STAT 741, March, 2008: Mixed Models With SAS

$$y_{ijk} = \mu + a_i + \beta_j + \epsilon_{ijk}, \quad i = 1, ..., 7, \quad j = 1, ..., 10$$

```
Start with a simple case without covariates of two factors
Subject (7 levels),  Movement (10 levels),
y1,....,y20, (sample size in each cell is 20), as follows:

S1 M1 y1
....
.....
S1 M1 Y20
----------
S1 M2 y1
...
...
S1 M2 y20
------------
.......
......
------------
S1 M10 y1
....
....
S1 M10 y20

==============
S2 M1 y1
....
.....
S2 M1 Y20
----------
S2 M2 y1
...
...
S2 M2 y20
------------
.......
......
```

```
------------
S2 M10 y1
....
....
S2 M10 y20

Repeat for remaining subjects S3,...,S7



Note: Used numerals 1,2,3,4,5,6,7 to denote subjects
      Used numerals 1,2,3,4,5,6,7,8,9,10 to denote movements

So must declare these as factors or characters!!!
In SAS use CLASS!!!

The data in LMM.dat1 = LMMDAT1 have the form (the first col is index!!!):


    S  M y
1   1  1 3.7   Subject 1 Movement 1
2   1  1 7.3
3   1  1 2.7
4   1  1 5.5
............
............
15  7 10 -5.3  Subject 7 Movement 10
16  7 10 -3.6
17  7 10 -3.2
18  7 10 -5.4
19  7 10 -5.9
20  7 10  2.7

-----------------------------------------------------------------
See: http://www.uky.edu/ComputingCenter/SSTARS/mixed1.htm#proc4
     http://cc.uoregon.edu/cnews/summer2004/procmixed.htm

The PROC MIXED syntax is similar to the syntax of PROC GLM. There are,
however, a few important differences. The random effects and repeated
statements are used differently, random effects are not listed in the
```

model statement, GLM has MEANS and LSMEANS statements, whereas MIXED has only the LSMEANS statement, GLM offers Type I, II, III and IV tests for fixed effects, while MIXED offers TYPE I and TYPE III. The following is a general form of PROC MIXED statement:

```
PROC MIXED options;
CLASS variable-list;
MODEL dependent=fixed effects/ options;
RANDOM random effects / options;
REPEATED repeated effects / options;
CONTRAST 'label' fixed-effect values | random-effect values/ options;
ESTIMATE 'label' fixed-effect values | random-effect values/ options;
LSMEANS fixed-effects / options;
MAKE 'table' OUT= SAS-data-set < options >;
RUN;
```

```
Proc mixed data=one method=reml covtest;
Class gender treat subject;
Model y=gender treat gender*treat /ddfm=satterth;
Random subject(gender);
Run;
```

```
xhost wam,  ssh bnk@wam.umd.edu, tap, tap sas913, sas
                                          sas82
-------------------------------------------------
METHOD: REML

OPTION PS=45 LS=70;

DATA MIX1;
INFILE '/homes/bnk/LMMDAT1/';
INPUT INDEX SUBJECT $ MOVEMENT $ GAZE;
RUN;
```

```
PROC MIXED DATA=MIX1 method=reml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = MOVEMENT / solution  HTYPE=3;
 RANDOM SUBJECT;
 RUN;
```

Note: If we dont include the option "solution" we do not get inference about fixed effects, only about random effects.

