MODEL} = \#groups - 1 = 3$$

"Mean Squares" are estimates of the variances associated with each source. For the "Factor A * Factor B" interaction:

$$MS_{INTER} = \frac{SS_{INTER}}{df_{INTER}} = \frac{36.000}{1} = 36.000$$

The "F" statistic is a ratio of the effect and within group (error) variance estimates. For the "Factor A * Factor B" interaction:

$$F_{INTER} = \frac{MS_{INTER}}{MS_{ERROR}} = \frac{36.000}{6.000} = 6.000$$

An *F* with 1 and 12 *df* that equals 6.000 has a two-tailed probability of .031, which is a statistically significant finding.

The "Factor A * Factor B" (interaction) statistics reflect the between- group variability not accounted for by the factors taken individually:

$$SS_{INTER} = SS_{MODEL} - SS_{FACTORA} - SS_{FACTORB}$$
$$SS_{INTER} = 56.000 - 4.000 - 16.000 = 36.000$$
$$df_{INTER} = df_{MODEL} - df_{FACTORA} - df_{FACTORB} = 1$$

The "Factor A" and "Factor B" statistics are a function of the level (marginal) means and sample sizes. For "Factor B":

$$SS_{FACB} = \sum n_{LEVEL}(M_{LEVEL} - M_{TOTAL})^2$$
$$SS_{FACTORB} = 8(4-5)^2 + 8(6-5)^2$$
$$SS_{FACTORB} = 16.000$$
$$df_{FACTORB} = \#levels - 1 = 1$$

"Error" statistics are a function of the within group variabilities. Because SS for each group can be determined ($SS = SD^2 \times df$):

$$SS_{ERROR} = SS_1 + SS_2 + SS_3 + SS_4$$
$$SS_{ERROR} = 18.000 + 18.000 + 18.000 + 18.000 = 72.000$$
$$df_{ERROR} = df_1 + df_2 + df_3 + df_4 = 12$$