One-Way ANOVA

Data

The following data set reflects a between-subjects design with one factor (with three levels). The data are presented in a format suitable for entry into statistical software.

	Factor	Outcome
1	1.00	.00
2	1.00	.00
3	1.00	3.00
4	1.00	5.00
5	2.00	4.00
6	2.00	7.00
7	2.00	4.00
8	2.00	9.00
9	3.00	9.00
10	3.00	6.00
11	3.00	4.00
12	3.00	9.00

Computer Output

The following tables represent typical output from statistical software. Options, labels, and layout vary from program to program.

The table of descriptive statistics can be used to determine the inferential statistics.

	N	Mean	Std. Deviation	Std. Error Mean
Level 1	4	2.000	2.449	1.225
Level 2	4	6.000	2.449	1.225
Level 3	4	7.000	2.449	1.225

The table of inferential statistics shows the key elements to be calculated.

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

Calculations

Within Groups Statistics: Within-groups error statistics are a function of the within group variabilities.

$$SS_1 = (SD_1^2)(df_1) = (2.44949^2)(3) = 18.000$$
$$SS_2 = (SD_2^2)(df_2) = (2.44949^2)(3) = 18.000$$
$$SS_3 = (SD_3^2)(df_3) = (2.44949^2)(3) = 18.000$$

$$SS_{WITHIN} = SS_1 + SS_2 + SS_3 = 18.000 + 18.000 + 18.000 = 54.000$$
$$df_{WITHIN} = df_1 + df_2 + df_3 = 3 + 3 + 3 = 9$$

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

Grand (or Total) Mean: A grand mean can be determined by taking the weighted average of all of the group means.

$$M_{TOTAL} = \frac{\sum n(M_{GROUP})}{N} = \frac{4(2.000) + 4(6.000) + 4(7.000)}{(4 + 4 + 4)} = 5.000$$

Between Groups Statistics: The between-groups effect statistics are a function of the group (level) means and sample sizes.

$$SS_{BETWEEN} = \sum n_{GROUP}(M_{GROUP} - M_{TOTAL})^2 = 4(2.0 - 5.0)^2 + 4(6.0 - 5.0)^2 + 4(7.0 - 5.0)^2 = 56.000$$
$$df_{BETWEEN} = \#groups - 1 = 3 - 1 = 2$$

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

Statistical Significance: The F statistic is the ratio of the between- and within-group variance estimates.

$$F = \frac{MS_{BETWEEN}}{MS_{WITHIN}} = \frac{28.000}{6.000} = 4.667$$
With $df_{BETWEEN} = 2$ and $df_{WITHIN} = 9$, $F_{CRITICAL} = 4.256$
Because $F > F_{CRITICAL}$, $p < .05$

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

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

Confidence Intervals: For ANOVA, calculate the confidence intervals around (centered on) each mean separately.

Because each group has 3 df, $t_{CRITICAL} = \pm 3.182$
$CI_{M_1} = M \pm (t_{CRITICAL})(SE_M) = 2.000 \pm (3.182)(1.225) = [-1.898, 5.898]$
$CI_{M_2} = M \pm (t_{CRITICAL})(SE_M) = 6.000 \pm (3.182)(1.225) = [2.102, 9.898]$
$CI_{M_3} = M \pm (t_{CRITICAL})(SE_M) = 7.000 \pm (3.182)(1.225) = [3.102, 10.898]$

APA Style

The ANOVA provides an omnibus test of the differences across multiple groups. Because the ANOVA tests the overall differences among the groups, the text discusses the differences in general. The first example focuses on statistical significance testing, whereas the second version includes and emphasizes interpretation of the effect size.

A one way ANOVA showed that the differences in Outcome scores between the first group (n = 3, M = 2.00, SD = 2.45), the second group (n = 3, M = 6.00, SD = 2.45), and the third group (n = 3, M = 7.00, SD = 2.45) were statistically significant, $F(2,9) = 4.67$, $p = .041$.

Analyses revealed large overall differences in Outcome scores between the first group (n = 3, M = 2.00, SD = 2.45), the second group (n = 3, M = 6.00, SD = 2.45), and the third group (n = 3, M = 7.00, SD = 2.45), $\eta^2 = .51$, $F(2,9) = 4.67$, $p = .041$.

Alternatively, the means, standard deviations, and confidence intervals could be presented in a table or figure associated with this text.