Repeated Measures on tube data with proc mixed

```
/* uvtuberead.sas */
options linesize=79 pagesize=100 noovp formdlim='_';
title "Kohn's Fungus Tube data: Univariate Read";
/* Data definition file -- Use with %include */

data uvmould;
     infile 'tubes.dat';
     input line  mcg   replic  day  amlng  amscl  amlead  pmlng  pmscl  pmlead;
     length = (amlng+pmlng)/2;
     label mcg = 'Mycelial Compatibility Group';
     /* If there are no sclerotia, number is missing. Make zero. */
     if amscl=. then amscl=0; if pmscl=. then pmscl=0;
     tube = 1000*replic + mcg; /* Yields unique 4-digit identification code */

data first11; /* First 11 days */
     set uvmould;
     if day < 12; /* Eliminate other cases */

/********** Commented out ********************
proc freq;
     title2 'First 11 days only';
     tables mcg day replic tube;
proc means n mean std;
     title2 'First 11 days only';
     var length pmscl;
*****************************************/
```

```
/********************** tuberepeat2.sas *****************/
%include 'uvtuberead.sas';
options pagesize=200;
title2 'Proc Mixed repeated measures on Tubes Data';
proc mixed;
     title3 'Unknown Covariance Structure';
     class mcg day;
     model length = mcg|day;
     repeated / type=un subject=tube;

proc mixed;
     title3 'Compound Symmetry Covariance Structure';
     class mcg day;
     model length = mcg|day;
     repeated / type=cs subject=tube r;

/* Extra options on this one:
      * cl on proc mixed gives 95% CIs for covariance parameter estimates
      * lsmeans gives marginal means, adjusted for any covariates (none, here)
      * with the / adjust=bon option, all pairwise comparisons
      * estimate shows one of those pairwise comparisons
      * contrast tests departure from linearity starting with day 2  */

proc mixed cl;
     title3 'Covariance structure: First-order Autoregressive';
     class mcg day;
     model length = mcg|day;
     repeated / type=ar(1) subject=tube;
     lsmeans day;
     lsmeans day / adjust=bon;
     estimate 'Time1vs6' day 1 0 0 0 0 -1 0 0 0 0 0;
     contrast 'Linear starting with day 2'
       day 0 -1  2 -1  0  0  0  0  0  0  0,
       day 0  0 -1  2 -1  0  0  0  0  0  0,
       day 0  0  0 -1  2 -1  0  0  0  0  0,
       day 0  0  0  0 -1  2 -1  0  0  0  0,
       day 0  0  0  0  0 -1  2 -1  0  0  0,
       day 0  0  0  0  0  0 -1  2 -1  0  0,
       day 0  0  0  0  0  0  0 -1  2 -1  0,
       day 0  0  0  0  0  0  0  0 -1  2 -1;
```

The Mixed Procedure

Model Information

Data Set	WORK.FIRST11
Dependent Variable	length
Covariance Structure	Unstructured
Subject Effect	tube
Estimation Method	REML
Residual Variance Method	None
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225
day	11	1 2 3 4 5 6 7 8 9 10 11

Dimensions

Covariance Parameters	66
Columns in X	84
Columns in Z	0
Subjects	24
Max Obs Per Subject	11
Observations Used	264
Observations Not Used	0
Total Observations	264

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	396.31629789	
1	1	-115.25543455	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
UN(1,1)	tube	0.007465
UN(2,1)	tube	0.01143
UN(2,2)	tube	0.1090
UN(3,1)	tube	0.008880
UN(3,2)	tube	0.1371
UN(3,3)	tube	0.2527
UN(4,1)	tube	0.007248
UN(4,2)	tube	0.1515
UN(4,3)	tube	0.2474
UN(4,4)	tube	0.2850
UN(5,1)	tube	0.006562
UN(5,2)	tube	0.1530
UN(5,3)	tube	0.2535
UN(5,4)	tube	0.2727
UN(5,5)	tube	0.3010
UN(6,1)	tube	0.007083
UN(6,2)	tube	0.1468
UN(6,3)	tube	0.2514
UN(6,4)	tube	0.2703
UN(6,5)	tube	0.2986
UN(6,6)	tube	0.3175
UN(7,1)	tube	0.006962
UN(7,2)	tube	0.1678
UN(7,3)	tube	0.2779
UN(7,4)	tube	0.2957
UN(7,5)	tube	0.3158
UN(7,6)	tube	0.3199
UN(7,7)	tube	0.3491
UN(8,1)	tube	0.004410
UN(8,2)	tube	0.1324
UN(8,3)	tube	0.2190
UN(8,4)	tube	0.2483
UN(8,5)	tube	0.2647
UN(8,6)	tube	0.2782
UN(8,7)	tube	0.2863
UN(8,8)	tube	0.2589
UN(9,1)	tube	0.007760
UN(9,2)	tube	0.1582
UN(9,3)	tube	0.2531
UN(9,4)	tube	0.2946
UN(9,5)	tube	0.3094
UN(9,6)	tube	0.3219
UN(9,7)	tube	0.3302
UN(9,8)	tube	0.2979
UN(9,9)	tube	0.3544
UN(10,1)	tube	0.01115
UN(10,2)	tube	0.1563
UN(10,3)	tube	0.2457
UN(10,4)	tube	0.2874
UN(10,5)	tube	0.3034
UN(10,6)	tube	0.3148
UN(10,7)	tube	0.3202
UN(10,8)	tube	0.2880

