Fall 2010, STAT 430

Repeated Measures Designs
===========================

ssh UserID@umeg.umd.edu, tap sas913, sas
https://www.statlab.umd.edu/sasdoc/sashtml/onldoc.htm

Subjects are measured at every level of a factor. For example, every subjects gets all possible treatments. Previously, every subjects received only one treatment. We'll make this clear in the following.

Ex1. One-Factor Repeated Experiment

Have 2 factors: SUBJECT and DRUG.

Each subjects is given all 4 treatments 1,2,3,4 for pain relief. Then the subject's pain tolerance is measured. Enough time is allowed to pass between treatments to prevent residual effects, and thus guarantee independence between measurements.

Subject	Drug1	Drug2	Drug3	Drug4	
1	5	9	6	11	
2	7	12	8	9	NOTE: ONE OBS/CELL
3	11	12	10	14	
4	3	8	5	8	

```
DATA PAIN;
INPUT SUBJECT DRUG PAIN;
1 1 5
1 2 9
1 3 6
1 4 11
2 1 7
2 2 12
2 3 8
ETC.
```

Better way to read the data using a do loop.

```
OPTION PS=35 LS=70;

DATA PAIN;
INPUT SUBJ @;
DO DRUG=1 TO 4;
INPUT PAIN @;
OUTPUT;
END;
DATALINES;
1  5  9  6  11
2  7 12  8   9
3 11 12 10  14
4  3  8  5   8
;

PROC PRINT DATA=PAIN;
RUN;
```

Obs	SUBJ	DRUG	PAIN
1	1	1	5
2	1	2	9
3	1	3	6
4	1	4	11
5	2	1	7
6	2	2	12
7	2	3	8
8	2	4	9
9	3	1	11
10	3	2	12
11	3	3	10
12	3	4	14
13	4	1	3
14	4	2	8
15	4	3	5
16	4	4	8

Now do 2-way ANOVA with 1 obs/cell (i.e. no interaction).

```
y_ij = mu + a_i + b_j + epsilon_ij

PROC ANOVA DATA=PAIN;
CLASS SUBJ DRUG;
MODEL PAIN=SUBJ DRUG;
MEANS DRUG/SNK;
RUN;
```

The ANOVA Procedure

Class Level Information

Class	Levels	Values
SUBJ	4	1 2 3 4
DRUG	4	1 2 3 4

Number of Observations Read	16
Number of Observations Used	16

Dependent Variable: PAIN

Source	DF	Sum of Squares	Mean Square	F Value
Model	6	120.5000000	20.0833333	13.64
Error	9	13.2500000	1.4722222	
Corrected Total	15	133.7500000		

Source	Pr > F
Model	0.0005
Error	
Corrected Total	

R-Square	Coeff Var	Root MSE	PAIN Mean
0.900935	14.06785	1.213352	8.625000

Source	DF	Anova SS	Mean Square	F Value
SUBJ	3	70.25000000	23.41666667	15.91
DRUG	3	50.25000000	16.75000000	11.38

Source	Pr > F
SUBJ	0.0006
DRUG	0.0020

Therefore DRUG effects are not all zero: The 4 DRUGS not equally effective in treating pain.

NOTE: Denominator df=9 comes from ERROR df in the first table.

Student-Newman-Keuls Test for PAIN

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	9
Error Mean Square	1.472222

Number of Means	2	3	4
Critical Range	1.9407923	2.3954582	2.6784122

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	DRUG
A	10.5000	4	4
A			
A	10.2500	4	2
B	7.2500	4	3
B			
B	6.5000	4	1

We see that DRUGS 4,2 and 3,1 are "same". Assuming a higher mean indicates greater pain, DRUGS 1,3 more effective in treating pain.

