Example 4b: Multivariate General Linear Models for Family (Triadic) Data
Part 1 in SAS MIXED and STATAMIXED; Part 2 also in Mplus and STATA SEM
(complete syntax and output available for SAS and STATA electronically)

These data were collected as part of a study of family dynamics conducted at Penn State University. The sample for this example includes 141 families with data from three family members: a mother, a father, and an adult child. The example outcome is a scale mean (range from 1–4) of attitudes about gender roles in marriage, in which higher scores indicate more conservative attitudes. The example predictors are the gender of the adult child (0=girl, 1=boy) and the years of education of each family member (centered such that 0=12 years). The observed outcome distributions of the showed some positive skew (with an observed floor effect for the adult children), but a conditional multivariate normal distribution appears to be adequate. This is evidenced in the final model by a Pearson $\chi^2/DF \approx .30$ for each outcome, as well as predicted outcomes that stayed within the outcome bounds without the use a link function to do so.

We will predict all family members' outcomes simultaneously two ways. In Part 1 we will estimate multivariate general linear models in SAS MIXED and STATA MIXED with conditional normal distributions using residual maximum likelihood (REML), and we will text fixed effects using Satterthwaite denominator degrees of freedom. Note that STATA provides incorrect AIC and BIC values using REML (it counts all parameters instead of variance parameters only), so those values are not referred to below. In Part 2, we will estimate the same models using path analysis in Mplus and STATA SEM, whose software restrictions mean we must switch to maximum likelihood and text fixed effects without denominator degrees of freedom. Finally, we will use an unstructured **R** matrix for all models (in which all variances and covariances are estimated separately without constraints).

Part 1: Multivariate General Linear Models via Univariate MIXED Software

Original data in <u>wide</u> format (was one row per family, person variables in separate columns):

	FamilyID: Family ID Number	KidBoy: Kid's Gender (0=girl, 1=boy)	KidEd12: Kid's Years of Education (0=12)	MomEd12: Mother's Years of Edcation (0=12)	DadEd12: Father's Years of Edcation (0=12)	KidMarital: Kid's Marital Gender Attitudes Mean (1-4)	MomMarital: Mom's Marital Gender Attitudes Mean (1-4)	DadMarital: Dad's Marital Gender Attitudes Mean (1-4)
1	3996	1	2	2	2	1	1.8333333333	1
2	4425	1	3	0	0	1	1.3333333333	2.5

New data in <u>stacked</u> format (one row per person per family) after transformation code below:

	FamilyID: Family ID Number	KidBoy: Kid's Gender (0=girl, 1=boy)	KidEd12: Kid's Years of Education (0=12)	MomEd12: Mother's Years of Edcation (0=12)	DadEd12: Father's Years of Edcation (0=12)	DV: 1K,2M,3D	kid: Is Adult Child (0=no, 1=yes)	mom: Is Mother (0=no, 1=yes)	dad: Is Father (0=no, 1=yes)	ed12: Person's Years of Education (0=12)	marital: Marital Gender Attitudes Mean (1-4)
1	3996	1	2	2	2	1.Kid	1	0	0	2	1
2	3996	1	2	2	2	2.Mom	0	1	0	2	1.8333333333
3	3996	1	2	2	2	3.Dad	0	0	1	2	1
4	4425	1	3	0	0	1.Kid	1	0	0	3	1
5	4425	1	3	0	0	2.Mom	0	1	0	0	1.3333333333
6	4425	1	3	0	0	3.Dad	0	0	1	0	2.5

STATA Syntax for Importing and Stacking Wide into Univariate (now one row <u>per person per family</u>):

```
// Define global variable for file location to be replaced in code below
   global filesave "C:\Dropbox\20_PSQF7375_Generalized\PSQF7375_Generalized_Example4b"

// Import example 4b multivariate data
   use "$filesave\Example4bWide.dta", clear

// Rename variables with numeric suffix to use with reshape (old)(new)
   rename (kidmarital mommarital dadmarital) (marital1 marital2 marital3)

// Stack data: list multivariate variables first, i(higher index) j(repeated)
   reshape long marital, i(familyid) j(DV)
```

```
// Create value labels and apply to dv
   label define dvlabel 1 "1.Kid" 2 "2.Mom" 3 "3.Dad"
   label values DV dvlabel

// Create dummy codes
   gen kid=0
   gen mom=0
   gen dad=0
   recode kid (0=1) if DV==1
   recode mom (0=1) if DV==2
   recode dad (0=1) if DV==3

// Label new variables
   label variable DV      "DV: 1K,2M,3D"
   label variable kid     "kid: Is Adult Child (0=no, 1=yes)"
   label variable mom     "mom: Is Mother (0=no, 1=yes)"
   label variable dad     "dad: Is Father (0=no, 1=yes)"
   label variable marital "marital: Marital Gender Attitudes Mean (1-4)"
```

