# 1-way Independent ANOVA

n = 6
K = 3
$n_T$ = 18

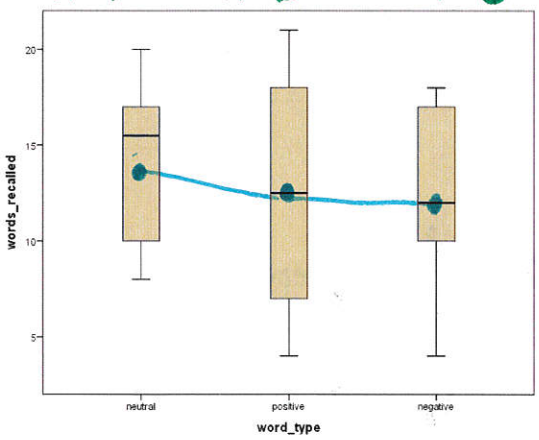
**Setup:** Started with 18 subjects, randomly divided them into three groups of six. Each group was given a type of word list to later recall.

| Neutral | Positive | Negative |
|---|---|---|
| 20 | 21 | 17 |
| 16 | 18 | 11 |
| 8 | 7 | 4 |
| 17 | 15 | 18 |
| 15 | 10 | 13 |
| 10 | 4 | 10 |
| $M_{Neu}$ = 14.33 | $M_{Pos}$ = 12.5 | $M_{Neg}$ = 12.17 |
| $S_{Neu}$ = 4.50 | $S_{Pos}$ = 6.60 | $S_{Neg}$ = 5.12 |
| n = 6 | n = 6 | n = 6 |

"grand mean"

$\bar{X}_G = \frac{14.33 + 12.5 + 12.17}{3} = \frac{39}{3} = 13$

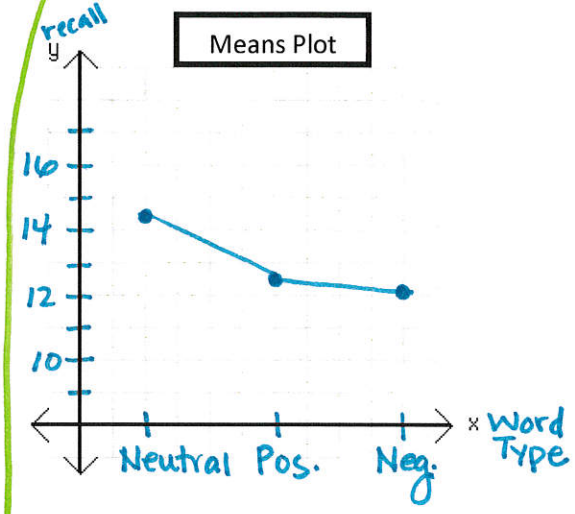
$\bar{X}_G = 13$




$df_{TOTAL}$ ($n_T - 1$) = 17

$df_{Bet\text{-}group}$ ($k - 1$) = 2

$df_{With\text{-}group}$ ($n_T - k$) = 15




| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Groups | 16.24 | 2 | 8.12 | 0.27 | >>>.05 |
| Within-Groups (**Residual**) | 450.15 | 15 | 30.01 | | |
| Total | 466.39 | 17 | | | |

TABLE → $F_{crit}(2, 15) = 3.68$

FORMULA 12.5B

$$MS_W = \frac{\Sigma S^2}{k} = \frac{4.5^2 + 6.6^2 + 5.12^2}{3} = 30.0081$$

FORMULA 12.7

$$MS_B = \frac{n \Sigma (\bar{X}_i - \bar{X}_G)^2}{k-1} = \frac{6 \cdot (14.33-13)^2 + (12.5-13)^2 + (12.17-13)^2}{3-1} = 8.1234$$

$$F = \frac{MS_B}{MS_W} = \frac{8.12}{30.01} = 0.27$$

=> All 3 groups have about the same mean # recall.