The Mixed Procedure

Model Information

Data Set	WORK.MIX1
Dependent Variable	GAZE
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
SUBJECT	7	1 2 3 4 5 6 7
MOVEMENT	10	1 10 2 3 4 5 6 7 8 9

Dimensions

Covariance Parameters	2
Columns in X (10+intercept!!!)	11
Columns in Z	7
Subjects	1
Max Obs Per Subject	1400
Observations Used	1400
Observations Not Used	0
Total Observations	1400

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	8271.81489187	
1	1	7806.44364795	0.00000000

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
SUBJECT	7.5068	4.3780	1.71	0.0432
Residual	15.2237	0.5787	26.31	<.0001

Fit Statistics

-2 Res Log Likelihood	7806.4
AIC (smaller is better)	7810.4<-- 2*(Cov Parm)=4
AICC (smaller is better)	7810.5
BIC (smaller is better)	7810.3

Solution for Fixed Effects

Effect	MOVEMENT	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		-3.7221	1.0868	6	-3.42	0.0141
MOVEMENT	1	0.5543	0.4663	1384	1.19	0.2348
MOVEMENT	10	-0.5021	0.4663	1384	-1.08	0.2818
MOVEMENT	2	0.6343	0.4663	1384	1.36	0.1740
MOVEMENT	3	0.9371	0.4663	1384	2.01	0.0447
MOVEMENT	4	1.5271	0.4663	1384	3.27	0.0011
MOVEMENT	5	0.1971	0.4663	1384	0.42	0.6726
MOVEMENT	6	2.1400	0.4663	1384	4.59	<.0001
MOVEMENT	7	1.1679	0.4663	1384	2.50	0.0124
MOVEMENT	8	0.7129	0.4663	1384	1.53	0.1266
MOVEMENT	9	0	.	.	.	.

Note: If we only include option HTYPE=3 but not option "solution",
we get:

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Den <-- Numerator and Denominator DF's Pr > F
MOVEMENT	9	1384	5.35	<.0001

Assume next there are no Random effects: Only Fixed effects

```
PROC MIXED DATA=MIX1 method=reml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = SUBJECT MOVEMENT / solution HTYPE=3;
 RUN;
```

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Residual	15.2237	0.5787	26.31	<.0001

The Mixed Procedure

Fit Statistics

-2 Res Log Likelihood	7775.3
AIC (smaller is better)	7777.3
AICC (smaller is better)	7777.3
BIC (smaller is better)	7782.5

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Estimate	Standard Error	DF	t Value
Intercept			-1.1189	0.4171	1384	-2.68
SUBJECT	1		1.2840	0.3902	1384	3.29
SUBJECT	2		-2.3230	0.3902	1384	-5.95
SUBJECT	3		-3.5500	0.3902	1384	-9.10
SUBJECT	4		-6.5150	0.3902	1384	-16.70
SUBJECT	5		-1.9005	0.3902	1384	-4.87
SUBJECT	6		-5.2185	0.3902	1384	-13.37
SUBJECT	7		0	.	.	.
MOVEMENT		1	0.5543	0.4663	1384	1.19

MOVEMENT	10	-0.5021	0.4663	1384	-1.08

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Pr > |t|
Intercept			0.0074
SUBJECT	1		0.0010
SUBJECT	2		<.0001
SUBJECT	3		<.0001
SUBJECT	4		<.0001
SUBJECT	5		<.0001
SUBJECT	6		<.0001
SUBJECT	7		.
MOVEMENT		1	0.2348
MOVEMENT		10	0.2818

Effect	SUBJECT	MOVEMENT	Estimate	Standard Error	DF	t Value
MOVEMENT		2	0.6343	0.4663	1384	1.36
MOVEMENT		3	0.9371	0.4663	1384	2.01
MOVEMENT		4	1.5271	0.4663	1384	3.27
MOVEMENT		5	0.1971	0.4663	1384	0.42
MOVEMENT		6	2.1400	0.4663	1384	4.59
MOVEMENT		7	1.1679	0.4663	1384	2.50
MOVEMENT		8	0.7129	0.4663	1384	1.53
MOVEMENT		9	0	.	.	.

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Pr > |t|
MOVEMENT		2	0.1740
MOVEMENT		3	0.0447
MOVEMENT		4	0.0011

MOVEMENT	5	0.6726
MOVEMENT	6	<.0001
MOVEMENT	7	0.0124
MOVEMENT	8	0.1266
MOVEMENT	9	.