SAS Syntax for Importing and Stacking Wide into Univariate (now one row <u>per person per family</u>):

```
* Define global variable for file location to be replaced in code below;
%LET filesave= C:\Dropbox\20_PSQF7375_Generalized\PSQF7375_Generalized_Example4b;
* Location for SAS files for these models (uses macro variable filesave);
LIBNAME filesave "&filesave.";

* Import example 4b multivariate data into work library and stack it;
DATA work.Example4b; SET filesave.Example4bWide; * Adding own ed for demo purposes;
     DV="1.Kid"; kid=1; mom=0; dad=0; ed12=KidEd12; marital=KidMarital; OUTPUT;
     DV="2.Mom"; kid=0; mom=1; dad=0; ed12=MomEd12; marital=MomMarital; OUTPUT;
     DV="3.Dad"; kid=0; mom=0; dad=1; ed12=DadEd12; marital=DadMarital; OUTPUT;
     LABEL DV=      "DV: 1K,2M,3D"
           kid=     "kid: Is Adult Child (0=no, 1=yes)"
           mom=     "mom: Is Mother (0=no, 1=yes)"
           dad=     "dad: Is Father (0=no, 1=yes)"
           ed12=    "ed12: Person's Years of Ed (0=12)"
           marital= "marital: Marital Gender Attitudes Mean (1-4)";
     DROP KidMarital MomMarital DadMarital; * Remove original outcomes; RUN;
```

Model 0: Empty Means, Unstructured Variance Model for Marital Conservative Gender Attitudes
Two Ways for DV-Specific Intercept Version: $\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

```
display as result "STATA Empty Means, Unstructured Variance Model for Marital Attitudes"
display as result "STATA DV-Specific Intercept Version using Dummy Codes"
mixed marital c.kid c.mom c.dad,  ///
         noconstant /// Remove fixed intercept
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  test (c.kid=c.mom)(c.kid=c.dad), small  // DF=2 Diff in Intercept
  lincom c.kid*-1 + c.mom*1, small // Kid vs. Mom: Intercept Diff
  lincom c.kid*-1 + c.dad*1, small // Kid vs. Dad: Intercept Diff
  lincom c.mom*-1 + c.dad*1, small // Mom vs. Dad: Intercept Diff

display as result "STATA DV-Specific Intercept Version using Categorical DV"
mixed marital ibn.DV,  ///
         noconstant /// Remove fixed intercept and keep all DV levels
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  test (1.DV=2.DV)(1.DV=3.DV), small  // DF=2 Diff in Intercept
  lincom 1.DV*-1 + 2.DV*1, small // Kid vs. Mom: Intercept Diff
  lincom 1.DV*-1 + 3.DV*1, small // Kid vs. Dad: Intercept Diff
  lincom 2.DV*-1 + 3.DV*1, small // Mom vs. Dad: Intercept Diff
```

```
TITLE2 "SAS DV-Specific Intercept Version using Dummy Codes";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom dad / NOINT SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     CONTRAST "DF=2 Diff in Intercept?" kid -1 mom 1, kid -1 dad 1;
     ESTIMATE "Kid vs. Mom: Intercept Diff"  kid -1 mom 1;
     ESTIMATE "Kid vs. Dad: Intercept Diff"  kid -1 dad 1;
     ESTIMATE "Mom vs. Dad: Intercept Diff"  mom -1 dad 1;
RUN; TITLE2;

TITLE2 "SAS DV-Specific Intercept Version using Categorical DV";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = DV / NOINT SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     CONTRAST "DF=2 Diff in Intercept?"  DV -1 0 1, DV -1 1 0;
     ESTIMATE "Kid vs. Mom: Intercept Diff"  DV -1  1  0;
     ESTIMATE "Kid vs. Dad: Intercept Diff"  DV -1  0  1;
     ESTIMATE "Mom vs. Dad: Intercept Diff"  DV  0 -1  1;
RUN; TITLE2;
```