UN(10,9)	tube	0.3497
UN(10,10)	tube	0.3643
UN(11,1)	tube	0.01210
UN(11,2)	tube	0.1681
UN(11,3)	tube	0.2630
UN(11,4)	tube	0.2965
UN(11,5)	tube	0.3030
UN(11,6)	tube	0.3100
UN(11,7)	tube	0.3162
UN(11,8)	tube	0.2809
UN(11,9)	tube	0.3366
UN(11,10)	tube	0.3497
UN(11,11)	tube	0.4034

Fit Statistics

-2 Res Log Likelihood	-115.3
AIC (smaller is better)	16.7
AICC (smaller is better)	84.3
BIC (smaller is better)	94.5

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
65	511.57	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
mcg	5	18	12.43	<.0001
day	10	18	43143.5	<.0001
mcg*day	50	18	54.03	<.0001

The Mixed Procedure

Model Information

Data Set	WORK.FIRST11
Dependent Variable	length
Covariance Structure	Compound Symmetry
Subject Effect	tube
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225
day	11	1 2 3 4 5 6 7 8 9 10 11

Dimensions

Covariance Parameters	2
Columns in X	84
Columns in Z	0
Subjects	24
Max Obs Per Subject	11
Observations Used	264
Observations Not Used	0
Total Observations	264

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	396.31629789	
1	1	151.03798067	0.00000000

Convergence criteria met.

Estimated R Matrix for Subject 1

Row	Col1	Col2	Col3	Col4	Col5	Col6	Col7
1	0.2730	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168
2	0.2168	0.2730	0.2168	0.2168	0.2168	0.2168	0.2168
3	0.2168	0.2168	0.2730	0.2168	0.2168	0.2168	0.2168
4	0.2168	0.2168	0.2168	0.2730	0.2168	0.2168	0.2168
5	0.2168	0.2168	0.2168	0.2168	0.2730	0.2168	0.2168
6	0.2168	0.2168	0.2168	0.2168	0.2168	0.2730	0.2168
7	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168	0.2730
8	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168
9	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168
10	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168
11	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168	0.2168

Estimated R Matrix for Subject 1

Row	Col8	Col9	Col10	Col11
1	0.2168	0.2168	0.2168	0.2168
2	0.2168	0.2168	0.2168	0.2168
3	0.2168	0.2168	0.2168	0.2168
4	0.2168	0.2168	0.2168	0.2168
5	0.2168	0.2168	0.2168	0.2168

6	0.2168	0.2168	0.2168	0.2168
7	0.2168	0.2168	0.2168	0.2168
8	0.2730	0.2168	0.2168	0.2168
9	0.2168	0.2730	0.2168	0.2168
10	0.2168	0.2168	0.2730	0.2168
11	0.2168	0.2168	0.2168	0.2730

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
CS	tube	0.2168
Residual		0.05613

Fit Statistics

-2 Res Log Likelihood	151.0
AIC (smaller is better)	155.0
AICC (smaller is better)	155.1
BIC (smaller is better)	157.4

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	245.28	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
mcg	5	18	12.43	<.0001
day	10	180	38110.7	<.0001
mcg*day	50	180	36.80	<.0001

The Mixed Procedure

Model Information

Data Set	WORK.FIRST11
Dependent Variable	length
Covariance Structure	Autoregressive
Subject Effect	tube
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information

Class	Levels	Values
mcg	6	198 205 213 221 223 225
day	11	1 2 3 4 5 6 7 8 9 10 11

Dimensions

Covariance Parameters	2
Columns in X	84
Columns in Z	0
Subjects	24
Max Obs Per Subject	11
Observations Used	264
Observations Not Used	0
Total Observations	264

