

Linear Models – $Y_{ij} = \mu + \beta_i + \tau_j + \beta\tau_{ij} + \varepsilon_{ijk}$ This is a Randomized Block Design (RBD) with a single factor treatment arrangement (2 levels) which are fixed.

```

1          *****;
2          *** Pygmalion effect study          ***;
3          *** In this study three platoons were used from each ***;
4          *** of 10 companies of soldiers. In each company, ***;
5          *** one of the 3 platoons was selected as the ***;
6          *** treatment group with higher expectations. ***;
7          *****;
8
9          dm'log;clear;output;clear';
10         options nodate nocenter nonumber ps=512 ls=99 nolabel;
11         ODS HTML style=minimal rs=none
12         ! body='C:\Geaghan\Current\EXST3201\Fall2005\SAS\Pygmalion01.html' ;
NOTE: Writing HTML Body file: C:\Geaghan\Current\EXST3201\Fall2005\SAS\Pygmalion01.html
13         Title1 'Chapter 13 : Pygmalion effect study';
14         filename input1 'C:\Geaghan\Current\EXST3201\Datasets\ASCII\case1302.csv';
15
16         data pygmalion; length treat $ 9; infile input1 missover DSD dlm="," firstobs=2;
17         input COMPANY $ TREAT $ SCORE;
18         label company = 'Company of soldiers'
19         treat = 'Pygmalion or control platoon'
20         score = 'Score on Practical Specialty Test';
21         datalines;
NOTE: The infile INPUT1 is:
      File Name=C:\Geaghan\Current\EXST3201\Datasets\ASCII\case1302.csv,
      RECFM=V,LRECL=256
NOTE: 29 records were read from the infile INPUT1.
      The minimum record length was 19.
      The maximum record length was 35.
NOTE: The data set WORK.PYGMALION has 29 observations and 3 variables.
NOTE: DATA statement used (Total process time):
      real time          0.04 seconds
      cpu time           0.05 seconds
22         run;
24         PROC PRINT DATA=pygmalion; TITLE2 'Data Listing'; RUN;
NOTE: There were 29 observations read from the data set WORK.PYGMALION.
NOTE: The PROCEDURE PRINT printed page 1.
NOTE: PROCEDURE PRINT used (Total process time):
      real time          0.35 seconds
      cpu time           0.03 seconds

```

Chapter 13 : Pygmalion effect study
Data Listing

| Obs | treat | COMPANY | SCORE | | | | |
|-----|-----------|---------|---------|----|-----------|-----|---------|
| 1 | PYGMALION | C1 | 80.0000 | 15 | PYGMALION | C6 | 89.8000 |
| 2 | CONTROL | C1 | 63.2000 | 16 | CONTROL | C6 | 78.9000 |
| 3 | CONTROL | C1 | 69.2000 | 17 | CONTROL | C6 | 84.7000 |
| 4 | PYGMALION | C2 | 83.9000 | 18 | PYGMALION | C7 | 76.1000 |
| 5 | CONTROL | C2 | 63.1000 | 19 | CONTROL | C7 | 60.6000 |
| 6 | CONTROL | C2 | 81.5000 | 20 | CONTROL | C7 | 69.6000 |
| 7 | PYGMALION | C3 | 68.2000 | 21 | PYGMALION | C8 | 71.5000 |
| 8 | CONTROL | C3 | 76.2000 | 22 | CONTROL | C8 | 67.8000 |
| 9 | PYGMALION | C4 | 76.5000 | 23 | CONTROL | C8 | 73.2000 |
| 10 | CONTROL | C4 | 59.5000 | 24 | PYGMALION | C9 | 69.5000 |
| 11 | CONTROL | C4 | 73.5000 | 25 | CONTROL | C9 | 72.3000 |
| 12 | PYGMALION | C5 | 87.8000 | 26 | CONTROL | C9 | 73.9000 |
| 13 | CONTROL | C5 | 73.9000 | 27 | PYGMALION | C10 | 83.7000 |
| 14 | CONTROL | C5 | 78.5000 | 28 | CONTROL | C10 | 63.7000 |
| | | | | 29 | CONTROL | C10 | 77.7000 |

The only replication of the Pygmalion treatment is through the blocking. There are however additional replicates of the control treatment in many of the blocks.

```

26      PROC mixed DATA=pygmalion cl covtest; class company treat;
27      Title2 'Randomized block design';
28      MODEL score = treat / outp=next2;
29      random company company*treat;
30      lsmeans treat / pdiff adjust=tukey cl;
31      ods output lsmeans = mmm;
32      RUN;

```

NOTE: Convergence criteria met.