# 2-way Independent ANOVA

n = 3
c = 3
r = 2
$n_T$ = 18

**Setup:** Started with 18 subjects, 9 with preexisting depression & 9 without. Randomly divided each set of 9 them into three groups of three. Each group was given a type of word list to later recall.

| | Neutral | Positive | Negative | |
|---|---|---|---|---|
| NOT Depressed | 20, 16, 8 — M = 14.67, S = 6.11 | 21, 18, 7 — M = 15.33, S = 7.37 | 17, 11, 4 — M = 10.67, S = 6.51 | $M_{Dep}$ = 13.56, n=9 |
| ~~Not~~ depressed | 17, 15, 10 — M = 14.00, S = 3.61 | 15, 10, 4 — M = 9.67, S = 5.51 | 18, 13, 10 — M = 13.67, S = 4.04 | $M_{Not}$ = 12.44, n=9 |
| | $M_{Neu}$ = 14.33, n=6 | $M_{Pos}$ = 12.5, n=6 | $M_{Neg}$ = 12.17, n=6 | $M_{Grand}$ = 13, n=18 |

$df_{TOTAL}$ ( $n_T - 1$ ) = 17

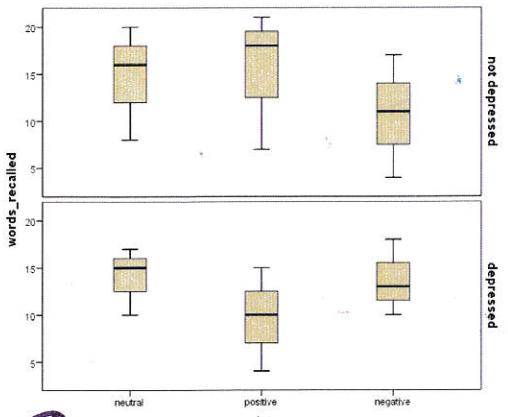
$df_{Bet\text{-}Cell}$ ( $rc - 1$ ) = 5

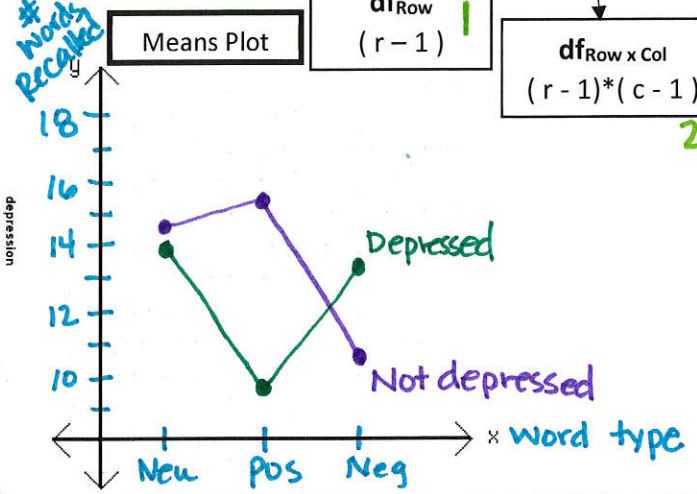
$df_{With\text{-}Cell}$ ( $n_T - rc$ ) = 12

$df_{Row}$ ( $r - 1$ ) = 1

$df_{Row \times Col}$ ( $r - 1$ )*( $c - 1$ ) = 2

$df_{Col}$ ( $c - 1$ ) = 2




**GIVEN TO YOU:**

| Source | SS | Df | MS | F | p |
|---|---|---|---|---|---|
| Between-Cells | 78.55 | 5 | | | |
| DEPression Row Groups | 5.64 | 1 | 5.64 | 0.17 | >>.05 |
| word type Column Groups | 16.24 | 2 | 8.12 | 0.25 | >>.05 |
| INTER (Row x Col) | 56.67 | 2 | 28.34 | 0.87 | >>.05 |
| Within-Cells (**Residual**) | 387.49 | 12 | 32.29 | | |
| Total | 466.24 | 17 | | | |

all six cells =

$F_{crit}(1, 12) = 4.75$

$F_{crit}(2, 12) = 3.89$

**Formula 12.5B**

$$MS_{Cell} = \frac{\Sigma s^2}{\#Cell} = \frac{6.11^2 + 7.37^2 + \cdots + 5.51^2 + 4.04^2}{6} = 32.2905$$

