SOURCEBOOK

CREATE Articles

Annotated Output

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

Keywords: CREATE output, annotation, statistical interpretation

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Frequencies and Descriptives

Group Statistics CI % : 95

Variable	N	M	SD	SE	Lower	Upper
Total	8	4.000	3.117	1.102	1.394	6.606

Group Statistics

Variable	N	Min	Max	25 %tile	50 %tile	75 %tile
Total	8	0.000	9.000	0.750	4.000	6.500

Frequency Distribution

Value	f	%	Cum f	Cum %	z	PR
0.000	2	25.000	2	25.000	-1.283	0.100
3.000	1	12.500	3	37.500	-0.321	0.374
4.000	2	25.000	5	62.500	0.000	0.500
5.000	1	12.500	6	75.000	0.321	0.626
7.000	1	12.500	7	87.500	0.963	0.832
9.000	1	12.500	8	100.000	1.604	0.946

The Mean and Standard Deviation are calculated as unbiased estimates of the respective population parameter. Here, the mean ("M") 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 Standard Deviation are both functions of the Sum of Squares (not shown in the output) of the scores in the frequency distribution:

$$SS = \sum f(Y-M)$$
$$SS = 2(0-4)^2 + 1(3-4)^2 + 2(4-4)^2 + 1(5-4)^2 + 1(7-4)^2 + 1(8-4)^2 = 68$$

Then, the Variance (also known as Mean Squares) is calculated as:

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

Finally, the Standard Deviation ("SD") is determined by:

$$SD = \sqrt{MS} = \sqrt{9.71} = 3.117$$

"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.

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

The "%" 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%.

Cumulative Frequency ("Cum) and Cumulative Percent ("Cum") involve the sum of all frequencies or 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

Paired Samples Statistics

CI % : 95

Group	N	M	SD	SE	Lower	Upper
Time 1	4	2.000	2.449	1.225	-1.898	5.898
Time 2	4	6.000	2.449	1.225	2.102	9.898

These statistics were obtained using same formulas as in the previous section on Frequencies and Descriptives. Note that they are calculated separately for each variable.

Correlations

		Time 1	Time 2
Time 1	r	1.000	0.500
	SCP	18.000	9.000
	COV	6.000	3.000
Time 2	r	0.500	1.000
	SCP	9.000	18.000
	COV	3.000	6.000

These matrices represent the conjunction of both variables and therefore present the statistics relevant to the relationship between the two variables.

The 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 ("COV") 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 Correlation coefficient ("r") is a function of the covariance and the standard deviations of both variables:

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

Regression

Model Statistics

	Unstand	SE	Standard	t	p
Intercept	5.000				
Time 1	0.500	0.612	0.500	0.816	0.500

The Unstandardized Regression Coefficients ("Unstand") are also a function of the Covariance and the descriptive statistics:

$$B_1 = \frac{COV}{(SD_X)^2} = \frac{3.000}{(2.449)^2} = 0.500$$

$$B_0 = M_Y - (B_1)(M_X) = 6.000 - (0.500)(2.000) = 5.000$$

The Standardized Regression Coefficient ("Standard") for the predictor can be similarly determined:

$$\beta_1 = B_1\left(\frac{SD_X}{SD_Y}\right) = 0.500\left(\frac{2.449}{2.449}\right) = 0.500$$

Model Summary

	R	R2	Adj R2	F	p
Model	0.500	0.250	-0.125	0.667	0.500

"R" is a function of the covariance and the standard deviations of both variables:

$$R = \frac{COV}{(SD_X)(SD_Y)} = \frac{3.000}{(2.45)(2.45)} = 0.500$$

$$R^2 = 0.500^2 = 0.250$$

Confidence Interval for the Mean

Group Statistics CI % : 95

Variable	N	M	SD	SE	Lower	Upper
Total	8	4.000	3.117	1.102	1.394	6.606

These statistics were obtained using same formulas as in the previous section on Frequencies and Descriptives.