NOTE: Estimated G matrix is not positive definite.

NOTE: The data set WORK.MMM has 2 observations and 10 variables.

NOTE: The data set WORK.NEXT2 has 29 observations and 10 variables.

NOTE: The PROCEDURE MIXED printed page 2.

NOTE: PROCEDURE MIXED used (Total process time):

```

real time      0.34 seconds
cpu time       0.18 seconds

```

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Randomized block design

The Mixed Procedure

Model Information

```

Data Set                WORK.PYGMALION
Dependent Variable      SCORE
Covariance Structure    Variance Components
Estimation Method       REML
Residual Variance Method Profile
Fixed Effects SE Method Model-Based
Degrees of Freedom Method Containment

```

Class Level Information

```

Class      Levels      Values
COMPANY    10      C1 C10 C2 C3 C4 C5 C6 C7 C8 C9
treat      2      CONTROL PYGMALION

```

Dimensions

```

Covariance Parameters      3
Columns in X                3
Columns in Z                30
Subjects                    1
Max Obs Per Subject        29

```

Number of Observations

```

Number of Observations Read      29
Number of Observations Used      29
Number of Observations Not Used  0

```

Iteration History

```

Iteration      Evaluations      -2 Res Log Like      Criterion
0              1              189.62816349
1              3              188.52486198      0.00001389
2              1              188.52387871      0.00000001
3              1              188.52387787      0.00000000

```

Convergence criteria met.

CovarianceParameter Estimates

| Cov Parm | Estimate | Standard Error | Z | Pr > Z | Alpha | Lower | Upper |
|---------------|----------|----------------|------|---------|-------|---------|---------|
| COMPANY | 11.5096 | 13.1166 | 0.88 | 0.1901 | 0.05 | 2.7832 | 1177.86 |
| COMPANY*treat | 0 | . | . | . | . | . | . |
| Residual | 42.9038 | 14.1942 | 3.02 | 0.0013 | 0.05 | 24.5843 | 93.1732 |

These are the estimates and tests of the random effects. The “company” is the estimate of the random effect of blocking. The “residual” comes from the replicate companies.

Recall that PROC MIXED can test for homogeneity of variance and can fit nonhomogeneous variances if needed (with / GROUP=TREAT added as an option to the random statement. I tested this and found that it was not significant for this example.

The expected mean squares for the random effects are given below. Since this is not balanced with equal replicates in each block the value of the number of replicates (n) would not be an integer value and would not necessarily be the same on each line of the expected mean squares (see GLM EMS below). Power is greatest when the analysis is balanced.

| Source | d.f. | Expected Mean Squares (Random) |
|-------------------|------------------|--|
| Block | $b - 1$ | $\sigma^2 + n\sigma_{\beta\tau}^2 + nt\sigma_{\tau 1}^2$ |
| Treatment | $t - 1$ | $\sigma^2 + n\sigma_{\beta\tau}^2 + Q_{\tau}$ |
| Block x Treatment | $(b - 1)(t - 1)$ | $\sigma^2 + n\sigma_{\beta\tau}^2$ |
| Error | $bt(n - 1)$ | σ^2 |

Fit Statistics

| | |
|--------------------------|-------|
| -2 Res Log Likelihood | 188.5 |
| AIC (smaller is better) | 192.5 |
| AICC (smaller is better) | 193.0 |
| BIC (smaller is better) | 193.1 |

Type 3 Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|--------|-----------|-----------|---------|--------|
| treat | 1 | 9 | 7.72 | 0.0214 |

Least Squares Means

| Effect | treat | Estimate | Standard Error | DF | t Value | Pr > t | Alpha | Lower | Upper |
|--------|-----------|----------|-------------------|----|---------|---------|-------|---------|---------|
| treat | CONTROL | 71.5776 | 1.8514 | 9 | 38.66 | <.0001 | 0.05 | 67.3895 | 75.7657 |
| treat | PYGMALION | 78.7000 | 2.3327 | 9 | 33.74 | <.0001 | 0.05 | 73.4231 | 83.9769 |

Differences of Least Squares Means

| Effect | treat | _treat | Estimate | Standard Error | DF | t Value | Pr > t | Adjustment | Adj P |
|--------|---------|-----------|----------|-------------------|----|---------|---------|--------------|--------|
| treat | CONTROL | PYGMALION | -7.1224 | 2.5626 | 9 | -2.78 | 0.0214 | Tukey-Kramer | 0.0214 |