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	396.31629789	
1	2	61.21897469	0.00121861
2	1	61.02714952	0.00000476
3	1	61.02642703	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Alpha	Lower	Upper
AR(1)	tube	0.9071	0.05	0.8638	0.9504
Residual		0.2421	0.05	0.1618	0.4016

Fit Statistics

-2 Res Log Likelihood	61.0
AIC (smaller is better)	65.0
AICC (smaller is better)	65.1
BIC (smaller is better)	67.4

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	335.29	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
mcg	5	18	15.76	<.0001
day	10	180	6205.88	<.0001
mcg*day	50	180	9.00	<.0001

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
Time1vs6	-12.5583	0.08823	180	-142.34	<.0001

Contrasts

Label	Num DF	Den DF	F Value	Pr > F
Linear starting with day 2	8	180	13.69	<.0001

Least Squares Means

Effect	day	Estimate	Standard Error	DF	t Value	Pr > |t|
day	1	0.5896	0.1004	180	5.87	<.0001
day	2	1.8240	0.1004	180	18.16	<.0001
day	3	4.4490	0.1004	180	44.30	<.0001
day	4	7.2448	0.1004	180	72.14	<.0001
day	5	10.2979	0.1004	180	102.54	<.0001
day	6	13.1479	0.1004	180	130.92	<.0001
day	7	16.1146	0.1004	180	160.46	<.0001
day	8	19.1167	0.1004	180	190.35	<.0001
day	9	22.1042	0.1004	180	220.10	<.0001
day	10	24.9396	0.1004	180	248.34	<.0001
day	11	28.1146	0.1004	180	279.95	<.0001
day	1	0.5896	0.1004	180	5.87	<.0001
day	2	1.8240	0.1004	180	18.16	<.0001
day	3	4.4490	0.1004	180	44.30	<.0001
day	4	7.2448	0.1004	180	72.14	<.0001
day	5	10.2979	0.1004	180	102.54	<.0001
day	6	13.1479	0.1004	180	130.92	<.0001
day	7	16.1146	0.1004	180	160.46	<.0001
day	8	19.1167	0.1004	180	190.35	<.0001
day	9	22.1042	0.1004	180	220.10	<.0001
day	10	24.9396	0.1004	180	248.34	<.0001
day	11	28.1146	0.1004	180	279.95	<.0001