Two Ways for General Intercept Version: $\widehat{Marital}_{fi} = \beta_{00} + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

```
display as result "STATA General Intercept Version using Dummy Codes"
mixed marital c.kid c.mom,  ///
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  test (c.kid=0)(c.mom=0), small   // DF=2 Diff in Intercept
  lincom _cons*1  + c.kid*1, small // Kid Intercept
  lincom _cons*1  + c.mom*1, small // Mom Intercept
  lincom c.kid*-1 + c.mom*1, small // Kid vs. Mom: Intercept Diff

display as result "STATA General Intercept Version using Categorical DV"
mixed marital ib(last).DV,  ///
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  test (1.DV=2.DV)(1.DV=3.DV), small  // DF=2 Diff in Intercept
  lincom _cons*1 + 1.DV*1, small   // Kid Intercept
  lincom _cons*1 + 2.DV*1, small   // Mom Intercept
  lincom 1.DV*-1 + 2.DV*1, small   // Kid vs. Mom: Intercept Diff

TITLE2 "SAS General Intercept Version using Dummy Codes";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom / SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     CONTRAST "DF=2 Diff in Intercept?" kid 1, mom 1;
     ESTIMATE "Kid Intercept"           intercept 1 kid 1 mom 0;
     ESTIMATE "Mom Intercept"           intercept 1 kid 0 mom 1;
     ESTIMATE "Kid vs. Mom: Intercept Diff"  kid -1 mom 1;
RUN; TITLE2;

TITLE2 "SAS General Intercept Version using Categorical DV";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = DV / SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     CONTRAST "DF=2 Diff in Intercept?" DV -1 0 1, DV -1 1 0;
     ESTIMATE "Kid Intercept"           intercept 1 DV 1 0 0;
     ESTIMATE "Mom Intercept"           intercept 1 DV 0 1 0;
     ESTIMATE "Kid vs. Mom: Intercept Diff"  DV -1 1 0;
RUN; TITLE2; TITLE1;
```

SAS Output—Variance parameters, fit statistics, and contrasts are the same from all four Model 0 variants:

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	729.02493914	
1	2	**706.95470511**	0.00000000

For your homework using SAS, get your −2LL value from this table to get two digits after the decimal.

Estimated R Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	**0.3312**	0.04133	0.08240
2	0.04133	**0.3230**	0.09371
3	0.08240	0.09371	**0.3196**

Estimated R Correlation Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	1.0000	0.1264	0.2533
2	**0.1264**	1.0000	0.2917
3	**0.2533**	**0.2917**	1.0000

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr Z	
UN(1,1)	FamilyID	0.3312	0.03973	8.34	<.0001	Variance across Kids
UN(2,1)	FamilyID	0.04133	0.02796	1.48	0.1394	Kid-Mom Covariance
UN(2,2)	FamilyID	0.3230	0.03875	8.34	<.0001	Variance across Moms
UN(3,1)	FamilyID	0.08240	0.02847	2.89	0.0038	Kid-Dad Covariance
UN(3,2)	FamilyID	0.09371	0.02839	3.30	0.0010	Mom-Dad Covariance
UN(3,3)	FamilyID	0.3196	0.03834	8.34	<.0001	Variance across Dads

Fit Statistics

-2 Res Log Likelihood	706.95
AIC (Smaller is Better)	719.0
AICC (Smaller is Better)	719.2
BIC (Smaller is Better)	736.6

Contrasts

Label	Num DF	Den DF	F Value	Pr > F
DF=2 Diff in Intercept?	2	139	16.19	<.0001

Model-Estimated Fixed Effects from <u>DV-Specific Intercept Version</u> using Dummy Codes:

$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|	
kid	1.6295	0.04864	139	33.50	<.0001	Kid intercept B01
mom	1.8998	0.04803	139	39.55	<.0001	Mom intercept B02
dad	1.9560	0.04778	139	40.94	<.0001	Dad intercept B00

Model-Estimated Fixed Effects from <u>DV-Specific Intercept Version</u> using Categorical DV:

$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

Solution for Fixed Effects

Effect	DV: 1K,2M,3D	Estimate	Standard Error	DF	t Value	Pr > |t|	
DV	1.Kid	1.6295	0.04864	139	33.50	<.0001	Kid intercept B01
DV	2.Mom	1.8998	0.04803	139	39.55	<.0001	Mom intercept B02
DV	3.Dad	1.9560	0.04778	139	40.94	<.0001	Dad intercept B00

Requested Linear Combination Estimates from <u>DV-Specific Intercept Version</u> either way:

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	
Kid vs. Mom: Intercept Diff	0.2702	0.06389	139	4.23	<.0001	B02 - B01
Kid vs. Dad: Intercept Diff	0.3264	0.05892	139	5.54	<.0001	B00 - B01
Mom vs. Dad: Intercept Diff	0.05619	0.05702	139	0.99	0.3261	B00 - B02

Model-Estimated Fixed Effects from General Intercept Version using Dummy Codes:

Solution for Fixed Effects $\widehat{Marital}_{fi} = \beta_{00} + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|		
Intercept	1.9560	0.04778	139	40.94	<.0001	Dad intercept	B00
kid	-0.3264	0.05892	139	-5.54	<.0001	Kid intercept diff	B01
mom	-0.05619	0.05702	139	-0.99	0.3261	Mom intercept diff	B02

Model-Estimated Fixed Effects from General Intercept Version using Categorical DV:

Solution for Fixed Effects $\widehat{Marital}_{fi} = \beta_{00} + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi})$

Effect	DV: 1K,2M,3D	Estimate	Standard Error	DF	t Value	Pr > |t|		
Intercept		1.9560	0.04778	139	40.94	<.0001	Dad intercept	B00
DV	1.Kid	-0.3264	0.05892	139	-5.54	<.0001	Kid intercept diff	B01
DV	2.Mom	-0.05619	0.05702	139	-0.99	0.3261	Mom intercept diff	B02
DV	3.Dad	0	.	.	.	.		

Requested Linear Combination Estimates from General Intercept Version either way:

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	
Kid Intercept	1.6295	0.04864	139	33.50	<.0001	B00 + B01
Mom Intercept	1.8998	0.04803	139	39.55	<.0001	B00 + B02
Kid vs. Mom: Intercept Diff	0.2702	0.06389	139	4.23	<.0001	B02 - B01

To avoid confusion, we will proceed using the first of the four approaches: DV-specific intercepts implemented via dummy codes. This approach also aligns most directly with path model variants of these models (Part 2).

Model 1: DV-Specific Intercept Version adding Kid's Gender as Predictor for Each Attitude

$$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi}) + \beta_{10}(Dad_{fi})(KidBoy_f) + \beta_{11}(Kid_{fi})(KidBoy_f) + \beta_{12}(Mom_{fi})(KidBoy_f)$$

```
display as result "STATA DV-Specific Intercept Version -- Add Kid Gender"
mixed marital c.kid c.mom c.dad c.kid#c.kidboy c.mom#c.kidboy c.dad#c.kidboy,  ///
         noconstant /// Remove fixed intercept
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  test (c.kid#c.kidboy=c.mom#c.kidboy)(c.kid#c.kidboy=c.dad#c.kidboy), small  // DF=2 Diff in Kidboy Effect
  lincom c.kid#c.kidboy*-1 + c.mom#c.kidboy*1, small // Kid vs. Mom: Kidboy Effect Diff
  lincom c.kid#c.kidboy*-1 + c.dad#c.kidboy*1, small // Kid vs. Dad: Kidboy Effect Diff
  lincom c.mom#c.kidboy*-1 + c.dad#c.kidboy*1, small // Mom vs. Dad: Kidboy Effect Diff
  lincom 0.5*(c.mom#c.kidboy*1 + c.dad#c.kidboy*1), small // Parent: Kidboy Effect
  lincom 0.5*(c.kid#c.kidboy*-2 + c.mom#c.kidboy*1 + c.dad#c.kidboy*1), small // M vs. D: Kidboy Effect Diff
```

```
TITLE "SAS DV-Specific Intercept Version -- Add Kid Gender";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom dad kid*KidBoy mom*KidBoy dad*KidBoy
                     / NOINT SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
      CONTRAST "DF=2 Diff in KidBoy Effect?" kid*KidBoy -1 Mom*KidBoy 1, kid*KidBoy -1 Dad*KidBoy 1;
      ESTIMATE "Kid vs. Mom: KidBoy Effect Diff"  kid*KidBoy -1 Mom*KidBoy 1;
      ESTIMATE "Kid vs. Dad: KidBoy Effect Diff"  kid*KidBoy -1 Dad*KidBoy 1;
      ESTIMATE "Mom vs. Dad: KidBoy Effect Diff"  Mom*KidBoy -1 Dad*KidBoy 1;
      ESTIMATE "Parent KidBoy Effect" Mom*KidBoy 1 Dad*KidBoy 1 / DIVISOR=2;
      ESTIMATE "Kid vs. Parents: KidBoy Effect Diff" Kid*KidBoy -2  Mom*KidBoy 1 Dad*KidBoy 1 / DIVISOR=2;
RUN; TITLE;
```

SAS Output for Model 1:

Estimated R Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	0.3136	0.03725	0.07733
2	0.03725	0.3244	0.09315
3	0.07733	0.09315	0.3203

Estimated R Correlation Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	1.0000	0.1168	0.2440
2	0.1168	1.0000	0.2890
3	0.2440	0.2890	1.0000