One Sample T Test Test: 7.000

t	df	p	Diff.	SE	Lower	Upper
-2.722	7	0.030	-3.000	1.102	-5.606	-0.394

This section provides a confidence interval around (centered on) the Mean ("M"). 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:

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

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

The Standard Error of the Mean ("SE") 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 t Test

Group Statistics CI % : 95

Variable	N	M	SD	SE	Lower	Upper
Total	8	4.000	3.117	1.102	1.394	6.606

These statistics were obtained using same formulas as in the previous section on Frequencies and Descriptives.

The Standard Error of the Difference ("SE") provides an estimate of how spread out the distribution of all possible random sample mean differences would be. Here it's calculated as:

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

One Sample T Test Test: 7.000

t	df	p	Diff.	SE	Lower	Upper
-2.722	7	0.030	-3.000	1.102	-5.606	-0.394

This section provides a confidence interval around (centered on) the Mean Difference ("Diff"). 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).

The Mean Difference ("Diff") 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 the significance test, the confidence interval, and the effect size.

The "t", "df", and "p" 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.

Paired Samples t Test

Paired Samples Statistics

CI % : 95

Group	N	M	SD	SE	Lower	Upper
Time 1	4	2.000	2.449	1.225	-1.898	5.898
Time 2	4	6.000	2.449	1.225	2.102	9.898

These statistics were obtained using same formulas as in the previous section on Frequencies and Descriptives. Note that they are calculated separately for each variable.

Paired Samples Correlations

Var	N	r	t	df	p
Diff	4	0.500	0.816	2.000	0.500

The Mean Difference ("Diff") is simply the difference between the two means listed above. However, the "SE" is not determinable from the summary statistics presented here but rather the raw data.

The Std. Deviation of the differences can be determined from this information:

$$SD_D = (SE_D)(\sqrt{N})$$
$$SD_D = (1.225)(\sqrt{4}) = 2.449$$

Paired Samples T Test

t	df	p	Diff.	SE	Lower	Upper
-3.266	3	0.047	-4.000	1.225	-7.898	-0.102

This confidence interval is centered on the Mean Difference ("Diff") 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:

$$CI_D = M_D \pm (t_{CRITICAL})(SE_D)$$
$$CI_D = 4.00 \pm (3.182)(1.225)$$

Thus, the researcher estimates that the true population mean difference is somewhere between 0.1.02 to 7.898 (knowing that the estimate could be incorrect).

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

$$t = \frac{M_D}{SE_D} = \frac{4.000}{1.225} = 3.226$$

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 3.226 has a two-tailed probability (p) of .047, a statistically significant finding.

Independent Samples t Test

Group Statistics CI % : 95

Group	N	M	SD	SE	Lower	Upper
1	4	2.000	2.449	1.225	-1.898	5.898
2	4	6.000	2.449	1.225	2.102	9.898
Total	8	4.000	3.117	1.102	1.394	6.606

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

Independent Samples T Test

t	df	p	Diff.	SE	Lower	Upper
-2.309	6	0.060	-4.000	1.732	-8.238	0.238

The standard errors for each condition can be calculated separately but note that both groups have the same standard deviation and sample size.:

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

The “SE” is a function of the two groups’ individual standard errors. When sample sizes are equal:

$$SE_{DIFF} = \sqrt{SE_1^2 + SE_2^2} = \sqrt{1.225^2 + 1.225^2} = 1.732$$

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.]

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

$$t = \frac{M_{DIFF}}{SE_{DIFF}} = \frac{-4.000}{1.732} = -2.309$$

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.

This section provides a confidence interval around (centered on) the Mean Difference (”Diff”). 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 ANOVA

Descriptives

CI % : 95

Group	N	M	SD	SE	Lower	Upper
1	4	2.000	2.449	1.225	-1.898	5.898
2	4	6.000	2.449	1.225	2.102	9.898
3	4	7.000	2.449	1.225	3.102	10.898
Total	12	5.000	3.162	0.913	2.991	7.009

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.