Differences of Least Squares Means

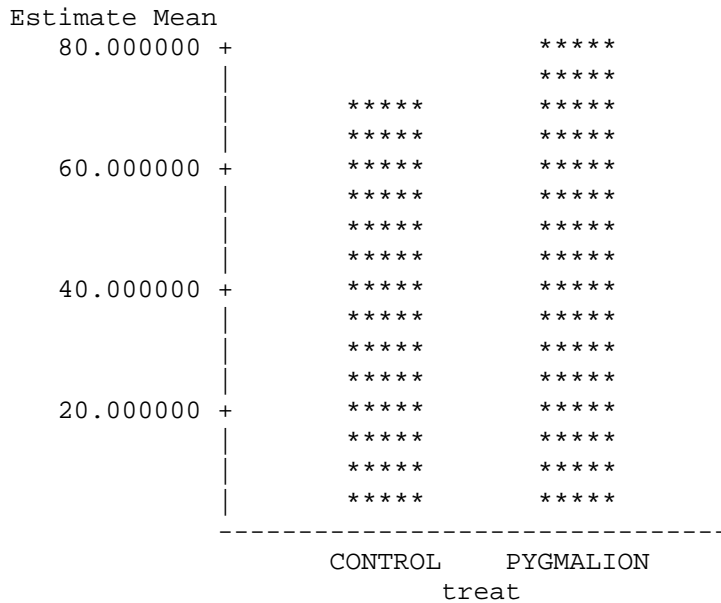
| Effect | treat | _treat | Alpha | Lower | Upper | Adj Lower | Adj Upper |
|--------|---------|-----------|-------|----------|---------|--------------|--------------|
| treat | CONTROL | PYGMALION | 0.05 | -12.9195 | -1.3254 | -12.9193 | -1.3256 |

The estimates above are for the fixed effects. Unadjusted (LSD) tests are provided by default and adjusted (TUKEY) tests when requested.

```

34      options ps=40 ls=99;
35      proc chart data=mmm; vbar treat / type=mean sumvar=estimate; run;
NOTE: The PROCEDURE CHART printed page 3.
NOTE: PROCEDURE CHART used (Total process time):
      real time          0.16 seconds
      cpu time           0.01 seconds
    
```

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```

36      PROC UNIVARIATE DATA=NEXT2 NORMAL PLOT; VAR resid; RUN;
NOTE: The PROCEDURE UNIVARIATE printed pages 4-6.
NOTE: PROCEDURE UNIVARIATE used (Total process time):
      real time          0.18 seconds
      cpu time           0.04 seconds
    
```

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The UNIVARIATE Procedure
 Variable: Resid

| Moments | | | |
|-----------------|------------|------------------|------------|
| N | 29 | Sum Weights | 29 |
| Mean | 0 | Sum Observations | 0 |
| Std Deviation | 5.94652996 | Variance | 35.3612185 |
| Skewness | -0.4620624 | Kurtosis | -1.0780926 |
| Uncorrected SS | 990.114118 | Corrected SS | 990.114118 |
| Coeff Variation | . | Std Error Mean | 1.10424289 |

| Basic Statistical Measures | | | |
|----------------------------|----------|---------------------|----------|
| Location | | Variability | |
| Mean | 0.000000 | Std Deviation | 5.94653 |
| Median | 1.637331 | Variance | 35.36122 |
| Mode | . | Range | 19.17585 |
| | | Interquartile Range | 10.02177 |

Tests for Location: Mu0=0

| Test | -Statistic- | | -----p Value----- |
|-------------|-------------|-----|-------------------|
| Student's t | t | 0 | Pr > t 1.0000 |
| Sign | M | 1.5 | Pr >= M 0.7111 |
| Signed Rank | S | 4.5 | Pr >= S 0.9245 |

Tests for Normality

| Test | --Statistic-- | | -----p Value----- |
|--------------------|---------------|----------|-------------------|
| Shapiro-Wilk | W | 0.912104 | Pr < W 0.0193 |
| Kolmogorov-Smirnov | D | 0.153833 | Pr > D 0.0788 |
| Cramer-von Mises | W-Sq | 0.151146 | Pr > W-Sq 0.0221 |
| Anderson-Darling | A-Sq | 0.949006 | Pr > A-Sq 0.0155 |

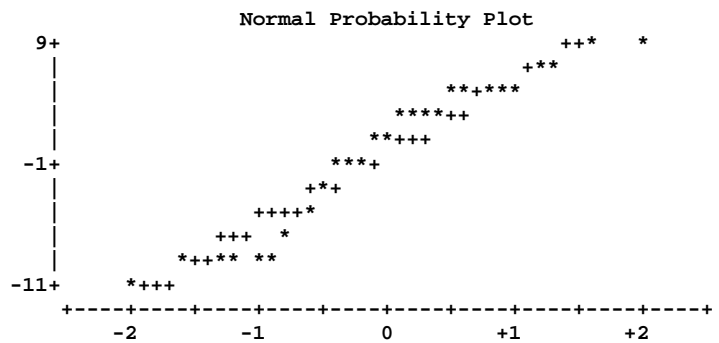
Quantiles (Definition 5)

| Quantile | Estimate |
|------------|-----------|
| 100% Max | 8.93474 |
| 99% | 8.93474 |
| 95% | 8.43361 |
| 90% | 6.41118 |
| 75% Q3 | 4.21231 |
| 50% Median | 1.63733 |
| 25% Q1 | -5.80945 |
| 10% | -9.46526 |
| 5% | -9.47383 |
| 1% | -10.24110 |
| 0% Min | -10.24110 |

Extreme Observations

| -----Lowest----- | | -----Highest----- | |
|------------------|-----|-------------------|-----|
| Value | Obs | Value | Obs |
| -10.24110 | 10 | 5.64860 | 8 |
| -9.47383 | 7 | 6.37323 | 12 |
| -9.46526 | 5 | 6.41118 | 15 |
| -8.66546 | 19 | 8.43361 | 17 |
| -8.35988 | 28 | 8.93474 | 6 |

| Stem Leaf | # | Boxplot |
|-----------|---|---------|
| 8 49 | 2 | |
| 6 44 | 2 | |
| 4 22566 | 5 | +-----+ |
| 2 67028 | 5 | |
| 0 36 | 2 | *-----* |
| -0 0443 | 4 | |
| -2 4 | 1 | |
| -4 8 | 1 | +-----+ |
| -6 0 | 1 | |
| -8 55743 | 5 | |
| -10 2 | 1 | |