Now: Suppose the data were the results of assigning the 4 drugs at random to 16 subjects, then 1-Way ANOVA gives:

```
PROC ANOVA DATA=PAIN;
CLASS SUBJ DRUG;
MODEL PAIN=DRUG;
MEANS DRUG/SNK;
RUN;
```

The ANOVA Procedure

Class Level Information

Class	Levels	Values
SUBJ	4	1 2 3 4
DRUG	4	1 2 3 4

Number of Observations Read	16
Number of Observations Used	16

Dependent Variable: PAIN

Source	DF	Sum of Squares	Mean Square	F Value
Model	3	50.2500000	16.7500000	2.41
Error	12	83.5000000	6.9583333	
Corrected Total	15	133.7500000		

Source	Pr > F
Model	0.1180
Error	
Corrected Total	

R-Square	Coeff Var	Root MSE	PAIN Mean
0.375701	30.58395	2.637865	8.625000

Source	DF	Anova SS	Mean Square	F Value
DRUG	3	50.25000000	16.75000000	2.41

Source	Pr > F
DRUG	0.1180

Student-Newman-Keuls Test for PAIN

NOTE: This test controls the Type I experimentwise error rate under the complete null hypothesis but not under partial null hypotheses.

Alpha	0.05
Error Degrees of Freedom	12
Error Mean Square	6.958333

Number of Means	2	3	4
Critical Range	4.0640501	4.9760399	5.5375686

Means with the same letter are not significantly different.

SNK Grouping	Mean	N	DRUG
A	10.500	4	4
A			
A	10.250	4	2
A			
A	7.250	4	3
A			
A	6.500	4	1

We see: Before with only 4 subjects, the ERROR SS was only 13.25
with df=9, and the drugs effects were significant. But now with 16
subjects, the ERROR SS absorbed the SUBJ SS 70.25 and is equal to
13.25 + 70.25 = 83.5 with df=12, and the drug effects are not significant.

We see: Controlling for between-subject variability reduces the error
SS, and allows us to identify small treatment differences with
relatively fewer subjects.

Now: use REPEATED option

Data must have the form: SUBJ PAIN1 PAIN2 PAIN3 PAIN4,
where PAIN1-PAIN4 are the dependent obs from each drug.
Notice: No DRUG factor.

```
DATA REPEAT1;
INPUT SUBJ PAIN1-PAIN4;
DATALINES;
1  5  9  6  11
2  7 12  8   9
3 11 12 10  14
4  3  8  5   8
;

PROC PRINT DATA=REPEAT1;
ID SUBJ;
RUN;
```

SUBJ	PAIN1	PAIN2	PAIN3	PAIN4
1	5	9	6	11
2	7	12	8	9
3	11	12	10	14
4	3	8	5	8

```
PROC ANOVA DATA=REPEAT1;
MODEL PAIN1-PAIN4 = /NOUNI;<--No univariate analysis for each pain variable.
REPEATED DRUG 4 (1 2 3 4);<--DRUG has 4 levels, labeled 1,2,3,4
RUN;
```

```
                          The SAS System


                       The ANOVA Procedure

              Number of Observations Read           4
              Number of Observations Used           4

               Repeated Measures Analysis of Variance

                Repeated Measures Level Information

      Dependent Variable       PAIN1    PAIN2    PAIN3    PAIN4

           Level of DRUG           1        2        3        4


             MANOVA Test Criteria and Exact F Statistics
                 for the Hypothesis of no DRUG Effect
                    H = Anova SSCP Matrix for DRUG
                        E = Error SSCP Matrix

                        S=1    M=0.5    N=-0.5

Statistic                    Value  F Value  Num DF  Den DF  Pr > F

Wilks' Lambda           0.00909295    36.33       3       1  0.1212
Pillai's Trace          0.99090705    36.33       3       1  0.1212
Hotelling-Lawley Trace  108.97530864    36.33       3       1  0.1212
Roy's Greatest Root     108.97530864    36.33       3       1  0.1212
```

```
                    The ANOVA Procedure
           Repeated Measures Analysis of Variance
     Univariate Tests of Hypotheses for Within Subject Effects

Source                     DF       Anova SS    Mean Square   F Value

DRUG                        3    50.25000000    16.75000000     11.38
Error(DRUG)                 9    13.25000000     1.47222222

                                             Adj Pr > F
          Source                 Pr > F     G - G     H - F

          DRUG                   0.0020    0.0123    0.0020
          Error(DRUG)


                 Greenhouse-Geisser Epsilon    0.5998 <--GG-epsilon
                 Huynh-Feldt Epsilon           1.4433 <--HF-epsilon
```

Note:
The F test for DRUG is identical to the one from 2-Way ANOVA.