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
SUBJECT	6	1384	99.62	<.0001
MOVEMENT	9	1384	5.35	<.0001

==========

METHOD: MLE

```
 OPTION PS=45 LS=70;

 DATA MIX1;
 INFILE '/homes/bnk/LMMDAT1/';
 INPUT INDEX SUBJECT $ MOVEMENT $ GAZE;
 RUN;

 PROC MIXED DATA=MIX1 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = MOVEMENT / solution  HTYPE=3;
 RANDOM SUBJECT;
 RUN;

 PROC MIXED DATA=MIX1 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = MOVEMENT / solution  outp=res HTYPE=3;   <-- To get residuals.
 RANDOM SUBJECT;
 RUN;
```

The Mixed Procedure

Model Information

Data Set	WORK.MIX1
Dependent Variable	GAZE
Covariance Structure	Variance Components
Estimation Method	ML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
SUBJECT	7	1 2 3 4 5 6 7
MOVEMENT	10	1 10 2 3 4 5 6 7 8 9

Dimensions

Covariance Parameters	2
Columns in X	11
Columns in Z	7
Subjects	1
Max Obs Per Subject	1400
Observations Used	1400
Observations Not Used	0
Total Observations	1400

Iteration History

Iteration	Evaluations	-2 Log Like	Criterion
0	1	8271.51652818	
1	1	7807.12766355	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
SUBJECT	6.4240	3.4742	1.85	0.0322
Residual	15.1254	0.5731	26.39	<.0001

Fit Statistics

-2 Log Likelihood	7807.1	
AIC (smaller is better)	7831.1	(p=12 !!!)
AICC (smaller is better)	7831.4	
BIC (smaller is better)	7830.5	

Solution for Fixed Effects

Effect	MOVEMENT	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		-3.7221	1.0128	6	-3.68	0.0104
MOVEMENT	1	0.5543	0.4648	1384	1.19	0.2333
MOVEMENT	10	-0.5021	0.4648	1384	-1.08	0.2802
MOVEMENT	2	0.6343	0.4648	1384	1.36	0.1726
MOVEMENT	3	0.9371	0.4648	1384	2.02	0.0440
MOVEMENT	4	1.5271	0.4648	1384	3.29	0.0010
MOVEMENT	5	0.1971	0.4648	1384	0.42	0.6716
MOVEMENT	6	2.1400	0.4648	1384	4.60	<.0001
MOVEMENT	7	1.1679	0.4648	1384	2.51	0.0121

MOVEMENT	8	0.7129	0.4648	1384	1.53	0.1254
MOVEMENT	9	0	.	.	.	.

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
MOVEMENT	9	1384	5.38	<.0001

