The following data is part of a larger study on substance abuse (see Curran, Stice and Chassin, 1997). This dataset collected three waves of data on 82 adolescents (beginning at 14 years of age). The variables in the dataset are:

- 'alcuse' alcohol use (main outcome) measured on an 8-point scale from 0="not at all" to 7="everyday".
- 'coa' indicating whether the adolescent is a child of an alcoholic
- 'peer' a measure of alcohol use among the adolescent's peers, measured on a 6-point scale from 0="none" to 5="all".
- 'age'
- Centered values of coa and peer are also included in the data.

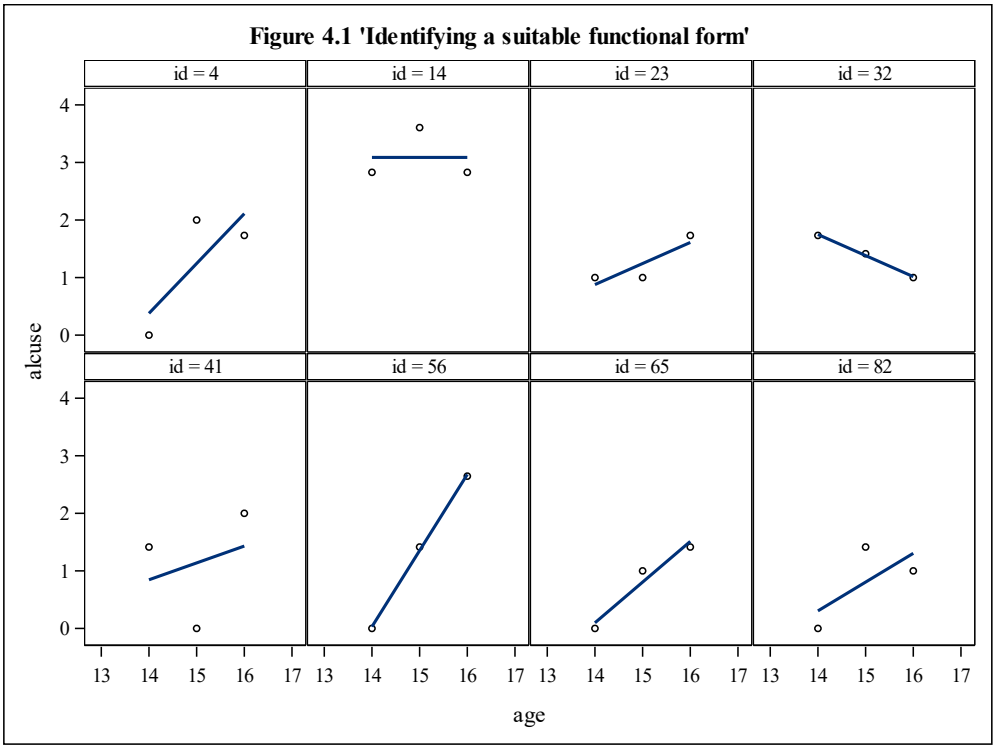
```
data alcohol1_pp;
input id    age   coa   male  age_14       alcuse     peer  cpeer ccoa;
datalines;
1     14    1     0     0     1.732050776 1.264911056 0.246911056 0.549
1     15    1     0     1     2     1.264911056 0.246911056 0.549
1     16    1     0     2     2     1.264911056 0.246911056 0.549
2     14    1     1     0     0     0.89442718  -0.12357282 0.549
……
82    15    0     0     1     1.414213538 2.190890312 1.172890312 -0.451
82    16    0     0     2     1     2.190890312 1.172890312 -0.451
;
run;

proc print data=alcohol1_pp (obs=10);
run;
```

