Covariance Structure Approach to Within-Cases

```
/* grapefruit2.sas */
options linesize=79 pagesize=500 noovp formdlim='_';
title "Oneway ANOVA with repeated measures: Covariance Structure Approach";
title2 'Grapefruit data (Kutner et al. 5th ed. Prob 27.6)';

data grape1;
     infile 'grapefruit1.data' firstobs=2; /* Skip the labels */
     input store sales1-sales3;
     label sales1 = 'Sales at Price 1'
           sales2 = 'Sales at Price 2'
           sales3 = 'Sales at Price 3';
     d12 = sales1-sales2; d13 = sales1-sales3; d23=sales2-sales3;

proc glm;
     title3 'Multivariate approach with proc glm';
     model sales1-sales3 = ;
     repeated price / short summary mean;


data grape2;     /* This data set will have 3n cases. */
     set grape1;
     price = 1; sales = sales1; output; /* Output creates a new case. */
     price = 2; sales = sales2; output;
     price = 3; sales = sales3; output;
     keep store price sales;

proc print;
     title3 'Data set with one case per observation';

proc mixed;
     title3 'Proc mixed with unknown covariance structure';
     title4 'Compare F = 29.66 with df = 2, 6';
     class price;
     model sales = price;
     repeated / type=un subject=store r;

proc mixed;
     title3 'Proc mixed with compound symmetry cov. structure and contrasts';
     title4 'Compare F = 49.35 with df = 2, 14';
     class price;
     model sales = price;
     contrast '1vs2' price 1 -1  0;
     contrast '1vs3' price 1  0 -1;
     contrast '2vs3' price 0  1 -1;
     repeated / type=cs subject=store r;
```

The GLM Procedure

Number of Observations Read	8
Number of Observations Used	8

Skipping the univariate output …

The GLM Procedure
Repeated Measures Analysis of Variance

Repeated Measures Level Information

Dependent Variable	sales1	sales2	sales3
Level of price	1	2	3

MANOVA Test Criteria and Exact F Statistics
for the Hypothesis of no price Effect
H = Type III SSCP Matrix for price
E = Error SSCP Matrix

S=1 M=0 N=2

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.09185282	29.66	2	6	0.0008
Pillai's Trace	0.90814718	29.66	2	6	0.0008
Hotelling-Lawley Trace	9.88698145	29.66	2	6	0.0008
Roy's Greatest Root	9.88698145	29.66	2	6	0.0008

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

Source	DF	Type III SS	Mean Square	F Value	Pr > F
price	2	67.48083333	33.74041667	49.35	<.0001
Error(price)	14	9.57250000	0.68375000		

And skipping the remaining multivariate output.

Recall that the original data file looked like this:

Store	sales1	sales2	sales3
1	62.1	61.3	60.8
2	58.2	57.9	55.1
3	51.6	49.2	46.2
4	53.7	51.5	48.3
5	61.4	58.7	56.6
6	58.5	57.2	54.3
7	46.8	43.2	41.5
8	51.2	49.8	47.9

And here is the output from `proc print`:

Oneway ANOVA with repeated measures: Covariance Structure Approach 9
Grapefruit data (Kutner et al. 5th ed. Prob 27.6)
Data set with one case per observation

Obs	store	price	sales
1	1	1	62.1
2	1	2	61.3
3	1	3	60.8
4	2	1	58.2
5	2	2	57.9
6	2	3	55.1
7	3	1	51.6
8	3	2	49.2
9	3	3	46.2
10	4	1	53.7
11	4	2	51.5
12	4	3	48.3
13	5	1	61.4
14	5	2	58.7
15	5	3	56.6
16	6	1	58.5
17	6	2	57.2
18	6	3	54.3
19	7	1	46.8
20	7	2	43.2
21	7	3	41.5
22	8	1	51.2
23	8	2	49.8
24	8	3	47.9

Grapefruit data (Kutner et al. 5th ed. Prob 27.6)
Proc mixed with unknown covariance structure
Compare F = 29.66 with df = 2, 6

The Mixed Procedure

Model Information

Data Set	WORK.GRAPE2
Dependent Variable	sales
Covariance Structure	Unstructured
Subject Effect	store
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
price	3	1 2 3

Dimensions

Covariance Parameters	6
Columns in X	4
Columns in Z	0
Subjects	8
Max Obs Per Subject	3

Number of Observations

Number of Observations Read	24
Number of Observations Used	24
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	141.05309845	
1	1	86.03317486	0.00000000

Convergence criteria met.