To get the 1400 residuals:

```
PROC PRINT DATA=RES;
 RUN;
```

Obs	INDEX	SUBJECT	MOVEMENT	GAZE	Predicted	Std Error Predicted	DF	Alpha	Lower	Upper	Residual
1	1	1	1	3.7	0.67420	0.41486	1384	0.05	-0.13962	1.48802	3.02580
2	2	1	1	7.3	0.67420	0.41486	1384	0.05	-0.13962	1.48802	6.62580
3	3	1	1	2.7	0.67420	0.41486	1384	0.05	-0.13962	1.48802	2.02580
4	4	1	1	5.5	0.67420	0.41486	1384	0.05	-0.13962	1.48802	4.82580
5	5	1	1	3.3	0.67420	0.41486	1384	0.05	-0.13962	1.48802	2.62580
6	6	1	1	9.2	0.67420	0.41486	1384	0.05	-0.13962	1.48802	8.52580
7	7	1	1	2.8	0.67420	0.41486	1384	0.05	-0.13962	1.48802	2.12580
8	8	1	1	3.2	0.67420	0.41486	1384	0.05	-0.13962	1.48802	2.52580
9	9	1	1	2.5	0.67420	0.41486	1384	0.05	-0.13962	1.48802	1.82580
10	10	1	1	2.9	0.67420	0.41486	1384	0.05	-0.13962	1.48802	2.22580
11	11	1	1	4.6	0.67420	0.41486	1384	0.05	-0.13962	1.48802	3.92580
12	12	1	1	2.0	0.67420	0.41486	1384	0.05	-0.13962	1.48802	1.32580

```
   13 13 1 1 4.3 0.67420 0.41486 1384 0.05 -0.13962 1.48802  3.62580
   14 14 1 1 1.5 0.67420 0.41486 1384 0.05 -0.13962 1.48802  0.82580
   15 15 1 1 0.3 0.67420 0.41486 1384 0.05 -0.13962 1.48802 -0.37420
   16 16 1 1 5.4 0.67420 0.41486 1384 0.05 -0.13962 1.48802  4.72580
   17 17 1 1 2.1 0.67420 0.41486 1384 0.05 -0.13962 1.48802  1.42580
   18 18 1 1 1.4 0.67420 0.41486 1384 0.05 -0.13962 1.48802  0.72580
.....................................................
.....................................................
```

Obs	INDEX	SUBJECT	MOVEMENT	GAZE	Pred	Pred
1395	15	7	10	-5.3	-1.65129	0.41486
1396	16	7	10	-3.6	-1.65129	0.41486
1397	17	7	10	-3.2	-1.65129	0.41486
1398	18	7	10	-5.4	-1.65129	0.41486
1399	19	7	10	-5.9	-1.65129	0.41486
1400	20	7	10	2.7	-1.65129	0.41486

Obs	DF	Alpha	Lower	Upper	Resid
1395	1384	0.05	-2.46511	-0.83747	-3.64871
1396	1384	0.05	-2.46511	-0.83747	-1.94871
1397	1384	0.05	-2.46511	-0.83747	-1.54871
1398	1384	0.05	-2.46511	-0.83747	-3.74871
1399	1384	0.05	-2.46511	-0.83747	-4.24871
1400	1384	0.05	-2.46511	-0.83747	4.35129

```
PROC UNIVARIATE DATA=RES NORMAL PLOT;
VAR RESID;
qqplot  resid; <---Gives a nice qqplot
RUN;
```

The UNIVARIATE Procedure
Variable: Resid

Moments

N	1400	Sum Weights	1400
Mean	0	Sum Observations	0
Std Deviation	3.88078755	Variance	15.060512
Skewness	-0.2457047	Kurtosis	0.2989837
Uncorrected SS	21069.6563	Corrected SS	21069.6563
Coeff Variation	.	Std Error Mean	0.10371841