Obs	id	age	coa	male	age_14	alcuse	peer	cpeer	ccoa
1	1	14	1	0	0	1.73205	1.26491	0.24691	0.549
2	1	15	1	0	1	2.00000	1.26491	0.24691	0.549
3	1	16	1	0	2	2.00000	1.26491	0.24691	0.549
4	2	14	1	1	0	0.00000	0.89443	-0.12357	0.549
5	2	15	1	1	1	0.00000	0.89443	-0.12357	0.549
6	2	16	1	1	2	1.00000	0.89443	-0.12357	0.549
7	3	14	1	1	0	1.00000	0.89443	-0.12357	0.549
8	3	15	1	1	1	2.00000	0.89443	-0.12357	0.549
9	3	16	1	1	2	3.31662	0.89443	-0.12357	0.549
10	4	14	1	1	0	0.00000	1.78885	0.77085	0.549

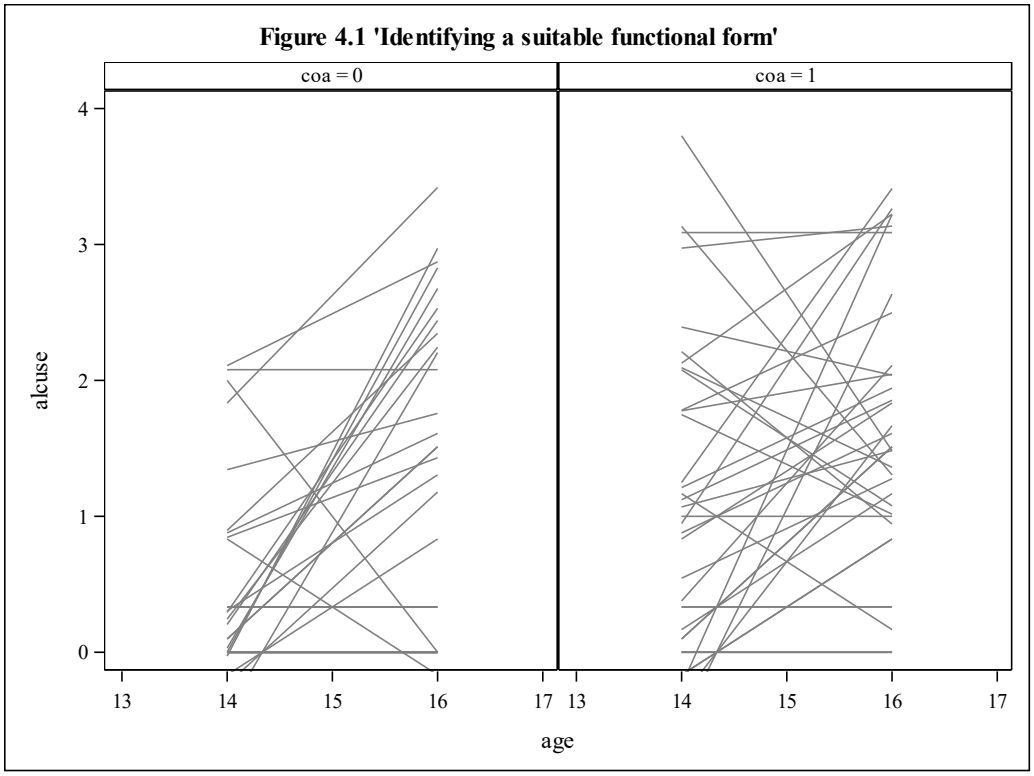
Let's look at the data for a few subjects.

```
proc sgpanel data = alcohol1_pp (where = (id in (4, 14, 23, 32, 41, 56, 65, 82)))
     noautolegend  ;
  panelby id / columns = 4 rows = 2;
  colaxis values = (13, 14, 15, 16, 17) ;
  rowaxis min = 0 max = 4;
  reg x = age y = alcuse;
run;
```



Now let's look at a panel plot by coa status.

```
proc sgpanel data = alcohol1_pp noautolegend ;
  panelby coa / columns = 2 rows = 1;
  colaxis values = (13 14, 15, 16, 17) ;
  rowaxis min = 0 max = 4 ;
  reg x = age y = alcuse / group = id nomarkers LINEATTRS = (COLOR= gray PATTERN = 1
THICKNESS = 1);
run;
```



This next part is a little different. As you'll see it adds some formatting to the Peer variable so that it's value doesn't change but it is separated into low and high alcohol consumption of peers.