Fit Statistics

-2 Res Log Likelihood	707.01
AIC (Smaller is Better)	719.0
AICC (Smaller is Better)	719.2
BIC (Smaller is Better)	736.7

Contrasts

Label	Num DF	Den DF	F Value	Pr > F
DF=2 Diff in KidBoy Effect?	2	138	1.90	0.1529

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|	
kid	1.4950	0.06554	138	22.81	<.0001	Kid intercept B01
mom	1.8703	0.06666	138	28.06	<.0001	Mom intercept B02
dad	1.9178	0.06624	138	28.95	<.0001	Dad intercept B00
kid*KidBoy	0.2811	0.09474	138	2.97	0.0035	girl vs boy for Kid B11
mom*KidBoy	0.06152	0.09636	138	0.64	0.5242	girl vs boy for Mom B12
dad*KidBoy	0.07970	0.09575	138	0.83	0.4066	girl vs boy for Dad B10

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	
Kid vs. Mom: Diff in KidBoy Effect	-0.2196	0.1270	138	-1.73	0.0860	B12 - B11
Kid vs. Dad: Diff in KidBoy Effect	-0.2014	0.1171	138	-1.72	0.0877	B10 - B11
Mom vs. Dad: Diff in KidBoy Effect	0.01818	0.1145	138	0.16	0.8741	B10 - B12
Parent KidBoy Effect	0.07061	0.07711	138	0.92	0.3614	.5*(B10+B12)
Kid vs. Parents: KidBoy Effect Diff	-0.2105	0.1079	138	-1.95	0.0531	.5*(B10+B12)-B11

It looks like we need to control for the effect of kid gender only for the kid. In the next model we'll test the effects of each person's education on their own attitude, followed by the incremental effect of dad's education on kid and mom attitudes after controlling for their own education.

Model 2: DV-Specific Intercept Version adding Own Education as Predictor of Own Attitude

$$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi}) + \beta_{11}(Kid_{fi})(KidBoy_f) + \beta_{20}(Dad_{fi})(DadEd_f - 12) + \beta_{31}(Kid_{fi})(KidEd_f - 12) + \beta_{42}(Mom_{fi})(MomEd_f - 12)$$

```
display as result "STATA DV-Specific Intercept Version -- KidBoy on Kid Only, Add Own Education"
mixed marital c.kid c.mom c.dad c.kid#c.kidboy ///
              c.kid#c.kided12 c.mom#c.momed12 c.dad#c.daded12,  ///
         noconstant /// Remove fixed intercept
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix

TITLE "SAS DV-Specific Intercept Version -- KidBoy on Kid Only, Add Own Education";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom dad kid*KidBoy kid*KidEd12 mom*MomEd12 dad*DadEd12
                     / NOINT SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
RUN; TITLE;
```

SAS Output for Model 2:

```
   Estimated R Matrix for FAMILYID 3996
 Row        Col1        Col2        Col3
   1      0.3156     0.03837     0.07669
   2     0.03837      0.3205     0.08441
   3     0.07669     0.08441      0.2979

Estimated R Correlation Matrix for FAMILYID
3996
Row        Col1        Col2        Col3
  1      1.0000      0.1207      0.2501
  2      0.1207      1.0000      0.2732
  3      0.2501      0.2732      1.0000

          Fit Statistics
-2 Res Log Likelihood           708.64
AIC (Smaller is Better)         720.6
AICC (Smaller is Better)        720.8
BIC (Smaller is Better)         738.3

                       Solution for Fixed Effects
                         Standard
Effect         Estimate      Error      DF    t Value    Pr > |t|
kid              1.5117    0.09814     141      15.40      <.0001  Kid intercept B01
mom              1.9359    0.05976     142      32.39      <.0001  Mom intercept B02
dad              2.0700    0.05663     145      36.55      <.0001  Dad intercept B00
kid*KidBoy       0.2641    0.09204     137       2.87      0.0048  girl vs boy for Kid B11
kid*KidEd12    -0.00280    0.02344     138      -0.12      0.9052  Kid Ed for kid B31
mom*MomEd12    -0.01725    0.01711     142      -1.01      0.3150  Mom Ed for mom B42
dad*DadEd12    -0.05447    0.01570     143      -3.47      0.0007  Dad Ed for dad B20
```