Estimated R Matrix for Subject 1

Row	Col1	Col2	Col3
1	29.6084	33.0114	34.0598
2	33.0114	37.5886	38.7000
3	34.0598	38.7000	40.6255

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
UN(1,1)	store	29.6084
UN(2,1)	store	33.0114
UN(2,2)	store	37.5886
UN(3,1)	store	34.0598
UN(3,2)	store	38.7000
UN(3,3)	store	40.6255

Fit Statistics

-2 Res Log Likelihood	86.0
AIC (smaller is better)	98.0
AICC (smaller is better)	104.0
BIC (smaller is better)	98.5

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
5	55.02	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
price	2	7	34.60	0.0002

Compare F = 29.66 with df = 2, 6

Grapefruit data (Kutner et al. 5th ed. Prob 27.6)
Proc mixed with compound symmetry cov. structure and contrasts
Compare F = 49.35 with df = 2, 14

The Mixed Procedure

Model Information

Data Set	WORK.GRAPE2
Dependent Variable	sales
Covariance Structure	Compound Symmetry
Subject Effect	store
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
price	3	1 2 3

Dimensions

Covariance Parameters	2
Columns in X	4
Columns in Z	0
Subjects	8
Max Obs Per Subject	3

Number of Observations

Number of Observations Read	24
Number of Observations Used	24
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	141.05309845	
1	1	93.18551859	0.00000000

Convergence criteria met.

Estimated R Matrix for Subject 1

Row	Col1	Col2	Col3
1	35.9408	35.2571	35.2571
2	35.2571	35.9408	35.2571
3	35.2571	35.2571	35.9408

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
CS	store	35.2571
Residual		0.6838

Fit Statistics

-2 Res Log Likelihood	93.2
AIC (smaller is better)	97.2
AICC (smaller is better)	97.9
BIC (smaller is better)	97.3

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	47.87	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
price	2	14	49.35	<.0001

Contrasts

Label	Num DF	Den DF	F Value	Pr > F
1vs2	1	14	19.75	0.0006
1vs3	1	14	98.34	<.0001
2vs3	1	14	29.95	<.0001

Eating Norm Study

```
/dos/brunner/442f09/lecture > head RepeatPliner.data
ID,cdnNorm,cdnOrder,ResEater,amtEatC,amtEatA,fullc,fulla,deptimec,deptimea
8,0.0,0.0,1.0,16.00,11.00,2.00,4.00,2.30,4.30
102,0.0,0.0,1.0,12.00,12.00,1.00,1.00,17.25,5.25
106,0.0,0.0,2.0,12.00,13.00,1.00,1.00,2.90,3.40
12,0.0,0.0,1.0,11.00,11.00,1.00,1.00,4.75,7.25
14,0.0,0.0,1.0,10.00,7.00,1.00,1.00,18.12,5.12
88,0.0,0.0,2.0,8.50,10.00,3.00,5.00,2.93,2.93
108,0.0,0.0,1.0,8.00,11.00,1.00,1.00,16.00,16.00
19,0.0,0.0,2.0,6.00,14.00,1.00,2.00,7.88,7.38
20,0.0,0.0,1.0,6.00,9.00,3.00,4.00,1.77,3.77



/* eatingnorm.sas */
options linesize=79 pagesize=500 noovp formdlim='_' nodate;
title 'Social facilitation in eating: ANCOVA with time-varying covariates';

proc format;
     value ofmt 0 = 'AloneConfederate' 1 = 'ConfederateAlone';
     value amtfmt 0 = 'A little'  1 = 'A lot';


data hungry;
     infile 'RepeatPliner.data' firstobs=2 delimiter=',';
     input ID cdnNorm cdnOrder ResEater amtEatC amtEatA fullC fullA deptimeC
           deptimeA;
     label
           cdnOrder = 'Order'
           cdnNorm  = 'Amount eaten by Confederate'
           amtEatC  = 'Amount eaten with confederate present'
           amtEatA  = 'Amount eaten with confederate absent'
           fullC    = 'Rated fullness before eating, confederate present'
           fullA    = 'Rated fullness before eating, confederate absent'
           deptimeC = 'Deprivation time, confederate present'
           deptimeA = 'Deprivation time, confederate absent';
      format cdnOrder ofmt.;
      format  cdnNorm amtfmt.;

proc freq;
     tables cdnOrder*cdnNorm / norow nocol nopercent missing;
```

```
data fressen; /* Separate cases for confederate present, absent */
     set hungry;
     confed = 'Present';
          amtEat = amtEatC; full = fullC; deptime = deptimeC; output;
     confed = 'Absent';
          amtEat = amtEatA; full = fullA; deptime = deptimeA; output;
     keep ID cdnNorm cdnOrder confed amtEat full deptime;
     label
           cdnOrder = 'Order'
           cdnNorm  = 'Amount eaten by Confederate'
           amtEat   = 'Amount eaten'
           full     = 'Rated fullness before eating'
           deptime  = 'Food Deprivation time';
      format cdnOrder ofmt.;
      format  cdnNorm amtfmt.;

proc print;

proc mixed;
     title2 'Covariates: Deprivation time and rated fullness';
     class cdnOrder cdnNorm confed;
     model amtEat = deptime full cdnOrder|cdnNorm|confed;
     repeated / type=un subject=id r;
     lsmeans cdnOrder|cdnNorm|confed;
```

