

Repeated Measures Part 2: Cartoon data

```
/****** cartoonglm.sas *****/
options linesize=79 noovp formdlim='_';
title 'Cartoon Data: STA442/1008 F 2005';
proc format; /* value labels used in data step below */
  value cfmt 0 = 'Black & White'    1 = 'Colour';
data disney;
  infile 'cartoon.dat';
  input id colour educ location otis cartoon1 real1 cartoon2 real2;
  label
    colour      = 'Colour versus Black & white training materials'
    educ        = 'Education'
    location    = 'Where did respondent come from?'
    otis        = 'Otis Mental Ability Test'
    cartoon1    = 'Cartoon test score at time 1'
    real1       = 'Realistic test score at time 1'
    cartoon2    = 'Cartoon test score at time 2'
    real2       = 'Realistic test score at time 2'
    memory      = 'Recall of training materials'
    type        = 'Training materials: Cartoon versus realistic ';
  format colour cfmt.;
  util = real2+cartoon2;
  if util = . then miss2='Yes'; else miss2='No ';
  label miss2 = 'Time 2 data missing';

proc glm;
  title2 'Repeated, no covariate';
  class colour;
  model real1 real2 cartoon1 cartoon2 = colour / nouni;
  repeated r_vs_car 2, time 2 / short summary;
  means colour;

proc glm;
  title2 'Repeated with covariate';
  class colour;
  model real1 real2 cartoon1 cartoon2 = otis colour / nouni;
  repeated r_vs_car 2, time 2 / short summary;
  lsmeans colour;

proc ttest;
  title2 'Time 2 missing at random?';
  class miss2;
  var real1 cartoon1 otis;
page numberspage numbers
```

Cartoon Data: STA442/1008 F 2005 1
Repeated, no covariate
10:47 Friday, November 25, 2005

The GLM Procedure

Class Level Information

Class	Levels	Values
colour	2	Black & White Colour

Number of observations 179

NOTE: Observations with missing values will not be included in this analysis.
Thus, only 104 observations can be used in this analysis.

Cartoon Data: STA442/1008 F 2005 2
Repeated, no covariate
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The GLM Procedure

Repeated Measures Analysis of Variance

Repeated Measures Level Information

Dependent Variable	real1	real2	cartoon1	cartoon2
Level of r_vs_car	1	1	2	2
Level of time	1	2	1	2

Manova Test Criteria and Exact F Statistics

for the Hypothesis of no r_vs_car Effect

H = Type III SSCP Matrix for r_vs_car

E = Error SSCP Matrix

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.68349183	47.23	1	102	<.0001
Pillai's Trace	0.31650817	47.23	1	102	<.0001
Hotelling-Lawley Trace	0.46307528	47.23	1	102	<.0001
Roy's Greatest Root	0.46307528	47.23	1	102	<.0001

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*colour Effect
H = Type III SSCP Matrix for r_vs_car*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98671133	1.37	1	102	0.2439
Pillai's Trace	0.01328867	1.37	1	102	0.2439
Hotelling-Lawley Trace	0.01346764	1.37	1	102	0.2439
Roy's Greatest Root	0.01346764	1.37	1	102	0.2439

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

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.37343179	171.14	1	102	<.0001
Pillai's Trace	0.62656821	171.14	1	102	<.0001
Hotelling-Lawley Trace	1.67786524	171.14	1	102	<.0001
Roy's Greatest Root	1.67786524	171.14	1	102	<.0001

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The GLM Procedure
Repeated Measures Analysis of Variance

Manova Test Criteria and Exact F Statistics
for the Hypothesis of no time*colour Effect
H = Type III SSCP Matrix for time*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.93373521	7.24	1	102	0.0083
Pillai's Trace	0.06626479	7.24	1	102	0.0083
Hotelling-Lawley Trace	0.07096743	7.24	1	102	0.0083
Roy's Greatest Root	0.07096743	7.24	1	102	0.0083

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*time Effect
H = Type III SSCP Matrix for r_vs_car*time
E = Error SSCP Matrix

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99214080	0.81	1	102	0.3708
Pillai's Trace	0.00785920	0.81	1	102	0.3708
Hotelling-Lawley Trace	0.00792146	0.81	1	102	0.3708
Roy's Greatest Root	0.00792146	0.81	1	102	0.3708