Model 3: DV-Specific Intercept Version adding Dad Education as Predictor of Kid and Mom Attitudes

$$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi}) + \beta_{11}(Kid_{fi})(KidBoy_f) + \beta_{20}(Dad_{fi})(DadEd_f - 12) + \beta_{31}(Kid_{fi})(KidEd_f - 12) + \beta_{42}(Mom_{fi})(MomEd_f - 12) + \beta_{21}(Kid_{fi})(DadEd_f - 12) + \beta_{22}(Mom_{fi})(DadEd_f - 12)$$

```
display as result "STATA DV-Specific Intercept Version -- Add Dad Educ (Control for Own Educ)"
mixed marital c.kid c.mom c.dad c.kid#c.kidboy c.kid#c.kided12 c.mom#c.momed12 ///
              c.dad#c.daded12 c.kid#c.daded12 c.mom#c.daded12,  ///
         noconstant /// Remove fixed intercept
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  lincom c.kid#c.daded12*-1 + c.mom#c.daded12*1, small // Kid vs. Mom: Dad Educ Effect Diff
  lincom c.kid#c.daded12*-1 + c.dad#c.daded12*1, small // Kid vs. Dad: Dad Educ Effect Diff
  lincom c.mom#c.daded12*-1 + c.dad#c.daded12*1, small // Mom vs. Dad: Dad Educ Effect Diff

TITLE "SAS DV-Specific Intercept Version -- Add Dad Educ (Controlling for Own Educ)";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom dad kid*KidBoy Kid*KidEd12 Mom*MomEd12 Dad*DadEd12
                     Kid*DadEd12 Mom*DadEd12 / NOINT SOLUTION DDFM=Satterthwaite;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     ESTIMATE "Kid vs. Mom: Dad Educ Effect Diff"  kid*DadEd12 -1 mom*DadEd12 1;
     ESTIMATE "Kid vs. Dad: Dad Educ Effect Diff"  kid*DadEd12 -1 dad*DadEd12 1;
     ESTIMATE "Mom vs. Dad: Dad Educ Effect Diff"  mom*DadEd12 -1 dad*DadEd12 1;
RUN; TITLE;
```

SAS Output for Model 3:

```
   Estimated R Matrix for FAMILYID 3996
 Row        Col1        Col2        Col3
   1      0.3179     0.03856     0.07720
   2     0.03856      0.3229     0.08514
   3     0.07720     0.08514      0.2982

Estimated R Correlation Matrix for FAMILYID 3996
Row        Col1        Col2        Col3
  1      1.0000      0.1204      0.2508
  2      0.1204      1.0000      0.2744
  3      0.2508      0.2744      1.0000
```

Fit Statistics	
-2 Res Log Likelihood	720.78
AIC (Smaller is Better)	732.8
AICC (Smaller is Better)	733.0
BIC (Smaller is Better)	750.4

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|	
kid	1.5123	0.1003	140	15.08	<.0001	Kid intercept B01
mom	1.9373	0.06305	138	30.73	<.0001	Mom intercept B02
dad	2.0707	0.05769	138	35.89	<.0001	Dad intercept B00
kid*KidBoy	0.2639	0.09258	136	2.85	0.0050	girl vs boy for Kid B11
kid*KidEd12	-0.00264	0.02458	136	-0.11	0.9147	Kid Ed for kid B31
mom*MomEd12	-0.01624	0.02068	137	-0.79	0.4338	Mom Ed for mom B42
dad*DadEd12	-0.05484	0.01654	138	-3.32	0.0012	Dad Ed for dad B20
kid*DadEd12	-0.00048	0.01791	138	-0.03	0.9787	Dad Ed for kid B21
mom*DadEd12	-0.00169	0.02069	141	-0.08	0.9349	Dad Ed for mom B22

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	
Kid vs. Mom: Dad Educ Effect Diff	-0.00121	0.02601	162	-0.05	0.9629	B22 - B21
Kid vs. Dad: Dad Educ Effect Diff	-0.05436	0.02127	143	-2.56	0.0117	B20 - B21
Mom vs. Dad: Dad Educ Effect Diff	-0.05314	0.02335	154	-2.28	0.0242	B20 - B22

Moral of the story? Multivariate models can be estimated in univariate software to capture the relationships between person-specific predictors and person-specific outcomes (such as in "actor–partner" models for dyadic data as well).

Example results section for Part 1 Models 0–3:

The extent to which gender and education predicted marital attitudes was examined in 141 families, in which responses were collected from adult children, their mothers, and their fathers, and in which higher outcomes indicated more conservative marital attitudes (i.e., gender-traditional attitudes measured as the mean across items on a scale of 1 to 4). Given that the outcomes were correlated within families, multivariate general linear models (i.e., with conditionally multivariate normal residuals) were used to predict all three outcomes for each family simultaneously. All models were estimated using residual maximum likelihood and Satterthwaite denominator degrees of freedom. All models allowed separate means and residual variances across the three outcomes for the three types of family members, as well as covariances among the residuals from the same family. ESTIMATE statements were used to estimate simple slopes and simple slope differences as linear combinations of the model fixed effects. Prior to adding predictors, an empty means model (i.e., an unconditional model with no predictors) revealed significant differences in marital attitudes across type of family member, $F(2,139) = 1.19$, $p < .001$. Although mean attitudes were similar across mothers and fathers (1.90 and 1.96, respectively, $p = .27$), the mean attitudes of children (1.63) were significantly less conservative on average than those of their parents ($p < .001$ for both comparisons).