Social facilitation in eating: ANCOVA with time-varying covariates 1

The FREQ Procedure

Table of cdnOrder by cdnNorm

cdnOrder(Order)	cdnNorm(Amount eaten by Confederate)		
Frequency	A little	A lot	Total
AloneConfederate	17	19	36
ConfederateAlone	20	18	38
Total	37	37	74

Social facilitation in eating: ANCOVA with time-varying covariates 2

Obs	ID	cdnNorm	cdnOrder	confed	amt Eat	full	deptime
1	8	A little	AloneConfederate	Present	16.0	2	2.30
2	8	A little	AloneConfederate	Absent	11.0	4	4.30
3	102	A little	AloneConfederate	Present	12.0	1	17.25
4	102	A little	AloneConfederate	Absent	12.0	1	5.25
5	106	A little	AloneConfederate	Present	12.0	1	2.90
6	106	A little	AloneConfederate	Absent	13.0	1	3.40

7	12	A little	AloneConfederate	Present	11.0	1	4.75
8	12	A little	AloneConfederate	Absent	11.0	1	7.25
9	14	A little	AloneConfederate	Present	10.0	1	18.12
10	14	A little	AloneConfederate	Absent	7.0	1	5.12
			. . .				
145	41	A lot	ConfederateAlone	Present	4.0	1	3.48
146	41	A lot	ConfederateAlone	Absent	5.0	3	2.98
147	77	A lot	ConfederateAlone	Present	4.0	1	2.95
148	77	A lot	ConfederateAlone	Absent	5.0	1	2.95

The Mixed Procedure

Model Information

Data Set	WORK.FRESSEN
Dependent Variable	amtEat
Covariance Structure	Unstructured
Subject Effect	ID
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
cdnOrder	2	AloneConfederate ConfederateAlone
cdnNorm	2	A little A lot
confed	2	Absent Present

Dimensions

Covariance Parameters	3
Columns in X	29
Columns in Z	0
Subjects	74
Max Obs Per Subject	2

Number of Observations

Number of Observations Read	148
Number of Observations Used	148
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	876.26433335	
1	2	821.28897703	0.00000037
2	1	821.28887267	0.00000000

Convergence criteria met.

Estimated R Matrix
for Subject 1

Row	Col1	Col2
1	24.6631	19.1859
2	19.1859	27.0831

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
UN(1,1)	ID	24.6631
UN(2,1)	ID	19.1859
UN(2,2)	ID	27.0831

Fit Statistics

-2 Res Log Likelihood	821.3
AIC (smaller is better)	827.3
AICC (smaller is better)	827.5
BIC (smaller is better)	834.2

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
2	54.98	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
deptime	1	70	0.10	0.7537
full	1	70	4.17	0.0450
cdnOrder	1	70	0.01	0.9187
cdnNorm	1	70	10.40	0.0019
cdnOrder*cdnNorm	1	70	0.41	0.5258
confed	1	70	4.98	0.0289
cdnOrder*confed	1	70	5.57	0.0210
cdnNorm*confed	1	70	14.28	0.0003
cdnOrd*cdnNor*confed	1	70	2.11	0.1506