Basic Statistical Measures

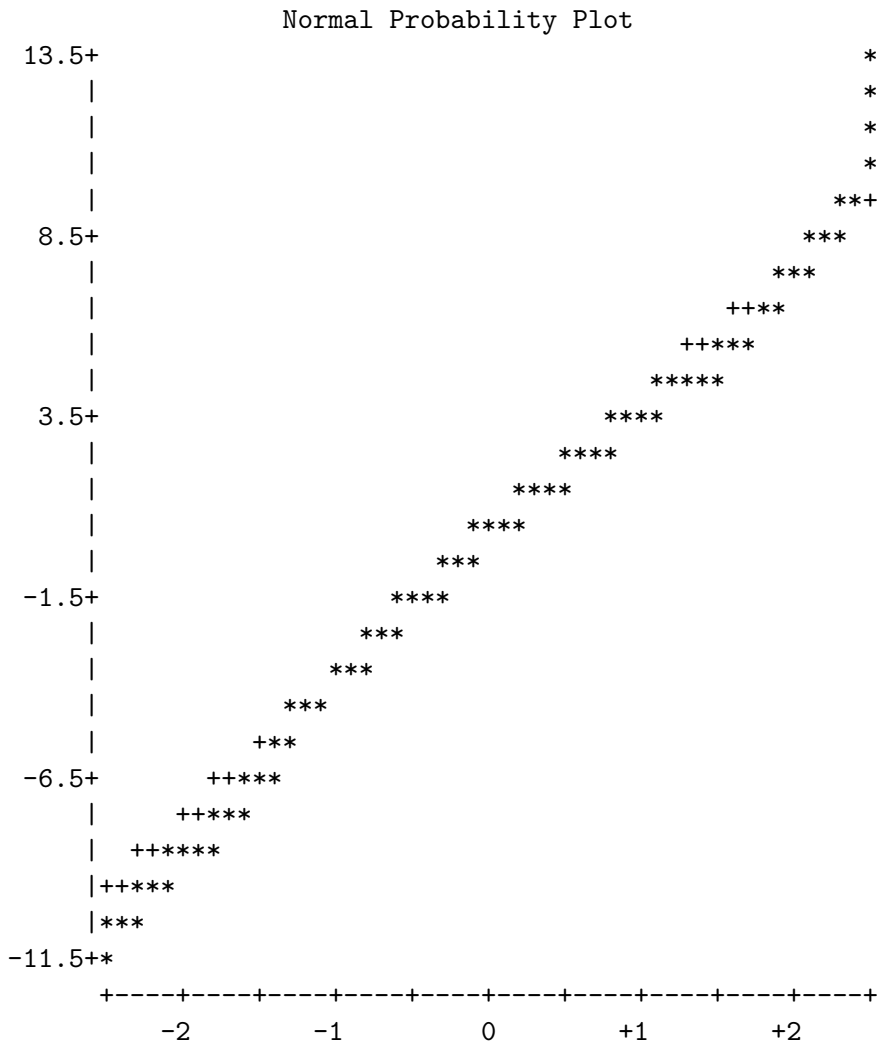
Location		Variability	
Mean	0.00000	Std Deviation	3.88079
Median	0.35000	Variance	15.06051
Mode	-2.93300	Range	25.15907
		Interquartile Range	5.07757

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	0	Pr > |t|	1.0000

Sign	M	47	Pr >= |M|	0.0129
Signed Rank	S	18628.5	Pr >= |S|	0.2184

```
                 Histogram                      #         Boxplot
 13.5+*                                         1            0
     .*                                         2            0
     .*                                         1            0
     .**                                        6            0
     .*                                         4            |
  8.5+****                                     13            |
     .***                                      11            |
     .*****                                    18            |
     .*********                                34            |
     .************************                 95            |
  3.5+*******************************         117            |
     .************************************    144         +-----+
     .****************************************159         |     |
     .************************************    142         *--+--*
     .***********************************     136         |     |
 -1.5+*******************************          125         |     |
     .************************               102         +-----+
     .*********************                     84            |
     .*****************                         65            |
     .*********                                35            |
 -6.5+*********                                33            |
     .******                                   23            |
     .*******                                  26            |
     .***                                      10            |
     .**                                        8            0
-11.5+**                                        6            0
      ----+----+----+----+----+----+----+----+
      * may represent up to 4 counts
```


Normal Probability Plot
13.5+
8.5+
3.5+
-1.5+
-6.5+
-11.5+
-2
-1
0
+1
+2

http://listserv.uga.edu/cgi-bin/wa?A2=ind0502a&L=sas-l&T=0&P=17453

Only fixed effects:

```
 PROC MIXED DATA=MIX1 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = SUBJECT MOVEMENT / solution  outp=res HTYPE=3;
 RUN;
```

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Residual	15.0498	0.5688	26.46	<.0001

Fit Statistics

-2 Log Likelihood	7768.9	
AIC (smaller is better)	7802.9	(p=17!!!)
AICC (smaller is better)	7803.4	
BIC (smaller is better)	7892.1	

NOTE: AIC from the mixed effects model was 7831.1.