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*time*colour Effect
H = Type III SSCP Matrix for r_vs_car*time*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=50

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98633300	1.41	1	102	0.2373
Pillai's Trace	0.01366700	1.41	1	102	0.2373
Hotelling-Lawley Trace	0.01385638	1.41	1	102	0.2373
Roy's Greatest Root	0.01385638	1.41	1	102	0.2373

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

Source	DF	Type III SS	Mean Square	F Value	Pr > F
colour	1	85.540602	85.540602	5.26	0.0238
Error	102	1657.303148	16.248070		

Cartoon Data: STA442/1008 F 2005
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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
r_vs_car	1	72.7900321	72.7900321	47.23	<.0001
r_vs_car*colour	1	2.1169551	2.1169551	1.37	0.2439
Error(r_vs_car)	102	157.1883333	1.5410621		

Source	DF	Type III SS	Mean Square	F Value	Pr > F
time	1	410.8585506	410.8585506	171.14	<.0001
time*colour	1	17.3777813	17.3777813	7.24	0.0083
Error(time)	102	244.8698148	2.4006845		

Source	DF	Type III SS	Mean Square	F Value	Pr > F
r_vs_car*time	1	0.77003205	0.77003205	0.81	0.3708
r_vs_car*time*colour	1	1.34695513	1.34695513	1.41	0.2373
Error(r_vs_car*time)	102	97.20833333	0.95302288		

Cartoon Data: STA442/1008 F 2005
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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

r_vs_car_N represents the contrast between the nth level of r_vs_car and the last

Contrast Variable: r_vs_car_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	291.1601282	291.1601282	47.23	<.0001
colour	1	8.4678205	8.4678205	1.37	0.2439
Error	102	628.7533333	6.1642484		

Cartoon Data: STA442/1008 F 2005

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Repeated, no covariate

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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

time_N represents the contrast between the nth level of time and the last

Contrast Variable: time_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	1643.434202	1643.434202	171.14	<.0001
colour	1	69.511125	69.511125	7.24	0.0083
Error	102	979.479259	9.602738		

Cartoon Data: STA442/1008 F 2005

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Repeated, no covariate

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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

r_vs_car_N represents the contrast between the nth level of r_vs_car and the last

time_N represents the contrast between the nth level of time and the last

Contrast Variable: r_vs_car_1*time_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	3.0801282	3.0801282	0.81	0.3708
colour	1	5.3878205	5.3878205	1.41	0.2373
Error	102	388.8333333	3.8120915		

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The GLM Procedure

Level of colour	N	-----real1----- Mean	Std Dev	-----real2----- Mean	Std Dev
Black & White	54	6.833333333	2.15222570	4.40740741	2.18501344
Colour	50	5.26000000	2.69398423	3.88000000	2.67749502

Level of colour	N	-----cartoon1----- Mean	Std Dev	-----cartoon2----- Mean	Std Dev
Black & White	54	7.50000000	1.75638995	5.12962963	1.96234646
Colour	50	6.44000000	2.47567760	4.66000000	2.40416306

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The GLM Procedure

Class Level Information

Class	Levels	Values
colour	2	Black & White Colour

Number of observations 179

NOTE: Observations with missing values will not be included in this analysis.
 Thus, only 104 observations can be used in this analysis.

Cartoon Data: STA442/1008 F 2005
 Repeated with covariate

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The GLM Procedure

Repeated Measures Analysis of Variance

Repeated Measures Level Information

Dependent Variable	real1	real2	cartoon1	cartoon2
Level of r_vs_car	1	1	2	2
Level of time	1	2	1	2

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

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.91678965	9.17	1	101	0.0031
Pillai's Trace	0.08321035	9.17	1	101	0.0031
Hotelling-Lawley Trace	0.09076275	9.17	1	101	0.0031
Roy's Greatest Root	0.09076275	9.17	1	101	0.0031

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*otis Effect
H = Type III SSCP Matrix for r_vs_car*otis
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.95444085	4.82	1	101	0.0304
Pillai's Trace	0.04555915	4.82	1	101	0.0304
Hotelling-Lawley Trace	0.04773387	4.82	1	101	0.0304
Roy's Greatest Root	0.04773387	4.82	1	101	0.0304