The adjusted p-valued G-G (Greenhouse-Geisser correction) and H-F (Huynh-Feldt correction) take into account correlation among the repeated measures and resort to the so called "sphericity assumption" where numerator and denominator degrees of freedom are multiplied by "epsilon", and the significance of the F ratio is evaluated with the new degrees of freedoms. Greenhouse-Geisser correction is more Conservative.

With REPEATED statement, to get pairwise comparisons use: CONTRAST(n).
In our case
DRUG CONTRAST(1) gives comparisons of 1 vs 2,3,4
DRUG CONTRAST(2) gives comparisons of 2 vs 1,3,4
DRUG CONTRAST(3) gives comparisons of 1 vs 2,3,4
This is equivalent to multiple t-tests.

For example:

```
PROC ANOVA DATA=REPEAT1;
MODEL PAIN1-PAIN4 = /NOUNI;
REPEATED DRUG 4 CONTRAST(1)/NOM SUMMARY; <--No Multivariate stats.
RUN;                                        SUMMARY requests ANOVA
```

```
                         The ANOVA Procedure

               Number of Observations Read           4
               Number of Observations Used           4

                         The ANOVA Procedure
                Repeated Measures Analysis of Variance

                 Repeated Measures Level Information

      Dependent Variable       PAIN1    PAIN2    PAIN3    PAIN4

           Level of DRUG           1        2        3        4

                         The ANOVA Procedure
                Repeated Measures Analysis of Variance
      Univariate Tests of Hypotheses for Within Subject Effects

Source                      DF        Anova SS    Mean Square   F Value

DRUG                         3     50.25000000    16.75000000     11.38
Error(DRUG)                  9     13.25000000     1.47222222

                                                Adj Pr > F
          Source                 Pr > F     G - G     H - F

          DRUG                   0.0020    0.0123    0.0020
          Error(DRUG)


                 Greenhouse-Geisser Epsilon    0.5998
                 Huynh-Feldt Epsilon           1.4433
```

```
                    The ANOVA Procedure
          Repeated Measures Analysis of Variance
        Analysis of Variance of Contrast Variables

DRUG_N represents the contrast between the nth level of DRUG and the
1st

Contrast Variable: DRUG_2


Source                      DF        Anova SS    Mean Square   F Value

Mean                         1     56.25000000    56.25000000     15.70
Error                        3     10.75000000     3.58333333

                    Source                 Pr > F

                    Mean                   0.0287 <-- 1 and 2 not "same"
                    Error

NOTE: Apparently SAS is doing matched pair comparison with df=n-1=4-1=3
      which makes sense if "wash-out" period is perceived too short.



Contrast Variable: DRUG_3


Source                      DF        Anova SS    Mean Square   F Value

Mean                         1      2.25000000     2.25000000      1.42
Error                        3      4.75000000     1.58333333

                    Source                 Pr > F

                    Mean                   0.3189 <--1 and 3 are "same"
                    Error
```

```
                     The ANOVA Procedure
           Repeated Measures Analysis of Variance
          Analysis of Variance of Contrast Variables

DRUG_N represents the contrast between the nth level of DRUG and the
1st

Contrast Variable: DRUG_4


Source                    DF        Anova SS    Mean Square   F Value

Mean                       1     64.00000000    64.00000000     19.20
Error                      3     10.00000000     3.33333333

                    Source                Pr > F

                    Mean                  0.0220 <--1 and 4 are not "same"
                   Error

Now PROC MIXED
--------------
The previous analysis assumes the interest focuses on the 4 subjects
only. But if we think of the subjects as being a sample from a large
population of subjects, then we deal with subject random effects.
Many would say this is the best way to analyze our data. We can
judge this by AIC, BIC!!!

DATA PAIN;
INPUT SUBJ @;
DO DRUG=1 TO 4;
INPUT PAIN @;
OUTPUT;
END;
DATALINES;
1  5  9  6  11
2  7 12  8   9
3 11 12 10  14
4  3  8  5   8
;
```

```
PROC MIXED DATA=PAIN;
CLASS SUBJ DRUG;
MODEL PAIN=DRUG;
RANDOM SUBJ; <---Random component. Random effects.
RUN;
QUIT;
```

```
                              The SAS System

                           The Mixed Procedure

                            Model Information

        Data Set                     WORK.PAIN
        Dependent Variable           PAIN
        Covariance Structure         Variance Components
        Estimation Method            REML  <-----@@@@@ The default method.
        Residual Variance Method     Profile
        Fixed Effects SE Method      Model-Based
        Degrees of Freedom Method    Containment


                          Class Level Information

          Class    Levels    Values

          SUBJ          4    1 2 3 4
          DRUG          4    1 2 3 4

                               Dimensions

                 Covariance Parameters            2
                 Columns in X                     5
                 Columns in Z                     4
                 Subjects                         1
                 Max Obs Per Subject             16
```