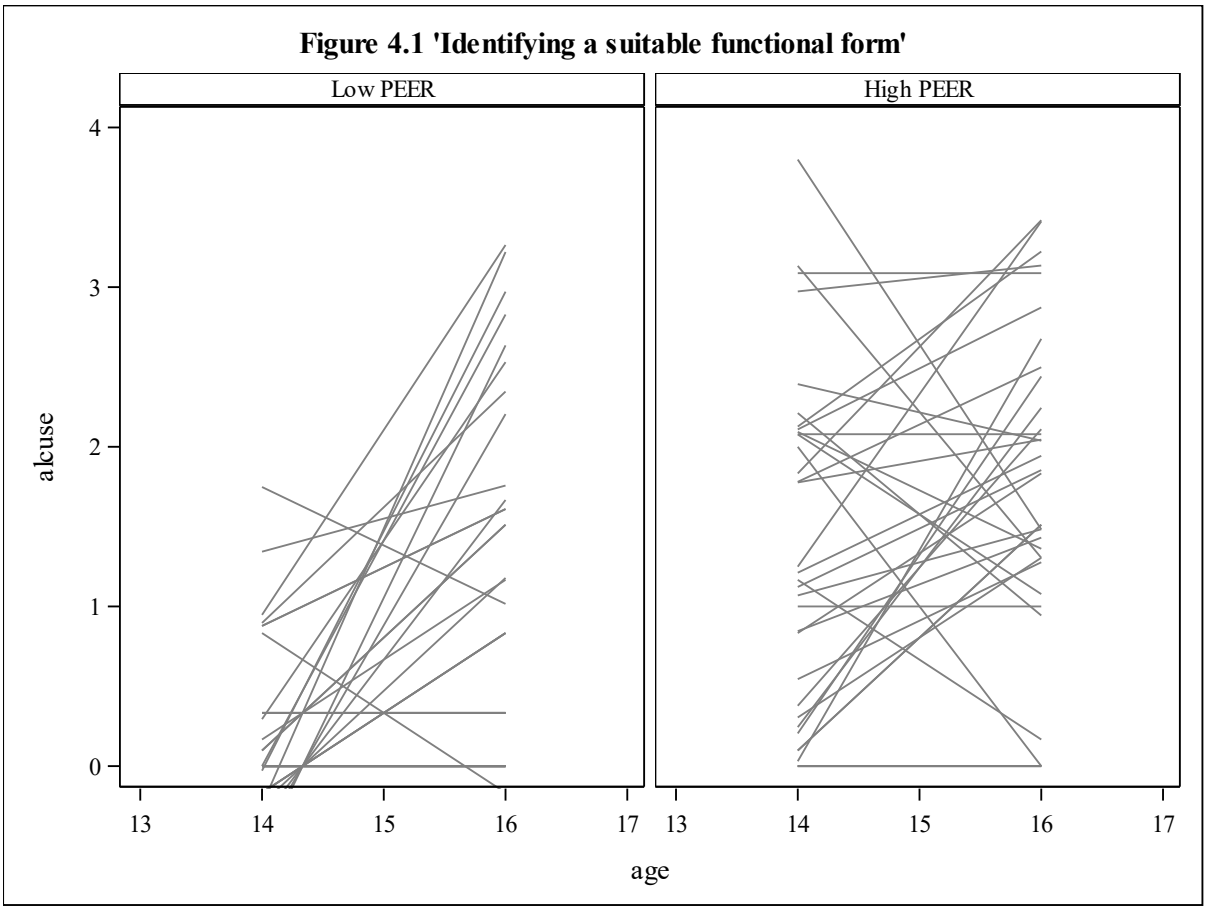
```
proc sql;
  select mean(peer) into :mpeer
  from alcohol1_pp;
quit;
proc format;
  value peer
  low -< &mpeer = "Low PEER"
  &mpeer - high = "High PEER";
run;

proc print data=alcohol1_pp (obs=10);
run;
```