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Estimate	Standard Error	DF	t Value
Intercept			-1.1189	0.4147	1384	-2.70
SUBJECT	1		1.2840	0.3879	1384	3.31
SUBJECT	2		-2.3230	0.3879	1384	-5.99
SUBJECT	3		-3.5500	0.3879	1384	-9.15
SUBJECT	4		-6.5150	0.3879	1384	-16.79
SUBJECT	5		-1.9005	0.3879	1384	-4.90

SUBJECT	6		-5.2185	0.3879	1384	-13.45
SUBJECT	7		0	.	.	.
MOVEMENT		1	0.5543	0.4637	1384	1.20
MOVEMENT		10	-0.5021	0.4637	1384	-1.08

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Pr > |t|
Intercept			0.0071
SUBJECT	1		0.0010
SUBJECT	2		<.0001
SUBJECT	3		<.0001
SUBJECT	4		<.0001
SUBJECT	5		<.0001
SUBJECT	6		<.0001
SUBJECT	7		.
MOVEMENT		1	0.2321
MOVEMENT		10	0.2790

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Estimate	Standard Error	DF	t Value
MOVEMENT		2	0.6343	0.4637	1384	1.37
MOVEMENT		3	0.9371	0.4637	1384	2.02
MOVEMENT		4	1.5271	0.4637	1384	3.29
MOVEMENT		5	0.1971	0.4637	1384	0.43
MOVEMENT		6	2.1400	0.4637	1384	4.62
MOVEMENT		7	1.1679	0.4637	1384	2.52
MOVEMENT		8	0.7129	0.4637	1384	1.54
MOVEMENT		9	0	.	.	.

Solution for Fixed Effects

Effect	SUBJECT	MOVEMENT	Pr > |t|

MOVEMENT	2	0.1716
MOVEMENT	3	0.0435
MOVEMENT	4	0.0010
MOVEMENT	5	0.6708
MOVEMENT	6	<.0001
MOVEMENT	7	0.0119
MOVEMENT	8	0.1244
MOVEMENT	9	.

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
SUBJECT	6	1384	100.77	<.0001
MOVEMENT	9	1384	5.41	<.0001

Summary ML Method :

Model		p	AIC
Mixed	y=mu+a+beta+epsilon	12	7831.1
Fixed	y=mu+alpha+beta+epsilon	17	7802.9

==========

METHOD: MLE

```
 OPTION PS=45 LS=70;

20  7 10 -7.0 -9.571 -2.650 2.087

 DATA MIX2;
 INFILE '/homes/bnk/LMMDAT2/';
 INPUT INDEX SUBJECT $ MOVEMENT $ GAZE WRIST ELBOW SHOULDER;
 RUN;
```

```
Mixed effects model:
y = mu + a_i + beta_j + beta1*wr + epsilon  (p=13)

 PROC MIXED DATA=MIX2  method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = MOVEMENT WRIST/ solution  outp=res  HTYPE=3; <- Get resids.
 RANDOM SUBJECT;
 RUN;
```


The Mixed Procedure

Model Information

Data Set	WORK.MIX2
Dependent Variable	GAZE
Covariance Structure	Variance Components
Estimation Method	ML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
SUBJECT	7	1 2 3 4 5 6 7
MOVEMENT	10	1 10 2 3 4 5 6 7 8 9

Dimensions

Covariance Parameters	2
Columns in X	12

Columns in Z	7
Subjects	1
Max Obs Per Subject	1400
Observations Used	1400
Observations Not Used	0
Total Observations	1400

Iteration History

Iteration	Evaluations	-2 Log Like	Criterion
0	1	7953.05847449	
1	2	7239.03156696	0.00000000

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
SUBJECT	7.1104	3.8275	1.86	0.0316
Residual	10.0550	0.3810	26.39	<.0001

Fit Statistics

-2 Log Likelihood	7239.0
AIC (smaller is better)	7265.0 (p=13)
AICC (smaller is better)	7265.3
BIC (smaller is better)	7264.3