A grand mean can be determined by taking the weighted average of all of the group means:

$$M_{TOTAL} = \frac{\sum n(M_{GROUP})}{N} = \frac{4(2) + 4(6) + 4(7)}{4 + 4 + 4} = 5.000$$

Tests of Between Subjects Effects

Source	SS	df	MS	F	p	Eta-Sq
Between	56.000	2	28.000	4.667	0.041	0.509
Within	54.000	9	6.000			
Total	110.000	11				

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.

“Within” statistics are a function of the within group variabilities. Because SS for each group equals 2.00 (*SS = SD² x df*):

$$SS_{WITHIN} = SS_1 + SS_2 + SS_3 = 18.000 + 18.000 + 18.000 = 54.000$$

The degrees of freedom (“df”) are a function of the number of people in each group:

$$df_{WITHIN} = df_1 + df_2 + df_3 = 9$$

The “Mean Square” is the ratio of the “Sum of Squares” to the “df”:

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

“Between” statistics are a function of the differences among the groups:

$$SS_{BETWEEN} = \sum n(M_{GROUP} - M_{TOTAL})^2$$

$$SS_{BETWEEN} = 4(2-5)^2 + 4(6-5)^2 + 4(7-5)^2 = 56.000$$

The degrees of freedom (“df”) are a function of the number of groups:

$$df_{BETWEEN} = \#groups - 1 = 2$$

The “Mean Square” is the ratio of the “Sum of Squares” to the “df”:

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

The “Eta-Squared” statistic is a ratio of the between group and the total group variability (“Sum of Squares”) estimates:

$$\eta^2 = \frac{SS_{BETWEEN}}{SS_{TOTAL}} = \frac{SS_{BETWEEN}}{SS_{BETWEEN} + SS_{WITHIN}}$$

$$\eta^2 = \frac{56.000}{56.000 + 54.000} = 0.509$$

Thus, 50.9% of the total variability among all of the scores in the study is accounted for by group membership.

Post Hoc Comparisons

Descriptives

CI % : 95

Group	N	M	SD	SE	Lower	Upper
1	4	2.000	2.449	1.225	-1.898	5.898
2	4	6.000	2.449	1.225	2.102	9.898
3	4	7.000	2.449	1.225	3.102	10.898
Total	12	5.000	3.162	0.913	2.991	7.009

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.

A grand mean can be determined by taking the weighted average of all of the group means:

$$M_{TOTAL} = \frac{\sum n(M_{GROUP})}{N} = \frac{4(2) + 4(6) + 4(7)}{4 + 4 + 4} = 5.000$$

Tests of Between Subjects Effects

Source	SS	df	MS	F	p	Eta-Sq
Between	56.000	2	28.000	4.667	0.041	0.509
Within	54.000	9	6.000			
Total	110.000	11				

Mean Difference ("Diff") is the difference between the means for the two listed groups.

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:

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

$$SE_{DIFF} = \sqrt{\left(\frac{6}{4}\right) + \left(\frac{6}{4}\right)} = 1.732$$

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

Multiple Comparisons (HSD)

(I) IV	(J) IV	Diff.	SE	p	Lower	Upper
1	2	-4.000	1.732	0.106	-8.836	0.836
	3	-5.000	1.732	0.044	-9.836	-0.164
2	1	4.000	1.732	0.106	-0.836	8.836
	3	-1.000	1.732	0.836	-5.836	3.836
3	1	5.000	1.732	0.044	0.164	9.836
	2	1.000	1.732	0.836	-3.836	5.836

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).

The "t" column provides an HSD value that is conceptually similar to a *t* statistic in that it is a function of the "Diff" and the "SE". For the first comparison in the example:

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

The "p" column provides the probability of the HSD statistic. 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, a finding that is not statistically significant.

Repeated Measures ANOVA

Descriptives

CI %: 95

Level	N	M	SD	SE	Lower	Upper
1	4	2.000	2.449	1.225	-1.898	5.898
2	4	6.000	2.449	1.225	2.102	9.898
Total	8	4.000	3.117	1.102	1.394	6.606

Tests of Within Subjects Effects

Source	SS	df	MS	F	p	Eta-Sq
Factor	32.000	1	32.000	10.667	0.047	0.780
Error	24.667	6	4.111			

Tests of Between Subjects Effects

Source	SS	df	MS
Error	27.000	3	9.000

These descriptive statistics are calculated separately for each level or condition. Because sample sizes are equal, a grand mean can be determined by averaging these two level means:

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

The statistics for the effect ("Factor") are functions of the means of the levels or conditions and the sample sizes:

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

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 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} *x 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.