Obs	id	age	coa	male	age_14	alcuse	peer	cpeer	ccoa
1	1	14	1	0	0	1.73205	1.26491	0.24691	0.549
2	1	15	1	0	1	2.00000	1.26491	0.24691	0.549
3	1	16	1	0	2	2.00000	1.26491	0.24691	0.549
4	2	14	1	1	0	0.00000	0.89443	-0.12357	0.549
5	2	15	1	1	1	0.00000	0.89443	-0.12357	0.549
6	2	16	1	1	2	1.00000	0.89443	-0.12357	0.549
7	3	14	1	1	0	1.00000	0.89443	-0.12357	0.549
8	3	15	1	1	1	2.00000	0.89443	-0.12357	0.549
9	3	16	1	1	2	3.31662	0.89443	-0.12357	0.549
10	4	14	1	1	0	0.00000	1.78885	0.77085	0.549

Now let's plot using the new formatting.

```
proc sgpanel data = alcohol1_pp noautolegend;
  panelby peer / columns = 2 rows = 1 spacing = 5 novarname;
  format peer peer.;
  colaxis values = (13, 14, 15, 16, 17) ;
  rowaxis min = 0 max = 4 ;
  reg x = age y = alcuse / group = id nomarkers LINEATTRS = (COLOR= gray PATTERN = 1
THICKNESS = 1); run;
```



Now we're going to fit some models to the data. First we'll look at mean structure, then the variance structure, then we'll look at the mean again.

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model A";
  class id;
  model alcuse = /solution notest;
  random intercept/sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Log Like**	**Criterion**
0	1	727.22549220	
1	1	670.15598863	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr > Z**
Intercept	id	0.5639	0.1191	4.73	<.0001
Residual		0.5617	0.06203	9.06	<.0001

Fit Statistics	
-2 Log Likelihood	670.2
AIC (Smaller is Better)	676.2
AICC (Smaller is Better)	676.3
BIC (Smaller is Better)	683.4

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.9220	0.09571	81	9.63	<.0001

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model A";
  class id;
  model alcuse = age_14/solution notest;
  random intercept/sub=id;
```

Iteration History			
Iteration	Evaluations	-2 Log Like	Criterion
0	1	716.31428500	
1	1	647.24146091	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	id	0.5883	0.1187	4.96	<.0001
Residual		0.4885	0.05395	9.06	<.0001

Fit Statistics	
-2 Log Likelihood	647.2
AIC (Smaller is Better)	655.2
AICC (Smaller is Better)	655.4
BIC (Smaller is Better)	664.9

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.6513	0.1102	81	5.91	<.0001
age_14	0.2707	0.05458	163	4.96	<.0001

Now we're going to consider adding a random slope to the model. Note that we go back to using REML.

```
proc mixed data=alcohol1_pp noclprint noinfo covtest;
  title2 "Model A";
  class id;
  model alcuse = age_14/solution notest;
  random intercept/sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	723.08763739	
1	1	654.06574340	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr > Z**
Intercept	id	0.5966	0.1209	4.94	<.0001
Residual		0.4915	0.05444	9.03	<.0001

Fit Statistics	
-2 Res Log Likelihood	654.1
AIC (Smaller is Better)	658.1
AICC (Smaller is Better)	658.1
BIC (Smaller is Better)	662.9