Number of Observations

Number of Observations Read	16
Number of Observations Used	16
Number of Observations Not Used	0

The Mixed Procedure

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	62.87898203	
1	1	52.54100308	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	
SUBJ	5.4861	<--Subject variance.
Residual	1.4722	<--Resid variance.

Fit Statistics

-2 Res Log Likelihood	52.5
AIC (smaller is better)	56.5
AICC (smaller is better)	57.9
BIC (smaller is better)	55.3

```
                    Type 3 Tests of Fixed Effects

                        Num     Den
            Effect       DF      DF    F Value    Pr > F

            DRUG          3       9      11.38    0.0020 <--Same as brfore
```

If we use fixed effects as in two-way ANOVA as before we get better
AIC and BIC(!!!) as we see next.

```
PROC MIXED DATA=PAIN;
   CLASS SUBJ DRUG;
   MODEL PAIN=SUBJ DRUG;   <--No RANDOM component!!!
   RUN;
   QUIT;
```

```
                         The Mixed Procedure

                          Model Information

        Data Set                     WORK.PAIN
        Dependent Variable           PAIN
        Covariance Structure         Diagonal
        Estimation Method            REML <-----@@@@@
        Residual Variance Method     Profile
        Fixed Effects SE Method      Model-Based
        Degrees of Freedom Method    Residual


                       Class Level Information

          Class    Levels    Values

          SUBJ          4    1 2 3 4
          DRUG          4    1 2 3 4
```

```
                    Dimensions

      Covariance Parameters             1
      Columns in X                      9
      Columns in Z                      0
      Subjects                          1
      Max Obs Per Subject              16


             Covariance Parameter
                   Estimates

             Cov Parm     Estimate

             Residual       1.4722


                Fit Statistics

     -2 Res Log Likelihood          37.3
     AIC (smaller is better)        39.3 <--Smaller
     AICC (smaller is better)       39.9
     BIC (smaller is better)        39.5 <--Smaller


          Type 3 Tests of Fixed Effects

                  Num     Den
 Effect            DF      DF    F Value    Pr > F

 SUBJ               3       9      15.91    0.0006
 DRUG               3       9      11.38    0.0020

NOTE: This ANOVA is identical to 2-Way above.


====================================================================
```

Now compare with NON-RESTRICTED ML:

Recall the mixed effects model from above:

y_{ij}=mu + a_i + beta_j + epsilon_{ij}, i,j=1,2,3,4

```
OPTION PS=35 LS=70;

 DATA PAIN;
 INPUT SUBJ @;
 DO DRUG=1 TO 4;
 INPUT PAIN @;
 OUTPUT;
 END;
 DATALINES;
 1  5  9  6  11
 2  7 12  8   9
 3 11 12 10  14
 4  3  8  5   8
 ;

 PROC MIXED DATA=PAIN METHOD=ML; <--Default is REML.
 CLASS SUBJ DRUG;
 MODEL PAIN=DRUG;
 RANDOM SUBJ;
 RUN;
 QUIT;
```

```
                           The SAS System
                         The Mixed Procedure

                          Model Information

        Data Set                      WORK.PAIN
        Dependent Variable            PAIN
        Covariance Structure          Variance Components
        Estimation Method             ML  (Before it was REML)
        Residual Variance Method      Profile
        Fixed Effects SE Method       Model-Based
```

Degrees of Freedom Method   Containment

Class Level Information

Class	Levels	Values
SUBJ	4	1 2 3 4
DRUG	4	1 2 3 4

Dimensions

Covariance Parameters	2
Columns in X	5
Columns in Z	4
Subjects	1
Max Obs Per Subject	16

The Mixed Procedure
Number of Observations

Number of Observations Read	16
Number of Observations Used	16
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Log Like	Criterion
0	1	71.84215962	
1	1	58.05818768	0.00000000

Convergence criteria met.