Solution for Fixed Effects

Effect	MOVEMENT	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		-1.1476	1.0467	6	-1.10	0.3149
MOVEMENT	1	2.1069	0.3854	1383	5.47	<.0001
MOVEMENT	10	0.4819	0.3794	1383	1.27	0.2042
MOVEMENT	2	2.3988	0.3802	1383	6.31	<.0001

MOVEMENT	3	1.6596	0.3791	1383	4.38	<.0001
MOVEMENT	4	2.1827	0.3792	1383	5.76	<.0001
MOVEMENT	5	2.1163	0.3813	1383	5.55	<.0001
MOVEMENT	6	2.0134	0.3795	1383	5.30	<.0001
MOVEMENT	7	1.9238	0.3790	1383	5.08	<.0001
MOVEMENT	8	1.1079	0.3790	1383	2.92	0.0035
MOVEMENT	9	0	.	.	.	.
WRIST		0.5249	0.01750	1383	29.99	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
MOVEMENT	9	1383	8.89	<.0001
WRIST	1	1383	899.11	<.0001

Fixed effects only:

y = mu + alpha_i + beta_j + beta1*wr + beta2*el + beta3*sh + epsilon

```
 PROC MIXED DATA=MIX2 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE =SUBJECT  MOVEMENT WRIST ELBOW SHOULDER/ solution  outp=res;
 RUN;
```

TWO-WAY MIXED MODEL: Subject+Movement+Covariates

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Residual	9.3184	0.3522	26.46	<.0001

Fit Statistics

-2 Log Likelihood	7097.8
AIC (smaller is better)	7137.8 (p=20)
AICC (smaller is better)	7138.4
BIC (smaller is better)	7242.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
SUBJECT	6	1381	183.58	<.0001
MOVEMENT	9	1381	7.34	<.0001
WRIST	1	1381	372.16	<.0001
ELBOW	1	1381	41.33	<.0001
SHOULDER	1	1381	5.52	0.0189

Mixed effects :
y = mu + a_i + beta_j + beta1*wr + beta2*el + beta3*sh + epsilon

```
 PROC MIXED DATA=MIX2 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE =MOVEMENT WRIST ELBOW SHOULDER/ solution outp=res;
 RANDOM SUBJECT;
 RUN;
```

Fit Statistics

-2 Log Likelihood	7140.2
AIC (smaller is better)	7170.2
AICC (smaller is better)	7170.6
BIC (smaller is better)	7169.4

Fixed effects : Simple regression on Wr, El, Sh
y = mu + beta1*wr + beta2*el + beta3*sh + epsilon

```
 PROC MIXED DATA=MIX2 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE =WRIST ELBOW SHOULDER/ solution outp=res;
 RUN;
```

TWO-WAY MIXED MODEL: Subject+Movement+Covariates 12
13:40 Sunday, April 15, 2007

The Mixed Procedure

Fit Statistics

-2 Log Likelihood	7944.7
AIC (smaller is better)	7954.7 (p=5)
AICC (smaller is better)	7954.7
BIC (smaller is better)	7980.9

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	-0.2265	0.5064	1396	-0.45	0.6547
WRIST	0.3905	0.02659	1396	14.68	<.0001
ELBOW	0.5097	0.06859	1396	7.43	<.0001
SHOULDER	0.2980	0.1933	1396	1.54	0.1234

Random effects only
Mixed effects :
y = mu + a_i + b_j + b1*wr + b2*el + b3*sh + epsilon

```
 PROC MIXED DATA=MIX2 method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE =/ solution outp=res;
 RANDOM SUBJECT MOVEMENT WRIST ELBOW SHOULDER ;
```

```
 RUN;
```