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*colour Effect
H = Type III SSCP Matrix for r_vs_car*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99092795	0.92	1	101	0.3385
Pillai's Trace	0.00907205	0.92	1	101	0.3385
Hotelling-Lawley Trace	0.00915511	0.92	1	101	0.3385
Roy's Greatest Root	0.00915511	0.92	1	101	0.3385

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The GLM Procedure
Repeated Measures Analysis of Variance

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

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.97954262	2.11	1	101	0.1495
Pillai's Trace	0.02045738	2.11	1	101	0.1495
Hotelling-Lawley Trace	0.02088463	2.11	1	101	0.1495
Roy's Greatest Root	0.02088463	2.11	1	101	0.1495

Manova Test Criteria and Exact F Statistics
for the Hypothesis of no time*otis Effect
H = Type III SSCP Matrix for time*otis
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99984283	0.02	1	101	0.9000
Pillai's Trace	0.00015717	0.02	1	101	0.9000
Hotelling-Lawley Trace	0.00015720	0.02	1	101	0.9000
Roy's Greatest Root	0.00015720	0.02	1	101	0.9000

Manova Test Criteria and Exact F Statistics
for the Hypothesis of no time*colour Effect
H = Type III SSCP Matrix for time*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.93497654	7.02	1	101	0.0093
Pillai's Trace	0.06502346	7.02	1	101	0.0093
Hotelling-Lawley Trace	0.06954555	7.02	1	101	0.0093
Roy's Greatest Root	0.06954555	7.02	1	101	0.0093

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The GLM Procedure
Repeated Measures Analysis of Variance

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*time Effect
H = Type III SSCP Matrix for r_vs_car*time
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.97044365	3.08	1	101	0.0825
Pillai's Trace	0.02955635	3.08	1	101	0.0825
Hotelling-Lawley Trace	0.03045654	3.08	1	101	0.0825
Roy's Greatest Root	0.03045654	3.08	1	101	0.0825

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*time*otis Effect
H = Type III SSCP Matrix for r_vs_car*time*otis
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.96625947	3.53	1	101	0.0633
Pillai's Trace	0.03374053	3.53	1	101	0.0633
Hotelling-Lawley Trace	0.03491870	3.53	1	101	0.0633
Roy's Greatest Root	0.03491870	3.53	1	101	0.0633

Manova Test Criteria and Exact F Statistics for
the Hypothesis of no r_vs_car*time*colour Effect
H = Type III SSCP Matrix for r_vs_car*time*colour
E = Error SSCP Matrix

S=1 M=-0.5 N=49.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98122191	1.93	1	101	0.1675
Pillai's Trace	0.01877809	1.93	1	101	0.1675
Hotelling-Lawley Trace	0.01913746	1.93	1	101	0.1675
Roy's Greatest Root	0.01913746	1.93	1	101	0.1675

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

Source	DF	Type III SS	Mean Square	F Value	Pr > F
otis	1	597.845588	597.845588	56.99	<.0001
colour	1	44.682406	44.682406	4.26	0.0416
Error	101	1059.457560	10.489679		

Cartoon Data: STA442/1008 F 2005
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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
r_vs_car	1	13.6168603	13.6168603	9.17	0.0031
r_vs_car*otis	1	7.1613672	7.1613672	4.82	0.0304
r_vs_car*colour	1	1.3735130	1.3735130	0.92	0.3385
Error(r_vs_car)	101	150.0269661	1.4854155		

Source	DF	Type III SS	Mean Square	F Value	Pr > F
time	1	5.1132113	5.1132113	2.11	0.1495
time*otis	1	0.0384868	0.0384868	0.02	0.9000
time*colour	1	17.0269294	17.0269294	7.02	0.0093
Error(time)	101	244.8313280	2.4240726		

Source	DF	Type III SS	Mean Square	F Value	Pr > F
r_vs_car*time	1	2.86073622	2.86073622	3.08	0.0825
r_vs_car*time*otis	1	3.27986034	3.27986034	3.53	0.0633
r_vs_car*time*colour	1	1.79755209	1.79755209	1.93	0.1675
Error(r_vs_car*time)	101	93.92847299	0.92998488		

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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

r_vs_car_N represents the contrast between the nth level of r_vs_car and the last