Covariance Parameter
Estimates

```
                        Cov Parm     Estimate

                        SUBJ           4.1146 (With REML get 5.4861)
                        Residual       1.1042 (With REML get 1.4722)

                           Fit Statistics

                -2 Log Likelihood                 58.1 (With REML get 52.5)
                AIC (smaller is better)           70.1 (With REML get 56.5)
                AICC (smaller is better)          79.4
                BIC (smaller is better)           66.4


            Type 3 Tests of Fixed Effects

                           Num     Den
    Effect         DF       DF    F Value    Pr > F

    DRUG            3        9      15.17    0.0007 (With REML get 0.002)
=====================================================================
```

```
Ex2. Two-Factor Repeated Experiment:
     Repeated measure on one factor.
--------------------------------------
```

Subjects are randomly assigned to control or treatment group. Then each subject is measured befored (PRE) and after (POST) treatment. The treatment for the conrol group is a placebo or no treatment at all.

```
GROUP     SUBJ    PRE  POST
----------------------------
           1       80   83
Control    2       85   86
           3       83   88
----------------------------   NOTE: Subject nested within group!
           4       82   94
Treatment  5       87   93
```

```
           6      84    98
----------------------------

Method I: Two-Sample t-test applied to the difference scores
          of POST-PRE to compare the difference means of the
          two groups. NOTE: Data assumed normal with equal variance.

For Control  : D1=3,  D2=1, D3=5
For Treatment: D1=12, D2=6, D3=14

H_0: mu_C = mu_T,      H_1: mu_C not equal mu_T


DATA PREPOST;
INPUT SUBJ  GROUP $ PRE POST;
DIFF = POST-PRE;
DATALNES;
1 C 80 83
2 C 85 86
3 C 83 88
4 T 82 94
5 T 87 93
6 T 84 98
;



PROC TTEST DATA=PREPOST;
CLASS GROUP;
VAR DIFF;
RUN;


                            The SAS System


                         The TTEST Procedure

                              Statistics
```

Variable	GROUP	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev
DIFF	C	3	-1.968	3	7.9683	1.0413
DIFF	T	3	0.3244	10.667	21.009	2.1677
DIFF	Diff (1-2)		-15.07	-7.667	-0.263	1.9568

Statistics

Variable	GROUP	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
DIFF	C	2	12.569	1.1547	1	5
DIFF	T	4.1633	26.165	2.4037	6	14
DIFF	Diff (1-2)	3.266	9.385	2.6667		

T-Tests

Variable	Method	Variances	DF	t Value	Pr > |t|
DIFF	Pooled	Equal	4	-2.88	0.0452 <--
DIFF	Satterthwaite	Unequal	2.88	-2.88	0.0671

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
DIFF	Folded F	2	2	4.33	0.3750

```
Check:
-------
Bar(Diff_C) - Bar(Diff_T) = 3-10.667 = -7.667
StdError(Bar(Diff_C) - Bar(Diff_T)) = 2.6667 with 4 df

> -7.667/2.6667
[1] -2.875089 approx -2.88 OK.
```

```
> pt(-2.87508,4)*2
[1] 0.04523655 approx 0.0452 OK.
```

Thus, at alpha=0.05, the treatment mean difference is significantly different from the control mean difference.

Method II: Two-way ANOVA with factors GROUP and TIME, with TIME as a repeated measure.

```
DATA PREPOST;
INPUT SUBJ  GROUP $ PRE POST;
DIFF = POST-PRE;
DATALNES;
1 C 80 83
2 C 85 86
3 C 83 88
4 T 82 94
5 T 87 93
6 T 84 98
;

PROC ANOVA DATA=PREPOST;
CLASS GROUP;
MODEL PRE POST = GROUP/NOUNI;
REPEATD TIME 2 (0 1);
MEANS GROUP;
RUN;
```

```
                         The ANOVA Procedure

                       Class Level Information

                    Class         Levels    Values
                    GROUP              2    C T


               Number of Observations Read          6
               Number of Observations Used          6
```