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.6513	0.1108	81	5.88	<.0001
age_14	0.2707	0.05474	163	4.94	<.0001

```
proc mixed data=alcohol1_pp noclprint noinfo covtest;
  title2 "Model B";
  class id;
  model alcuse = age_14/solution notest;
  random intercept age_14/type=un sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	723.08763739	
1	1	643.19155199	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr Z**
UN(1,1)	id	0.6355	0.1506	4.22	<.0001
UN(2,1)	id	-0.07137	0.07120	-1.00	0.3162
UN(2,2)	id	0.1552	0.05729	2.71	0.0034
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Res Log Likelihood	643.2
AIC (Smaller is Better)	651.2
AICC (Smaller is Better)	651.4
BIC (Smaller is Better)	660.8

Null Model Likelihood Ratio Test		
DF	**Chi-Square**	**Pr > ChiSq**
3	79.90	<.0001

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.6513	0.1057	81	6.16	<.0001
age_14	0.2707	0.06284	81	4.31	<.0001

Now let's refit the model using ml. We're going to look at adding some different mean parameters.

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model B";
  class id;
  model alcuse = age_14/solution notest;
  random intercept age_14/type=un sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Log Like**	**Criterion**
0	1	716.31428500	
1	1	636.61107724	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr Z**
UN(1,1)	id	0.6244	0.1481	4.22	<.0001
UN(2,1)	id	-0.06844	0.07008	-0.98	0.3288
UN(2,2)	id	0.1512	0.05647	2.68	0.0037
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Log Likelihood	636.6
AIC (Smaller is Better)	648.6
AICC (Smaller is Better)	649.0
BIC (Smaller is Better)	663.1

Null Model Likelihood Ratio Test		
DF	**Chi-Square**	**Pr > ChiSq**
3	79.70	<.0001

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.6513	0.1051	81	6.20	<.0001
age_14	0.2707	0.06245	81	4.33	<.0001

First, we'll see if the linear effect of age is better then a "profile" effect of age.

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model C";
  class id age_14;
  model alcuse = age_14/solution notest;
  random intercept age/type=un sub=id;
run;
```

Iteration History			
Iteration	Evaluations	-2 Log Like	Criterion
0	1	716.11581334	
1	1	635.97527189	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr Z
UN(1,1)	id	32.4703	12.4538	2.61	0.0046
UN(2,1)	id	-2.2048	0.8359	-2.64	0.0083
UN(2,2)	id	0.1525	0.05638	2.71	0.0034
Residual		0.3347	0.05227	6.40	<.0001

Fit Statistics	
-2 Log Likelihood	636.0
AIC (Smaller is Better)	650.0
AICC (Smaller is Better)	650.4
BIC (Smaller is Better)	666.8

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
3	80.14	<.0001

Solution for Fixed Effects						
Effect	age_14	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		1.1718	0.1255	81	9.33	<.0001
age_14	0	-0.5413	0.1249	81	-4.33	<.0001
age_14	1	-0.2081	0.1001	81	-2.08	0.0408
age_14	2	0	.	.	.	.

Here we'll add coa and an interaction between coa and age.

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model D";
  class id;
  model alcuse = coa age_14 coa*age_14/solution notest;
  random intercept age_14/type=un sub=id;
```

Iteration History			
Iteration	Evaluations	-2 Log Like	Criterion
0	1	687.35255332	
1	1	621.20261939	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr Z
UN(1,1)	id	0.4876	0.1278	3.81	<.0001
UN(2,1)	id	-0.05934	0.06573	-0.90	0.3666
UN(2,2)	id	0.1506	0.05639	2.67	0.0038
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Log Likelihood	621.2
AIC (Smaller is Better)	637.2
AICC (Smaller is Better)	637.8
BIC (Smaller is Better)	656.5

Null Model Likelihood Ratio Test		
DF	**Chi-Square**	**Pr > ChiSq**
3	66.15	<.0001

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.3160	0.1307	80	2.42	0.0179
coa	0.7432	0.1946	82	3.82	0.0003
age_14	0.2930	0.08423	80	3.48	0.0008
coa*age_14	-0.04943	0.1254	82	-0.39	0.6944

Now we'll add peer and an interaction between peer and age.

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model E";
  class id;
  model alcuse = coa peer age_14 coa*age_14 peer*age_14 /solution notest;
  random intercept age_14/type=un sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Log Like**	**Criterion**
0	1	642.55331293	
1	1	588.69064871	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr Z
UN(1,1)	id	0.2409	0.09259	2.60	0.0046
UN(2,1)	id	-0.00612	0.05500	-0.11	0.9115
UN(2,2)	id	0.1391	0.05481	2.54	0.0056
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Log Likelihood	588.7
AIC (Smaller is Better)	608.7
AICC (Smaller is Better)	609.6
BIC (Smaller is Better)	632.8

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
3	53.86	<.0001

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	-0.3165	0.1481	79	-2.14	0.0356
coa	0.5792	0.1625	82	3.56	0.0006
peer	0.6943	0.1115	82	6.23	<.0001
age_14	0.4294	0.1137	79	3.78	0.0003
coa*age_14	-0.01403	0.1248	82	-0.11	0.9107
peer*age_14	-0.1498	0.08564	82	-1.75	0.0840