Differences of Least Squares Means

Effect	day	_day	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment
day	1	2	-1.2344	0.04329	180	-28.51	<.0001	Bonferroni
day	1	3	-3.8594	0.05979	180	-64.55	<.0001	Bonferroni
day	1	4	-6.6552	0.07153	180	-93.04	<.0001	Bonferroni
day	1	5	-9.7083	0.08072	180	-120.28	<.0001	Bonferroni
day	1	6	-12.5583	0.08823	180	-142.34	<.0001	Bonferroni
day	1	7	-15.5250	0.09453	180	-164.24	<.0001	Bonferroni
day	1	8	-18.5271	0.09990	180	-185.46	<.0001	Bonferroni
day	1	9	-21.5146	0.1045	180	-205.83	<.0001	Bonferroni
day	1	10	-24.3500	0.1086	180	-224.30	<.0001	Bonferroni
day	1	11	-27.5250	0.1121	180	-245.56	<.0001	Bonferroni
day	2	3	-2.6250	0.04329	180	-60.63	<.0001	Bonferroni
day	2	4	-5.4208	0.05979	180	-90.67	<.0001	Bonferroni
day	2	5	-8.4740	0.07153	180	-118.47	<.0001	Bonferroni
day	2	6	-11.3240	0.08072	180	-140.29	<.0001	Bonferroni
day	2	7	-14.2906	0.08823	180	-161.97	<.0001	Bonferroni
day	2	8	-17.2927	0.09453	180	-182.94	<.0001	Bonferroni
day	2	9	-20.2802	0.09990	180	-203.01	<.0001	Bonferroni
day	2	10	-23.1156	0.1045	180	-221.14	<.0001	Bonferroni
day	2	11	-26.2906	0.1086	180	-242.18	<.0001	Bonferroni
day	3	4	-2.7958	0.04329	180	-64.58	<.0001	Bonferroni
day	3	5	-5.8490	0.05979	180	-97.83	<.0001	Bonferroni
day	3	6	-8.6990	0.07153	180	-121.61	<.0001	Bonferroni
day	3	7	-11.6656	0.08072	180	-144.52	<.0001	Bonferroni
day	3	8	-14.6677	0.08823	180	-166.25	<.0001	Bonferroni
day	3	9	-17.6552	0.09453	180	-186.78	<.0001	Bonferroni
day	3	10	-20.4906	0.09990	180	-205.12	<.0001	Bonferroni
day	3	11	-23.6656	0.1045	180	-226.40	<.0001	Bonferroni
day	4	5	-3.0531	0.04329	180	-70.52	<.0001	Bonferroni
day	4	6	-5.9031	0.05979	180	-98.74	<.0001	Bonferroni
day	4	7	-8.8698	0.07153	180	-124.00	<.0001	Bonferroni
day	4	8	-11.8719	0.08072	180	-147.08	<.0001	Bonferroni
day	4	9	-14.8594	0.08823	180	-168.42	<.0001	Bonferroni
day	4	10	-17.6948	0.09453	180	-187.20	<.0001	Bonferroni
day	4	11	-20.8698	0.09990	180	-208.92	<.0001	Bonferroni
day	5	6	-2.8500	0.04329	180	-65.83	<.0001	Bonferroni
day	5	7	-5.8167	0.05979	180	-97.29	<.0001	Bonferroni
day	5	8	-8.8188	0.07153	180	-123.29	<.0001	Bonferroni
day	5	9	-11.8063	0.08072	180	-146.27	<.0001	Bonferroni
day	5	10	-14.6417	0.08823	180	-165.95	<.0001	Bonferroni
day	5	11	-17.8167	0.09453	180	-188.49	<.0001	Bonferroni
day	6	7	-2.9667	0.04329	180	-68.53	<.0001	Bonferroni
day	6	8	-5.9688	0.05979	180	-99.84	<.0001	Bonferroni
day	6	9	-8.9563	0.07153	180	-125.21	<.0001	Bonferroni
day	6	10	-11.7917	0.08072	180	-146.09	<.0001	Bonferroni
day	6	11	-14.9667	0.08823	180	-169.64	<.0001	Bonferroni
day	7	8	-3.0021	0.04329	180	-69.34	<.0001	Bonferroni
day	7	9	-5.9896	0.05979	180	-100.18	<.0001	Bonferroni
day	7	10	-8.8250	0.07153	180	-123.38	<.0001	Bonferroni
day	7	11	-12.0000	0.08072	180	-148.67	<.0001	Bonferroni
day	8	9	-2.9875	0.04329	180	-69.01	<.0001	Bonferroni
day	8	10	-5.8229	0.05979	180	-97.40	<.0001	Bonferroni
day	8	11	-8.9979	0.07153	180	-125.79	<.0001	Bonferroni

day	9	10	-2.8354	0.04329	180	-65.49	<.0001	Bonferroni
day	9	11	-6.0104	0.05979	180	-100.53	<.0001	Bonferroni
day	10	11	-3.1750	0.04329	180	-73.34	<.0001	Bonferroni

Differences of Least Squares Means

Effect	day	_day	Adj P
day	1	2	<.0001
day	1	3	<.0001
day	1	4	<.0001
day	1	5	<.0001

The Mixed Procedure

Differences of Least Squares Means

Effect	day	_day	Adj P
day	1	6	<.0001
day	1	7	<.0001
day	1	8	<.0001
day	1	9	<.0001
day	1	10	<.0001
day	1	11	<.0001
day	2	3	<.0001
day	2	4	<.0001
day	2	5	<.0001
day	2	6	<.0001
day	2	7	<.0001
day	2	8	<.0001
day	2	9	<.0001
day	2	10	<.0001
day	2	11	<.0001
day	3	4	<.0001
day	3	5	<.0001
day	3	6	<.0001
day	3	7	<.0001
day	3	8	<.0001
day	3	9	<.0001
day	3	10	<.0001
day	3	11	<.0001
day	4	5	<.0001
day	4	6	<.0001
day	4	7	<.0001
day	4	8	<.0001
day	4	9	<.0001
day	4	10	<.0001
day	4	11	<.0001

day	5	6	<.0001
day	5	7	<.0001
day	5	8	<.0001
day	5	9	<.0001
day	5	10	<.0001
day	5	11	<.0001
day	6	7	<.0001
day	6	8	<.0001
day	6	9	<.0001
day	6	10	<.0001
day	6	11	<.0001
day	7	8	<.0001
day	7	9	<.0001
day	7	10	<.0001
day	7	11	<.0001
day	8	9	<.0001
day	8	10	<.0001
day	8	11	<.0001
day	9	10	<.0001
day	9	11	<.0001
day	10	11	<.0001