SIX CELLS

$F_{depress} = 5.64 / 32.29$

$F_{type} = 8.12 / 32.29$

$F_{inter} = 28.34 / 32.29$

**Formula 12.7**

$$MS_{col} = n_{col} \frac{\Sigma(\bar{X}_{col} - \bar{X}_G)^2}{\#col - 1}$$

$$MS_{row} = n_{row} \frac{\Sigma(\bar{X}_{row} - \bar{X}_G)^2}{\#rows - 1}$$

COLUMNS: THREE

$$MS_{TYPE} = 6\left[\frac{(14.33-13)^2 + (12.5-13)^2 + (12.17-13)^2}{(3-1)}\right] = 8.12$$

THREE COL

ROWS: TWO

$$MS_{dep} = 9\left[\frac{(13.56-13)^2 + (12.44-13)^2}{(2-1)}\right] = 5.64$$

two row

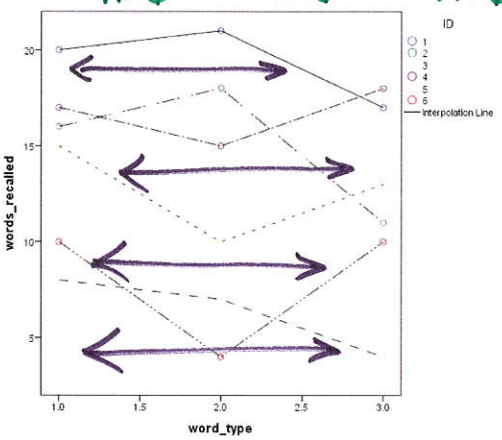
# 1-way Repeated Measures ANOVA

**Setup:** Started with 6 subjects, were each given all 3 type of word list to later recall. The words were actually all randomly included on the same list.

$n = 6$
$c = 3$
$n_T = 18$

| Subject ID | Neutral | Positive | Negative | |
|---|---|---|---|---|
| 1 | 20 | 21 | 17 | $M_1 = 19.33$ n=3 |
| 2 | 16 | 18 | 11 | $M_2 = 15.00$ n=3 |
| 3 | 7 | 7 | 4 | $M_3 = 6.33$ n=3 |
| 4 | 15 | 15 | 18 | $M_4 = 16.67$ n=3 |
| 5 | 10 | 10 | 13 | $M_5 = 12.67$ n=3 |
| 6 | 4 | 4 | 10 | $M_6 = 8.00$ n=3 |
| | $M_{Neu} = 14.33$ n=6 | $M_{Pos} = 12.5$ n=6 | $M_{Neg} = 12.17$ n=6 | $M_{Grand} = 13$ n=18 |

$df_{TOTAL}$ 17 ($n_T - 1$)
- $df_{Bet\text{-}Sub}$ 5 ($n - 1$)
- $df_{With\text{-}Sub}$ 12 ($n(c-1)$)
  - 2 $Df_{RM}$ ($c - 1$)
  - $Df_{SubxRM}$ 10 ($n - 1)(c - 1$)




**Shpericity violated? Now what?**

Mauchly's W ... $p < .05$

use an epsilon x df "Greenhouse Geisser"

$\varepsilon = \#$

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Subjects | 381.41 | 5 | 76.28 | | |
| Within-Subjects | 84.83 | 12 | | | |
| RM | 16.24 | 2 | 8.12 | 1.18 | > .05 |
| **Residual**: INTER(RM x Sub) | 68.59 | 10 | 6.86 | | |
| Total SAME AS ANOVA BEFORE | 466.24 | 17 | | | |

$F_{crit}(2, 10) = 4.10$

ROWS $MS_{Sub} = \dfrac{3\left[(19.33-13)^2 + \cdots + (8.0-13)^2\right]}{6-1} = 76.28$

(# in row = 3; SIX ROWS)

COLUMNS $MS_{RM} = \dfrac{6\left[(14.33-13)^2 + (12.5-13)^2 + (12.17-13)^2\right]}{3-1} = 8.12$