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.

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.

The partial "Eta-Squared" statistic is a ratio of the effect and the total group variability ("Sum of Squares") estimates:

$$Partial\ \eta^2 = \frac{SS_{EFFECT}}{SS_{EFFECT} + SS_{ERROR}}$$
$$Partial\ \eta^2 = \frac{32.000}{32.000 + 9.000} = 0.780$$

Thus, 78.0% of the variability in Outcome scores (after removing individual differences) is accounted for by the repeated measures.

Factorial ANOVA

Cell Descriptive Statistics (Factor A * B)

CI %:

Factor A	Factor B	N	M	SD	Lower
1	1	4	2.000	2.449	-0.668
	2	4	7.000	2.449	4.332
2	1	4	6.000	2.449	3.332
	2	4	5.000	2.449	2.332

These descriptive statistics are calculated separately for each group or condition. A level (marginal) mean can be determined by taking the weighted average of the appropriate group means. For example, the marginal mean for Level 1 of Factor A:

$$M_{LEVEL} = \frac{\sum n(M_{GROUP})}{n_{LEVEL}} = \frac{4(2)+4(7)}{8} = 4.500$$

A grand mean can be determined by taking the weighted average of all of the group means:

$$M_{TOTAL} = \frac{\sum n(M_{GROUP})}{N} = \frac{4(2)+4(7)+4(6)+4(5)}{4+4+4+4} = 5.000$$

Marginal Descriptive Statistics (Factor A)

A	B	N	M	SD	Lower
1	Total	8	4.500	3.505	2.613
3	Total	8	5.500	2.330	3.613

The statistics for the effects of “Factor A” and Factor B” are functions of the level (marginal) means and sample sizes. For “Factor B”:

$$SS_{FACTORB} = \sum n(M_{LEVEL} - M_{TOTAL})^2 = 8(4.5-5)^2 + 8(5.5-5)^2 = 4.000$$
$$df_{FACTORB} = \#levels - 1 = 2 - 1 = 1$$

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

$$SS_{INTERACTION} = SS_{MODEL} - SS_{FACTORA} - SS_{FACTORB} == 56.000 - 4.000 - 16.000 = 36.000$$
$$df_{INTERACTION} = df_A \times df_B = 1$$

Marginal Descriptive Statistics (Factor B)

A	B	N	M	SD	Lower
Total	1	8	4.000	3.117	2.113
Total	2	8	6.000	2.507	4.113

“Withinl” (error) statistics are a function of the within group variabilities. Because SS for each group can be determined (*SS = SD*^{2} *x df*):

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

Tests of Between Subjects Effects

Source	SS	df	MS	F	p	Eta-Sq
Factor A	4.000	1	4.000	0.667	0.430	0.053
Factor B	16.000	1	16.000	2.667	0.128	0.182
A * B	36.000	1	36.000	6.000	0.031	0.333
Within	72.000	12	6.000			
Total	128.000					

The “F” statistic is a ratio of the effect and within group (error) variance estimates. For “Factor B”:

$$F_{FACTORB} = \frac{MS_{FACTORB}}{MS_{ERROR}} = \frac{16.0}{6.0} = 2.667$$

An *F* with 1 and 12 *df* that equals 2.667 has a two-tailed probability of .128, which is not statistically significant.

The partial “Eta-Squared” statistic is a ratio of the effect and the effect plus residual variability. For “Factor B”:

$$\eta^2 p = \frac{SS_{FACTOR}}{SS_{FACTOR} + SS_{ERROR}} = \frac{16.000}{16.000 + 72.000} = 0.182$$

Thus, 18.2% of the variability among the scores is accounted for by Factor B.