Least Squares Means

Effect	confed	Order	Amount eaten by Confederate	Estimate
cdnOrder		AloneConfederate		9.7580
cdnOrder		ConfederateAlone		9.8717
cdnNorm			**A little**	**8.0104**
cdnNorm			**A lot**	**11.6193**
cdnOrder*cdnNorm		AloneConfederate	A little	8.3069
cdnOrder*cdnNorm		AloneConfederate	A lot	11.2091
cdnOrder*cdnNorm		ConfederateAlone	A little	7.7140
cdnOrder*cdnNorm		ConfederateAlone	A lot	12.0295
confed	**Absent**			**10.3000**
confed	**Present**			**9.3297**
cdnOrder*confed	**Absent**	**AloneConfederate**		**9.7403**
cdnOrder*confed	**Present**	**AloneConfederate**		**9.7757**
cdnOrder*confed	**Absent**	**ConfederateAlone**		**10.8596**
cdnOrder*confed	**Present**	**ConfederateAlone**		**8.8838**
cdnNorm*confed	**Absent**		**A little**	**9.3216**
cdnNorm*confed	**Present**		**A little**	**6.6992**
cdnNorm*confed	**Absent**		**A lot**	**11.2783**
cdnNorm*confed	**Present**		**A lot**	**11.9603**
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A little	9.4298
cdnOrd*cdnNor*confed	Present	AloneConfederate	A little	7.1839
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A lot	10.0508
cdnOrd*cdnNor*confed	Present	AloneConfederate	A lot	12.3674
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A little	9.2134
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A little	6.2145
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A lot	12.5058
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A lot	11.5531

Least Squares Means

Effect	confed	Order	Amount eaten by Confederate	Standard Error	DF
cdnOrder		AloneConfederate		0.7939	70
cdnOrder		ConfederateAlone		0.7724	70
cdnNorm			A little	0.7880	70
cdnNorm			A lot	0.7851	70
cdnOrder*cdnNorm		AloneConfederate	A little	1.1619	70
cdnOrder*cdnNorm		AloneConfederate	A lot	1.0942	70
cdnOrder*cdnNorm		ConfederateAlone	A little	1.0626	70
cdnOrder*cdnNorm		ConfederateAlone	A lot	1.1215	70
confed	Absent			0.6078	70
confed	Present			0.5799	70
cdnOrder*confed	Absent	AloneConfederate		0.8721	70
cdnOrder*confed	Present	AloneConfederate		0.8308	70
cdnOrder*confed	Absent	ConfederateAlone		0.8475	70
cdnOrder*confed	Present	ConfederateAlone		0.8094	70
cdnNorm*confed	Absent		A little	0.8745	70
cdnNorm*confed	Present		A little	0.8213	70
cdnNorm*confed	Absent		A lot	0.8591	70
cdnNorm*confed	Present		A lot	0.8233	70
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A little	1.2841	70
cdnOrd*cdnNor*confed	Present	AloneConfederate	A little	1.2138	70
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A lot	1.2025	70
cdnOrd*cdnNor*confed	Present	AloneConfederate	A lot	1.1445	70
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A little	1.1685	70
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A little	1.1110	70
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A lot	1.2283	70
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A lot	1.1747	70