(# in col = 6; THREE COLUMS)

$F_{RM} = 8.12/6.86 = 1.18 \Rightarrow$ All lines are flat ecentially

# 2-way Mixed Design ANOVA

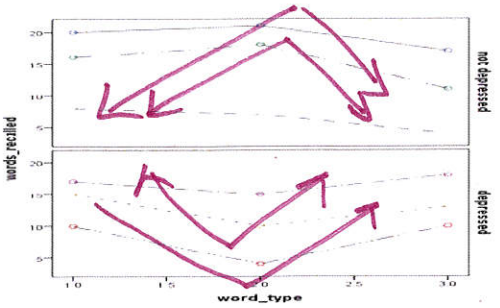
n = 3
k = 2
c = 3
$n_T$ = 18

**Setup:** Started with 6 subjects, 3 with preexisting depression & 3 without. All were each given all 3 type of word list to later recall.

Grp: Independent / Fixed

RM: repeated or "random"

| | | Neutral | Positive | Negative | |
|---|---|---|---|---|---|
| NOT Depressed | 1 | 20 | 21 | 17 | |
| | 2 | 16 M = 14.67 | 18 M = 15.33 | 11 M = 10.67 | $M_{Dep}$ = 13.56 |
| | 3 | 8 | 7 | 4 | |
| ~~Not~~ depressed | 4 | 17 | 15 | 18 | |
| | 5 | 15 M = 14.00 | 10 M = 9.67 | 13 M = 13.67 | $M_{Not}$ = 12.44 |
| | 6 | 10 | 4 | 10 | |
| | | $M_{Neu}$ = 14.33 | $M_{Pos}$ = 12.5 | $M_{Neg}$ = 12.17 | $M_{Grand}$ = 13 |




- $df_{TOTAL}$ 17 ($n_T - 1$)
  - $df_{Bet\text{-}Sub}$ 5 ($nk - 1$)
    - $df_{Group}$ 1 ($k - 1$)
    - $df_{With\text{-}group}$ 4 $k(n - 1)$
  - $df_{With\text{-}Sub}$ 12 $nk(c - 1)$
    - $df_{RM}$ 2 ($c - 1$)
    - $df_{Group \times RM}$ 2 $(k - 1)*(c - 1)$
    - $df_{Sub \times RM}$ 8 $k(c - 1)(n - 1)$

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Subjects | | 5 | | | |
| DEPression Groups | + | 1 | | | |
| **Residual:** Within-Groups | | 4 | | | |
| Within-Subjects | | 12 | | | |
| word type RM | | 2 | | | |
| dep x type INTER: Group x RM | + | 2 | | | |
| **Residual:** INTER(Sub x RM) | | 8 | | | |
| Total | | 17 | | | |

$F_{crit}(\_\_, \_\_) = \_\_\_\_$
$F_{crit}(\_\_, \_\_) = \_\_\_\_$

- Look at the interaction first!
- If the interaction → IS sig → Plot Means
  - NOT sig → look at the 2 main effects

# Compare ANOVA Method Results: by hand

### 1-way Independent ANOVA

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Groups | 16.26 | 2 | 8.13 | **0.27** | **> .05** |
| Within-Groups (**Residual**) | 450.15 | 15 | **30.01** | | |
| Total | 466 | 17 | | | |

$F_{crit}(2, 15) = 4.54$

### 2-way Independent ANOVA

| Source | SS | Df | MS | F | p |
|---|---|---|---|---|---|
| Between-Cells | 78.51 | 5 | | | |
| Row Groups | 5.64 | 1 | 5.64 | **0.17** | **> .05** |
| Column Groups | 16.26 | 2 | 8.13 | **0.25** | **> .05** |
| INTER (Row x Col) | 56.6 | 2 | 28.31 | **0.88** | **> .05** |
| Within-Cells (**Residual**) | 387.49 | 12 | **23.29** | | |
| Total | 466 | 17 | | | |