To begin, we examined the extent to which the gender of the adult child (coded 0=woman, 1=man) who was surveyed was related to the martial attitudes of each type of family member. Although the attitudes of adult male children were significantly more conservative than those of adult female children (diff = 0.28, $p = .004$), there were no significant effects of the gender of the adult child for the marital attitudes of their mothers or fathers. Thus, we retained a predictor for the gender of the adult child only for the adult child's outcome.

We then examined the extent to which the education (centered at 12 years) of each type of family member predicted their own attitudes, which was significant only for the father: for every additional year of father's education, his own attitudes were expected to be less conservative by 0.05 ($p < .001$). Next, we examined whether father's education incrementally predicted the marital attitudes of the mother or adult child after controlling for their own education, but neither effect was significant (and the effect of father's education on his own attitudes was significantly larger).

But how do we know if Model 3 is sufficient?? Stay tuned for Part 2 using path analysis (and Model 4 using MIXED)!

Part 2: Multivariate General Linear Models via Path Analysis Software

In Part 2, we begin by estimating Model 3 using path analysis in Mplus and STATA SEM, whose software restrictions mean we must switch to maximum likelihood and test fixed effects without denominator degrees of freedom.

STATA Syntax to import wide-format data for path models:

```
// Import example 4b multivariate data
   use "$filesave\Example4bWide.dta", clear

// Example of how to export .csv file for use in Mplus
// Replace all missing values with -999 for Mplus
   mvencode _all, mv(-999)

// export delimited below: using lists the path and name of the new .csv file
// replace means it will be replaced if a file already exists with that name
// delimiter indicates a comma-delimited file
// nolabel will save actual data (numbers) instead of any value labels included
// novarnames tells it not to write the names to the top of the .csv file
   export delimited using "$filesave\Example4bWide1.csv", ///
                    delimiter(",") replace nolabel novarnames

// Re-import example 4b multivariate data (without missing value codes)
   use "$filesave\Example4bWide.dta", clear
```

SAS Syntax to prepare wide-format data file in .csv format for Mplus:

```
* Export original wide format to Mplus;
DATA work.ForMplus; SET filesave.Example4bWide;
     * Fixing any missing values;
     ARRAY vars(8) FamilyID KidBoy KidEd12 MomEd12 DadEd12 KidMarital MomMarital DadMarital;
          DO i=1 TO 8; IF vars(i)=. THEN vars(i)=-999; END; RUN;
PROC EXPORT DATA=work.ForMplus OUTFILE= "&filesave.\Example4bWide.csv"
     DBMS=CSV REPLACE; PUTNAMES=NO; RUN;
```

Model 3: DV-Specific Intercept Version adding Dad Education as Predictor of Kid and Mom Attitudes

$$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi}) + \beta_{11}(Kid_{fi})(KidBoy_f) + \beta_{20}(Dad_{fi})(DadEd_f - 12) + \beta_{31}(Kid_{fi})(KidEd_f - 12) + \beta_{42}(Mom_{fi})(MomEd_f - 12) + \beta_{21}(Kid_{fi})(DadEd_f - 12) + \beta_{22}(Mom_{fi})(DadEd_f - 12)$$