Fit Statistics

-2 Log Likelihood	7185.1
AIC (smaller is better)	7199.1 (p=7)
AICC (smaller is better)	7199.2
BIC (smaller is better)	7198.7

```
Now: Unbalanced cell data. Use ML, INFILE '/homes/bnk/LMMDAT3/'

199  7  5  -1.6 -10.284 -2.141 3.134

OPTION PS=45 LS=70;

 DATA MIX3;
 INFILE '/homes/bnk/LMMDAT3/';
 INPUT INDEX SUBJECT $ MOVEMENT $ GAZE WRIST ELBOW SHOULDER;
 RUN;

Mixed effects model:
y = mu + a_i + beta_j + beta1*wr + epsilon  (p=13)

 PROC MIXED DATA=MIX3  method=ml covtest;
 TITLE 'TWO-WAY MIXED MODEL: Subject+Movement+Covariates';
 CLASS SUBJECT MOVEMENT;
 MODEL GAZE = MOVEMENT WRIST/ solution  outp=res  HTYPE=3; <- Get resids.
 RANDOM SUBJECT;
 RUN;
```

Balanced: 20 x-GAZE obs in each subject*movement cell
Unbalanced: About 20 x-GAZE obs in each subject*movement cell

Type	Model	p	Balanced 20 x-GAZE/Cell AIC	2nd	Unbalanced About 20/cell AIC
Mixed	y=mu+a+beta+epsilon	12	7831.1,7956.7		7875.9
Fixed	y=mu+alpha+beta+epsilon	17	7802.9,7928.5		7848.7
Mixed	y=mu+ a + beta + beta1*wr + epsilon	13	7265.0		7183.7
Mixed	y=mu+ a + beta + beta1*wr + beta2*el + beta3*sh + epsilon	15	7170.2		7077.1
Fixed	y=mu+ alpha + beta + beta1*wr + beta2*el + beta3*sh + epsilon	20	7137.8		7045.2
Fixed Simple regress	y = mu + beta1*wr + beta2*el + beta3*sh + epsilon	5	7954.7		7834.4
Random only	y = mu + a + b + b1*wr + b2*el + b3*sh + epsilon	7	7199.1		7104.5

Summury: MLE, 50/cell

Add Sigma Sqr = Var(Epsilon) as an estimated parameter.
Second AIC is from Ritaja. Very close even though she used
different sapled data.

Model	Random	Fixed	p	AIC	BIC
1	eps	mu,alpha,beta	17	19607.0	19711.7
Fixed efects: y=mu+alpha+beta+epsilon					
2	eps,a	mu,beta	12	19641.1	19640.5
			Ritaja--->	19645.7	
Mixed effects y=mu+a+beta+epsilon					
3	eps,a	mu,beta,beta1	13	17767.9	17767.2
y = mu + a + beta + beta1*wr + epsilon					
4	eps	mu,alpha,beta beta1,beta2,beta3	20	17429.8	17553.0
			Ritaja--->	17380.2	
Only fixed effects: y = mu + alpha+ beta+ beta1*wr + beta2*el + beta3*sh + epsilon					
5	eps,a	mu,beta, beta1,beta2,beta3	15	17468.3	17467.5
			Ritaja--->	17419.1	
Only subject random: y = mu + a + beta+ beta1*wr + beta2*el + beta3*sh + epsilon					

```
6        eps         mu,beta1,beta2,beta3  5   19510.3   19541.1

Fixed: Simple regression
y = mu + beta1*wr +
    beta2*el + beta3*sh +
      epsilon
-------------------------------------------------------------------
7    eps,a,b         mu
     b1,b2,b3                              7   17515.2   17514.9

All random except intercept:
y = mu  + a + b + b1*wr +
    b2*el + b3*sh + epsilon
-------------------------------------------------------------------
8    eps,a,b    mu,beta1,beta2,beta        7   17496.0   17495.6

Subject and movement random:
y = mu + a+b+ beta1*wr + beta2*el +
    beta3*sh + epsilon

-------------------------------------------------------------------
```