$F_{crit}(1, 12) = 4.75$
$F_{crit}(2, 12) = 3.89$

### 1-way Repeated Measures ANOVA

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Subjects | 381.42 | 5 | | | |
| Within-Subjects | 84.58 | 12 | | | |
| RM | 16.26 | 2 | 8.13 | **1.19** | **> .05** |
| **Residual**: INTER(Sub x RM) | 68.32 | 10 | **6.83** | | |
| Total | 466 | 17 | | | |

$F_{crit}(2, 10) = 4.10$

### 2-way Mixed Design ANOVA

| Source | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Between-Subjects | 381.42 | 5 | | | |
| Groups | 5.64 | 1 | 5.64 | **0.06** | **> .05** |
| **Residual**: Within-Groups | 375.78 | 4 | **93.95** | | |
| Within-Subjects | 84.58 | 12 | | | |
| RM | 16.26 | 2 | 8.13 | **5.57** | **< .05** |
| INTER: Group x RM | 56.64 | 2 | 28.32 | **19.40** | **< .05** |
| **Residual**: INTER(Sub x RM) | 11.68 | 8 | **1.46** | | |
| Total | 466 | 17 | | | |

$F_{crit}(1, 4) = 7.71$
$F_{crit}(2, 8) = 3.89$

# Compare ANOVA Method Results: by SPSS

## 1-way independent ANOVA: just word type

```
ONEWAY words_recalled BY word_type.
```

words_recalled

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 16.333 | 2 | 8.167 | .272 | .765 |
| Within Groups | 449.667 | 15 | 29.978 | | |
| Total | 466.000 | 17 | | | |

```
UNIANOVA words_recalled BY word_type
  /PLOT=PROFILE(word_type)
  /PRINT=ETASQ DESCRIPTIVE
  /DESIGN=word_type.
```

**Tests of Between-Subjects Effects**

Dependent Variable: words_recalled

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 16.333[a] | 2 | 8.167 | .272 | .765 | .035 |
| Intercept | 3042.000 | 1 | 3042.000 | 101.475 | .000 | .871 |
| word_type | 16.333 | 2 | 8.167 | .272 | .765 | .035 |
| Error | 449.667 | 15 | 29.978 | | | |
| Total | 3508.000 | 18 | | | | |
| Corrected Total | 466.000 | 17 | | | | |

a. R Squared = .035 (Adjusted R Squared = -.094)

## 2-way independent ANOVA: depression & word type

```
UNIANOVA words_recalled BY depression word_type
  /PLOT=PROFILE(word_type*depression)
  /PRINT=ETASQ DESCRIPTIVE
  /DESIGN=depression word_type depression*word_type.
```

**Tests of Between-Subjects Effects**

Dependent Variable: words_recalled

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 78.667[a] | 5 | 15.733 | .487 | .780 | .169 |
| Intercept | 3042.000 | 1 | 3042.000 | 94.244 | .000 | .887 |
| depression | 5.556 | 1 | 5.556 | .172 | .686 | .014 |
| word_type | 16.333 | 2 | 8.167 | .253 | .780 | .040 |
| depression * word_type | 56.778 | 2 | 28.389 | .880 | .440 | .128 |
| Error | 387.333 | 12 | 32.278 | | | |
| Total | 3508.000 | 18 | | | | |
| Corrected Total | 466.000 | 17 | | | | |

a. R Squared = .169 (Adjusted R Squared = -.178)

# 1-way RM ANOVA: just word type

```
GLM neutral positive negative
  /PLOT=PROFILE(type)
  /PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
  /WSDESIGN=type.
```

Measure: MEASURE_1

| Within Subjects Effect | Mauchly's W | Approx. Chi-Square | df | Sig. | Epsilon[b] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Greenhouse-Geisser | Huynh-Feldt | Lower-bound |
| type | .213 | 6.178 | 2 | .046 | .560 | .608 | .500 |