```

40      PROC glm DATA=pygmalion; class company treat;
41      Title2 'Randomized block design';
42      MODEL score = treat company treat*company;
43      test H=treat company E=treat*company;
44      random company treat*company;
45      RUN;

```

NOTE: TYPE I EMS not available without the E1 option.

46

NOTE: The PROCEDURE GLM printed pages 5-7.

NOTE: PROCEDURE GLM used (Total process time):

```

      real time          0.14 seconds
      cpu time           0.07 seconds

```

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The GLM Procedure

Class Level Information

| Class | Levels | Values |
|---------|--------|--------------------------------|
| COMPANY | 10 | C1 C10 C2 C3 C4 C5 C6 C7 C8 C9 |
| treat | 2 | CONTROL PYGMALION |

```

Number of Observations Read      29
Number of Observations Used      29

```

Dependent Variable: SCORE

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|----|----------------|-------------|---------|--------|
| Model | 19 | 1321.322322 | 69.543280 | 1.34 | 0.3358 |
| Error | 9 | 467.039883 | 51.893320 | | |
| Corrected Total | 28 | 1788.362205 | | | |

```

R-Square      Coeff Var      Root MSE      SCORE Mean
0.738845      9.725668      7.203702      74.06897

```

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---------------|----|-------------|-------------|---------|--------|
| treat | 1 | 327.3410535 | 327.3410535 | 6.31 | 0.0332 |
| COMPANY | 9 | 682.5172780 | 75.8352531 | 1.46 | 0.2905 |
| COMPANY*treat | 9 | 311.4639907 | 34.6071101 | 0.67 | 0.7221 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---------------|----|-------------|-------------|---------|--------|
| treat | 1 | 301.8426278 | 301.8426278 | 5.82 | 0.0391 |
| COMPANY | 9 | 665.6630817 | 73.9625646 | 1.43 | 0.3030 |
| COMPANY*treat | 9 | 311.4639907 | 34.6071101 | 0.67 | 0.7221 |

Tests of Hypotheses Using the Type III MS for COMPANY*treat as an Error Term

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---------|----|-------------|-------------|---------|--------|
| treat | 1 | 301.8426278 | 301.8426278 | 8.72 | 0.0161 |
| COMPANY | 9 | 665.6630817 | 73.9625646 | 2.14 | 0.1366 |

| Source | Type III Expected Mean Square |
|---------------|--|
| treat | Var(Error) + 1.2903 Var(COMPANY*treat) + Q(treat) |
| COMPANY | Var(Error) + 1.2991 Var(COMPANY*treat) + 2.5983 Var(COMPANY) |
| COMPANY*treat | Var(Error) + 1.2991 Var(COMPANY*treat) |

| | |
|-------|------------|
| Error | Var(Error) |
|-------|------------|