```
proc mixed data=alcohol1_pp method=ml noclprint noinfo covtest;
  title2 "Model F";
  class id;
  model alcuse = coa peer age_14 peer*age_14 /solution notest;
  random intercept age_14/type=un sub=id;
```

Iteration History			
Iteration	**Evaluations**	**-2 Log Like**	**Criterion**
0	1	642.56307121	
1	2	588.70329648	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr Z**
UN(1,1)	id	0.2409	0.09259	2.60	0.0046
UN(2,1)	id	-0.00614	0.05501	-0.11	0.9111
UN(2,2)	id	0.1392	0.05481	2.54	0.0056
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Log Likelihood	588.7
AIC (Smaller is Better)	606.7
AICC (Smaller is Better)	607.5
BIC (Smaller is Better)	628.4

Null Model Likelihood Ratio Test		
DF	**Chi-Square**	**Pr > ChiSq**
3	53.86	<.0001

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	-0.3138	0.1461	79	-2.15	0.0348
coa	0.5712	0.1462	82	3.91	0.0002
peer	0.6952	0.1113	82	6.25	<.0001
age_14	0.4247	0.1056	80	4.02	0.0001
peer*age_14	-0.1514	0.08451	82	-1.79	0.0770

Now we'll rerun the best model and look at the results.

```
proc mixed data=alcohol1_pp covtest;
  title2 "Model F";
  class id;
  model alcuse = coa cpeer age_14 cpeer*age_14 /solution;
  random intercept age_14/type=un sub=id;
  run;
```

Model Information	
Data Set	WORK.ALCOHOL1_PP
Dependent Variable	alcuse
Covariance Structure	Unstructured
Subject Effect	id
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
id	82	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

Dimensions	
Covariance Parameters	4
Columns in X	5
Columns in Z per Subject	2
Subjects	82
Max Obs per Subject	3

Number of Observations	
Number of Observations Read	246
Number of Observations Used	246
Number of Observations Not Used	0

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	658.45827217	
1	2	603.69775945	0.00000000

Convergence criteria met.

Covariance Parameter Estimates					
Cov Parm	**Subject**	**Estimate**	**Standard Error**	**Z Value**	**Pr Z**
UN(1,1)	id	0.2594	0.09639	2.69	0.0036
UN(2,1)	id	-0.01049	0.05680	-0.18	0.8534
UN(2,2)	id	0.1468	0.05641	2.60	0.0046
Residual		0.3373	0.05268	6.40	<.0001

Fit Statistics	
-2 Res Log Likelihood	603.7
AIC (Smaller is Better)	611.7
AICC (Smaller is Better)	611.9
BIC (Smaller is Better)	621.3

Null Model Likelihood Ratio Test		
DF	**Chi-Square**	**Pr > ChiSq**
3	54.76	<.0001

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.3939	0.1054	79	3.74	0.0004
coa	0.5712	0.1490	82	3.83	0.0002
cpeer	0.6952	0.1132	82	6.14	<.0001
age_14	0.2706	0.06203	80	4.36	<.0001
cpeer*age_14	-0.1514	0.08556	82	-1.77	0.0806

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
coa	1	82	14.70	0.0002
cpeer	1	82	37.70	<.0001
age_14	1	80	19.03	<.0001
cpeer*age_14	1	82	3.13	0.0806