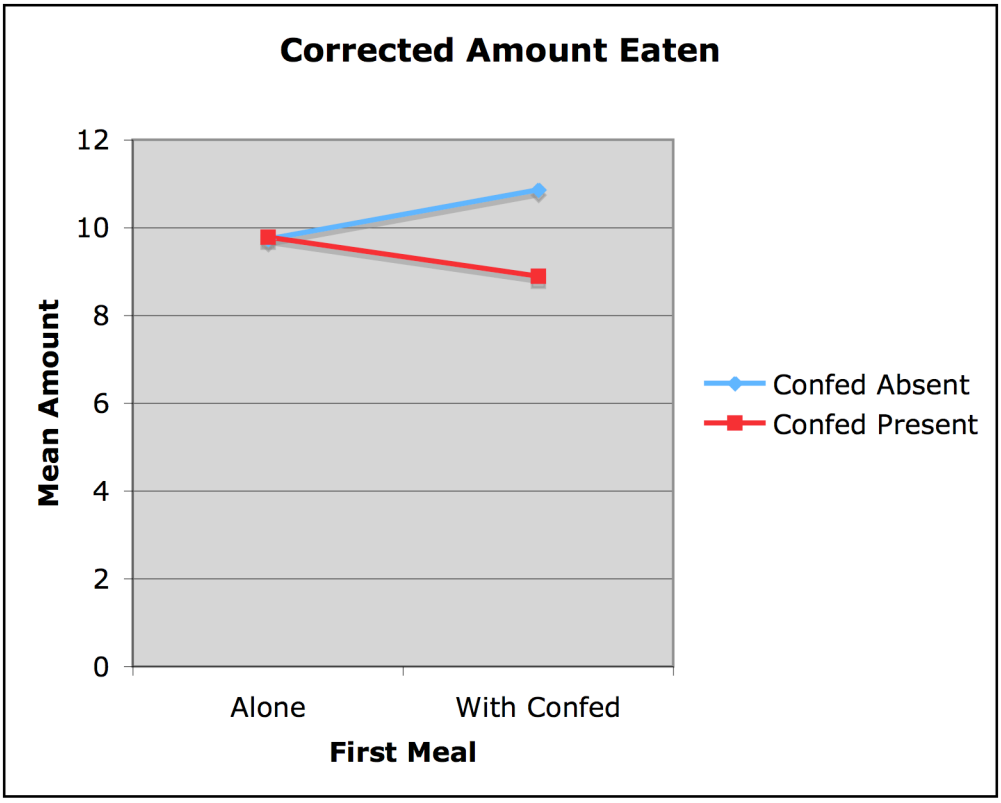
Least Squares Means

Effect	confed	Order	Amount eaten by Confederate	t Value	Pr > |t|
cdnOrder		AloneConfederate		12.29	<.0001
cdnOrder		ConfederateAlone		12.78	<.0001
cdnNorm			A little	10.17	<.0001
cdnNorm			A lot	14.80	<.0001
cdnOrder*cdnNorm		AloneConfederate	A little	7.15	<.0001
cdnOrder*cdnNorm		AloneConfederate	A lot	10.24	<.0001
cdnOrder*cdnNorm		ConfederateAlone	A little	7.26	<.0001
cdnOrder*cdnNorm		ConfederateAlone	A lot	10.73	<.0001
confed	Absent			16.95	<.0001
confed	Present			16.09	<.0001
cdnOrder*confed	Absent	AloneConfederate		11.17	<.0001
cdnOrder*confed	Present	AloneConfederate		11.77	<.0001
cdnOrder*confed	Absent	ConfederateAlone		12.81	<.0001
cdnOrder*confed	Present	ConfederateAlone		10.98	<.0001
cdnNorm*confed	Absent		A little	10.66	<.0001
cdnNorm*confed	Present		A little	8.16	<.0001
cdnNorm*confed	Absent		A lot	13.13	<.0001
cdnNorm*confed	Present		A lot	14.53	<.0001
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A little	7.34	<.0001
cdnOrd*cdnNor*confed	Present	AloneConfederate	A little	5.92	<.0001
cdnOrd*cdnNor*confed	Absent	AloneConfederate	A lot	8.36	<.0001
cdnOrd*cdnNor*confed	Present	AloneConfederate	A lot	10.81	<.0001
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A little	7.88	<.0001
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A little	5.59	<.0001
cdnOrd*cdnNor*confed	Absent	ConfederateAlone	A lot	10.18	<.0001
cdnOrd*cdnNor*confed	Present	ConfederateAlone	A lot	9.84	<.0001

Need Two Plots

Effect	confed	Order	Amount eaten by Confederate	Estimate
cdnOrder*confed	**Absent**	**AloneConfederate**		**9.7403**
cdnOrder*confed	**Present**	**AloneConfederate**		**9.7757**
cdnOrder*confed	**Absent**	**ConfederateAlone**		**10.8596**
cdnOrder*confed	**Present**	**ConfederateAlone**		**8.8838**

	First Meal	
	Alone	With Confed
Confed Absent	**9.7403**	**10.8596**
Confed Present	**9.7757**	**8.8838**



Effect	confed	Order	Amount eaten by Confederate	Estimate
cdnNorm*confed	**Absent**		**A little**	**9.3216**
cdnNorm*confed	**Present**		**A little**	**6.6992**
cdnNorm*confed	**Absent**		**A lot**	**11.2783**
cdnNorm*confed	**Present**		**A lot**	**11.9603**