Repeated Measures Analysis of Variance

Repeated Measures Level Information

Dependent Variable	PRE	POST
Level of TIME	0	1

MANOVA Test Criteria and Exact F Statistics
for the Hypothesis of no TIME Effect
H = Anova SSCP Matrix for TIME
E = Error SSCP Matrix

S=1 M=-0.5 N=1

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.13216314	26.27	1	4	0.0069
Pillai's Trace	0.86783686	26.27	1	4	0.0069
Hotelling-Lawley Trace	6.56640625	26.27	1	4	0.0069
Roy's Greatest Root	6.56640625	26.27	1	4	0.0069

The ANOVA Procedure
Repeated Measures Analysis of Variance

MANOVA Test Criteria and Exact F Statistics
for the Hypothesis of no TIME*GROUP Effect
H = Anova SSCP Matrix for TIME*GROUP
E = Error SSCP Matrix

S=1 M=-0.5 N=1

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.32611465	8.27	1	4	0.0452
Pillai's Trace	0.67388535	8.27	1	4	0.0452

```
Hotelling-Lawley Trace    2.06640625     8.27        1        4  0.0452
Roy's Greatest Root       2.06640625     8.27        1        4  0.0452


                         The ANOVA Procedure
                Repeated Measures Analysis of Variance
           Tests of Hypotheses for Between Subjects Effects

Source                     DF        Anova SS    Mean Square   F Value

GROUP                       1     90.75000000    90.75000000     11.84
Error                       4     30.66666667     7.66666667

                    Source                 Pr > F

                    GROUP                  0.0263 <---Groups are different.
                    Error

                         The ANOVA Procedure
                Repeated Measures Analysis of Variance
      Univariate Tests of Hypotheses for Within Subject Effects

Source                     DF        Anova SS    Mean Square   F Value

TIME                        1     140.0833333    140.0833333     26.27
TIME*GROUP                  1      44.0833333     44.0833333      8.27
Error(TIME)                 4      21.3333333      5.3333333

                    Source                 Pr > F

                    TIME                   0.0069
                    TIME*GROUP             0.0452<--Interaction significant
                    Error(TIME)

                         The ANOVA Procedure

 Level of     ------------PRE-----------  -----------POST-----------
 GROUP     N          Mean       Std Dev          Mean       Std Dev


 C         3    82.6666667    2.51661148    85.6666667    2.51661148
```

```
 T         3    84.3333333    2.51661148    95.0000000    2.64575131
```

Interesting to compare with simple TWO-WAY ANOVA with GROUP at 2 levels and TIME at 2 levels as factors, and 3 obs/cell.

```
DATA PREPOST;
INPUT GROUP $ TIME $ Y @@;
DATALNES;
C PRE 80 C POST 83
C PRE 85 C POST 86
C PRE 83 C POST 88
T PRE 82 T POST 94
T PRE 87 T POST 93
T PRE 84 T POST 98
;

PROC ANOVA DATA=PREPOST;
CLASS GROUP TIME;
MODEL Y = GROUP TIME GROUP*TIME;
RUN;
```

```
                          The ANOVA Procedure

                        Class Level Information

                  Class         Levels    Values

                  GROUP              2    C T
                  TIME               2    POST PRE

               Number of Observations Read          12
               Number of Observations Used          12


Dependent Variable: Y

                                         Sum of
Source                      DF          Squares    Mean Square   F Value
```

```
Model                  1+1+1=3    274.9166667     91.6388889     14.10
Error               2*2*(3-1)=8    52.0000000      6.5000000
Corrected Total        12-1=11    326.9166667

                    Source                  Pr > F

                    Model                   0.0015
                    Error
                    Corrected Total


          R-Square     Coeff Var      Root MSE        Y Mean

          0.840938      2.933281      2.549510      86.91667


Source                       DF        Anova SS    Mean Square   F Value

GROUP                         1      90.7500000     90.7500000     13.96
TIME                          1     140.0833333    140.0833333     21.55

                    Source                  Pr > F

                    GROUP                   0.0057 <--Sig
                    TIME                    0.0017 <--Sig


Dependent Variable: Y

Source                       DF        Anova SS    Mean Square   F Value

GROUP*TIME        (2-1)(2-1)=1      44.0833333     44.0833333      6.78

                    Source                  Pr > F

                    GROUP*TIME              0.0314 <--Sig
```