

# CALCULATIONS IN THE ANALYSIS OF VARIANCE (ANOVA)

Using the following set of data:

	Counting	Rhyming	Adjective	Imagery	Intentional	Total
	9	7	11	12	10	
	8	9	13	11	19	
	6	6	8	16	14	
	8	6	6	11	5	
	10	6	14	9	10	
	4	11	11	23	11	
	6	6	13	12	14	
	5	3	13	10	15	
	7	8	10	19	11	
	7	7	11	11	11	
<b>Mean</b>	7.00	6.90	11.00	13.40	12.00	10.06
<b>St. dev.</b>	1.83	2.13	2.49	4.50	3.74	4.01
<b>Variance</b>	3.33	4.54	6.22	20.27	14.00	16.058

Computations:

$SS_{total}$  = the sum of squares of all the observations, regardless of which treatment produced them from the grand mean, where  $\bar{X}_{..}$  represents the grand mean.

$$\begin{aligned}
 SS_{total} = \Sigma(X_{ij} - \bar{X}_{..})^2 = & (9 - 10.06)^2 + (8 - 10.06)^2 + (6 - 10.06)^2 + (8 - 10.06)^2 + \\
 & (10 - 10.06)^2 + (4 - 10.06)^2 + (6 - 10.06)^2 + (5 - 10.06)^2 + \\
 & (7 - 10.06)^2 + (7 - 10.06)^2 + (7 - 10.06)^2 + (9 - 10.06)^2 + \\
 & (6 - 10.06)^2 + (6 - 10.06)^2 + (6 - 10.06)^2 + (11 - 10.06)^2 + \\
 & (6 - 10.06)^2 + (3 - 10.06)^2 + (8 - 10.06)^2 + (7 - 10.06)^2 + \\
 & (11 - 10.06)^2 + (13 - 10.06)^2 + (8 - 10.06)^2 + (6 - 10.06)^2 + \\
 & (14 - 10.06)^2 + (11 - 10.06)^2 + (13 - 10.06)^2 + (13 - 10.06)^2 + \\
 & (10 - 10.06)^2 + (11 - 10.06)^2 + (12 - 10.06)^2 + (11 - 10.06)^2 + \\
 & (16 - 10.06)^2 + (11 - 10.06)^2 + (9 - 10.06)^2 + (23 - 10.06)^2 + \\
 & (12 - 10.06)^2 + (10 - 10.06)^2 + (19 - 10.06)^2 + (11 - 10.06)^2 + \\
 & (10 - 10.06)^2 + (19 - 10.06)^2 + (14 - 10.06)^2 + (5 - 10.06)^2 + \\
 & (10 - 10.06)^2 + (11 - 10.06)^2 + (14 - 10.06)^2 + (15 - 10.06)^2 + \\
 & (11 - 10.06)^2 + (11 - 10.06)^2 = \mathbf{786.82}
 \end{aligned}$$

## CALCULATIONS IN THE ANALYSIS OF VARIANCE (ANOVA)

$SS_{\text{treat}} = SS_{\text{Between}}$  = the sum of squares (deviations) of the group means from the grand mean, where  $\bar{X}_{..}$  represents the grand mean.

$$SS_{\text{treat}} = n\Sigma(X_j - \bar{X}_{..})^2 = 10(7.00 - 10.06)^2 + 10(6.90 - 10.06)^2 + 10(11.00 - 10.06)^2 + 10(13.40 - 10.06)^2 + 10(12.00 - 10.06)^2 = \mathbf{351.52}$$

$SS_{\text{error}} = SS_{\text{Within}} = (\mathbf{Error})$  = the sum over the sums of squared deviations of scores around their group's mean. It is also obtained from subtraction  $SS_{\text{total}} = SS_{\text{treat}} + SS_{\text{error}}$ , which means  $SS_{\text{error}} = SS_{\text{total}} - SS_{\text{treat}}$ .

$$SS_{\text{within Counting}} = (9 - 7.00)^2 + (8 - 7.00)^2 + (6 - 7.00)^2 + (8 - 7.00)^2 + (10 - 7.00)^2 + (4 - 7.00)^2 + (6 - 7.00)^2 + (5 - 7.00)^2 + (7 - 7.00)^2 + (7 - 7.00)^2 = 30.00$$

$$SS_{\text{within Rhyming}} = (7 - 6.90)^2 + (9 - 6.90)^2 + (6 - 6.90)^2 + (6 - 6.90)^2 + (6 - 6.90)^2 + (11 - 6.90)^2 + (6 - 6.90)^2 + (3 - 6.90)^2 + (8 - 6.90)^2 + (7 - 6.90)^2 = 40.90$$

$$SS_{\text{within Adjective}} = (11 - 11.00)^2 + (13 - 11.00)^2 + (8 - 11.00)^2 + (6 - 11.00)^2 + (14 - 11.00)^2 + (11 - 11.00)^2 + (13 - 11.00)^2 + (13 - 11.00)^2 + (10 - 11.00)^2 + (11 - 11.00)^2 = 56.00$$

$$SS_{\text{within Adjective}} = (12 - 13.40)^2 + (11 - 13.40)^2 + (16 - 13.40)^2 + (11 - 13.40)^2 + (9 - 13.40)^2 + (23 - 13.40)^2 + (12 - 13.40)^2 + (10 - 13.40)^2 + (19 - 13.40)^2 + (11 - 13.40)^2 = 182.40$$

$$SS_{\text{within Adjective}} = (10 - 12.00)^2 + (19 - 12.00)^2 + (14 - 12.00)^2 + (5 - 12.00)^2 + (10 - 12.00)^2 + (11 - 12.00)^2 + (14 - 12.00)^2 + (15 - 12.00)^2 + (11 - 12.00)^2 + (11 - 12.00)^2 = 126.00$$

$$SS_{\text{error}} = \Sigma(X_{ij} - \bar{X}_j)^2 = 30.00 + 40.90 + 56.00 + 182.40 + 126.00 = \mathbf{435.30}$$

$$SS_{\text{error}} = SS_{\text{total}} - SS_{\text{treat}} = 786.82 - 351.52 = \mathbf{435.30}$$

# CALCULATIONS IN THE ANALYSIS OF VARIANCE (ANOVA)

Summary Table for the One-way ANOVA

## Summary ANOVA

Source	Sum of Squares	Degrees of Freedom	Variance Estimate (Mean Square)	F Ratio
Between	$SS_B$	$K - 1$	$MS_B = \frac{SS_B}{K - 1}$	$\frac{MS_B}{MS_W}$
Within	$SS_W$	$N - K$	$MS_W = \frac{SS_W}{N - K}$	
Total	$SS_T = SS_B + SS_W$	$N - 1$		

Knowing that  $K$  (Groups) = 5 and  $N$  (Total Sample Size) = 50 ( $n = 10$  for each group)...

Table 1

### *Analysis of Variance for Number of Words Recalled*

Source	SS	df	MS	F	F <sub>CV</sub>
Between	351.52	4	87.88	9.08*	2.61
Within	435.30	45	9.67		
Total	786.82	49			

\*  $p < .05$

Output from SPSS:

## ANOVA

Number of words recalled

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	351.520	4	87.880	9.085	.000
Within Groups	435.300	45	9.673		
Total	786.820	49			

Showing  $p < .001$