**Tests of Within-Subjects Effects**

Measure: MEASURE_1

| Source | | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[a] |
|---|---|---|---|---|---|---|---|---|---|
| type | Sphericity Assumed | 16.333 | 2 | 8.167 | 1.195 | .342 | .193 | 2.390 | .205 |
| | Greenhouse-Geisser | 16.333 | 1.119 | 14.591 | 1.195 | .328 | .193 | 1.338 | .154 |
| | Huynh-Feldt | 16.333 | 1.215 | 13.438 | 1.195 | .331 | .193 | 1.453 | .160 |
| | Lower-bound | 16.333 | 1.000 | 16.333 | 1.195 | .324 | .193 | 1.195 | .146 |
| Error(type) | Sphericity Assumed | 68.333 | 10 | 6.833 | | | | | |
| | Greenhouse-Geisser | 68.333 | 5.597 | 12.208 | | | | | |
| | Huynh-Feldt | 68.333 | 6.077 | 11.244 | | | | | |
| | Lower-bound | 68.333 | 5.000 | 13.667 | | | | | |

a. Computed using alpha = .05

Measure: MEASURE_1
Transformed Variable: Average

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[a] |
|---|---|---|---|---|---|---|---|---|
| Intercept | 3042.000 | 1 | 3042.000 | 39.886 | .001 | .889 | 39.886 | .998 |
| Error | 381.333 | 5 | 76.267 | | | | | |

a. Computed using alpha = .05

# 2-way Mixed Design ANOVA: depression & word type

```
GLM neutral positive negative BY depression
  /PLOT=PROFILE(type*depression)
  /PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
  /WSDESIGN=type
  /DESIGN=depression.
```

**Mauchly's Test of Sphericity[a]**

Measure: MEASURE_1

| Within Subjects Effect | Mauchly's W | Approx. Chi-Square | df | Sig. | Epsilon[b] | | |
|---|---|---|---|---|---|---|---|
| | | | | | Greenhouse-Geisser | Huynh-Feldt | Lower-bound |
| type | .817 | .608 | 2 | .738 | .845 | 1.000 | .500 |

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + depression
Within Subjects Design: type

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

**Tests of Within-Subjects Effects**

Measure: MEASURE_1

| Source | | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[a] |
|---|---|---|---|---|---|---|---|---|---|
| type | Sphericity Assumed | 16.333 | 2 | 8.167 | 5.654 | .029 | .586 | 11.308 | .696 |
| | Greenhouse-Geisser | 16.333 | 1.690 | 9.665 | 5.654 | .039 | .586 | 9.555 | .630 |
| | Huynh-Feldt | 16.333 | 2.000 | 8.167 | 5.654 | .029 | .586 | 11.308 | .696 |
| | Lower-bound | 16.333 | 1.000 | 16.333 | 5.654 | .076 | .586 | 5.654 | .442 |
| type * depression | Sphericity Assumed | 56.778 | 2 | 28.389 | 19.654 | .001 | .831 | 39.308 | .997 |
| | Greenhouse-Geisser | 56.778 | 1.690 | 33.596 | 19.654 | .002 | .831 | 33.215 | .991 |
| | Huynh-Feldt | 56.778 | 2.000 | 28.389 | 19.654 | .001 | .831 | 39.308 | .997 |
| | Lower-bound | 56.778 | 1.000 | 56.778 | 19.654 | .011 | .831 | 19.654 | .904 |
| Error(type) | Sphericity Assumed | 11.556 | 8 | 1.444 | | | | | |
| | Greenhouse-Geisser | 11.556 | 6.760 | 1.709 | | | | | |
| | Huynh-Feldt | 11.556 | 8.000 | 1.444 | | | | | |
| | Lower-bound | 11.556 | 4.000 | 2.889 | | | | | |

a. Computed using alpha = .05

**Tests of Between-Subjects Effects**

Measure: MEASURE_1

Transformed Variable: Average

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[a] |
|---|---|---|---|---|---|---|---|---|
| Intercept | 3042.000 | 1 | 3042.000 | 32.381 | .005 | .890 | 32.381 | .985 |
| depression | 5.556 | 1 | 5.556 | .059 | .820 | .015 | .059 | .054 |
| Error | 375.778 | 4 | 93.944 | | | | | |

a. Computed using alpha = .05