Contrast Variable: r_vs_car_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	54.4674413	54.4674413	9.17	0.0031
otis	1	28.6454688	28.6454688	4.82	0.0304
colour	1	5.4940520	5.4940520	0.92	0.3385
Error	101	600.1078645	5.9416620		

Cartoon Data: STA442/1008 F 2005
Repeated with covariate

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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

time_N represents the contrast between the nth level of time and the last

Contrast Variable: time_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	20.4528450	20.4528450	2.11	0.1495
otis	1	0.1539473	0.1539473	0.02	0.9000
colour	1	68.1077177	68.1077177	7.02	0.0093
Error	101	979.3253119	9.6962902		

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The GLM Procedure
Repeated Measures Analysis of Variance
Analysis of Variance of Contrast Variables

r_vs_car_N represents the contrast between the nth level of r_vs_car and the last
time_N represents the contrast between the nth level of time and the last

Contrast Variable: r_vs_car_1*time_1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Mean	1	11.4429449	11.4429449	3.08	0.0825
otis	1	13.1194414	13.1194414	3.53	0.0633
colour	1	7.1902084	7.1902084	1.93	0.1675
Error	101	375.7138920	3.7199395		

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The GLM Procedure
Least Squares Means

colour	real1 LSMEAN	real2 LSMEAN	cartoon1 LSMEAN	cartoon2 LSMEAN
Black & White	6.70885721	4.26717317	7.38396506	5.03318154
Colour	5.39443421	4.03145298	6.56531773	4.76416393

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 Time 2 missing at random?
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The GLM Procedure

Class Level Information

Class	Levels	Values
miss2	2	No Yes

Number of observations 179

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The GLM Procedure

Dependent Variable: reall1 Realistic test score at time 1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	55.666707	55.666707	8.11	0.0049
Error	177	1215.171282	6.865374		
Corrected Total	178	1270.837989			

R-Square	Coeff Var	Root MSE	reall1 Mean
0.043803	46.76105	2.620186	5.603352

Source	DF	Type I SS	Mean Square	F Value	Pr > F
miss2	1	55.66670678	55.66670678	8.11	0.0049

Source	DF	Type III SS	Mean Square	F Value	Pr > F
miss2	1	55.66670678	55.66670678	8.11	0.0049

Time 2 missing at random?

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The TTEST Procedure

Statistics

Variable	miss2	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev
reall	No	104	5.5826	6.0769	6.5712	2.2369	2.5417
reall	Yes	75	4.3195	4.9467	5.5738	2.3485	2.7257
reall	Diff (1-2)		0.3469	1.1303	1.9136	2.3733	2.6202
cartoon1	No	104	6.5649	6.9904	7.4159	1.9255	2.1878
cartoon1	Yes	75	5.0282	5.64	6.2518	2.2912	2.6592
cartoon1	Diff (1-2)		0.634	1.3504	2.0667	2.1704	2.3962
otis	No	104	107.52	110.16	112.8	11.941	13.568
otis	Yes	75	100.1	103.13	106.17	11.372	13.198
otis	Diff (1-2)		3.0198	7.0301	11.04	12.151	13.414

Statistics

Variable	miss2	Upper CL Std Dev	Std Err	Minimum	Maximum
reall	No	2.9433	0.2492	0	9
reall	Yes	3.2484	0.3147	0	9
reall	Diff (1-2)	2.9248	0.3969		
cartoon1	No	2.5335	0.2145	0	9
cartoon1	Yes	3.1691	0.3071	0	9
cartoon1	Diff (1-2)	2.6747	0.363		
otis	No	15.711	1.3304	78	135
otis	Yes	15.729	1.524	82	133
otis	Diff (1-2)	14.974	2.0321		

T-Tests

Variable	Method	Variances	DF	t Value	Pr > t
reall	Pooled	Equal	177	2.85	0.0049
reall	Satterthwaite	Unequal	153	2.82	0.0055
cartoon1	Pooled	Equal	177	3.72	0.0003
cartoon1	Satterthwaite	Unequal	140	3.61	0.0004
otis	Pooled	Equal	177	3.46	0.0007
otis	Satterthwaite	Unequal	162	3.48	0.0007

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
reall	Folded F	74	103	1.15	0.5086
cartoon1	Folded F	74	103	1.48	0.0671
otis	Folded F	103	74	1.06	0.8079