STATA Syntax and Output for Previous Model 3 as a Path Model (estimated with ML; no denominator DF):

```
* /// means continue the command + comment
*  // means comment only

display as result "STATA Model 3: Own Education + Dad Education a Predictor of Each Attitude"
sem                                              ///
   (kidmarit mommarit dadmarit <- _cons)         /// All intercepts estimated (by default)
   (kidmarit <- kidboy kided12)                  /// Regressions: y outcomes ON x predictors
   (mommarit <- momed12)                         ///
   (kidmarit mommarit dadmarit <- daded12),      ///
    var(e.kidmarit e.mommarit e.dadmarit)        /// All residual variances estimated (by default)
    covariance(e.kidmarit*e.mommarit             /// All pairwise residual covariances (not default)
               e.mommarit*e.dadmarit             ///
               e.kidmarit*e.dadmarit)            ///
    method(mlmv)                                  // Full-information ML
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    sem, coeflegend                          // Print parameter labels, too (to use in lincom)
    sem, standardized                        // Print fully standardized solution, too
    estat gof, stats(all)                    // Print fit statistics
    estat eqgof                              // Print R2 per variable
```

```
    estat residuals                          // Print how far off each predicted covariance is
    estat mindices, minchi2(3.84) showpclass(all) // Print voodoo to improve model fit at p<.05

Structural equation model                    Number of obs     =        140
Estimation method  = mlmv
Log likelihood     = -1374.4822 → Does NOT match Mplus, but rest of the fit tests do match
------------------------------------------------------------------------------------------
UNSTANDARDIZED SOLUTION       |                 OIM
                              |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]   IN MIXED
------------------------------+-----------------------------------------------------------------
Structural                    |
  kidmarital <-               |
                       kidboy |   .2638938   .0914365     2.89   0.004     .0846816    .4431059    B11
                      kided12 |   -.002641   .0242338    -0.11   0.913    -.0501385    .0448565    B31
                      daded12 |  -.0004795   .0176566    -0.03   0.978    -.0350857    .0341268    B21
                        _cons |   1.512271   .0989087    15.29   0.000     1.318414    1.706129    B01
  ----------------------------+-----------------------------------------------------------------
  mommarital <-               |
                      momed12 |  -.0162593   .0211854    -0.77   0.443    -.0577819    .0252634    B42
                      daded12 |  -.0016793   .0206962    -0.08   0.935    -.0422431    .0388845    B22
                        _cons |   1.937305    .062596    30.95   0.000     1.814619    2.059991    B02
  ----------------------------+-----------------------------------------------------------------
  dadmarital <-               |
                      daded12 |  -.0548368    .016422    -3.34   0.001    -.0870233   -.0226502    B20
                        _cons |   2.070718   .0572756    36.15   0.000      1.95846    2.182976    B00
------------------------------+-----------------------------------------------------------------
            var(e.kidmarital)|   .3091381   .0369567                      .2445646    .3907613    UN(1,1)
            var(e.mommarital)|   .3161529   .0379111                      .2499347    .3999152    UN(2,2)
            var(e.dadmarital)|   .2938981   .0351275                      .2325192    .3714795    UN(3,3)
-----------------------------+-----------------------------------------------------------------
cov(e.kidmarital,e.mommarital)|   .0380059   .0266924     1.42   0.154    -.0143102     .090322    UN(2,1)
cov(e.kidmarital,e.dadmarital)|   .0761007   .0263037     2.89   0.004     .0245463    .1276551    UN(3,1)
cov(e.mommarital,e.dadmarital)|   .0839167   .0273732     3.07   0.002     .0302662    .1375671    UN(3,2)
------------------------------------------------------------------------------------------
LR test of model vs. saturated: chi2(6)   =     10.93, Prob > chi2 = 0.0906


.    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
 ( 1)  - [kidmarital]daded12 + [mommarital]daded12 = 0
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0011998   .0258607    -0.05   0.963    -.0518858    .0494862  B22 - B21
------------------------------------------------------------------------------

.    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
 ( 1)  - [kidmarital]daded12 + [mommarital]daded12 = 0
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0011998   .0258607    -0.05   0.963    -.0518858    .0494862  B20 - B21
------------------------------------------------------------------------------

.    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
 ( 1)  - [kidmarital]daded12 + [mommarital]daded12 = 0
------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0011998   .0258607    -0.05   0.963    -.0518858    .0494862  B20 - B22
------------------------------------------------------------------------------

.    sem, coeflegend                       // Print parameter labels, too (to use in lincom)
------------------------------------------------------------------------------
                              |      Coef.  Legend
------------------------------+-----------------------------------------------
Structural                    |
  kidmarital <-               |
                       kidboy |   .2638938  _b[kidmarital:kidboy]
                      kided12 |   -.002641  _b[kidmarital:kided12]
                      daded12 |  -.0004795  _b[kidmarital:daded12]
                        _cons |   1.512271  _b[kidmarital:_cons]
  ----------------------------+-----------------------------------------------
  mommarital <-               |
                      momed12 |  -.0162593  _b[mommarital:momed12]
                      daded12 |  -.0016793  _b[mommarital:daded12]
```

These unstandardized <- paths are the fixed slopes in MIXED.

Below are the residual variances and covariances from the **R** matrix in MIXED.

This table from `sem, coeflegend` provides the parameter names for the LINCOM statements above.

```
                       _cons |   1.937305  _b[mommarital:_cons]
  ---------------------------+-----------------------------------------------------------
  dadmarital <-              |
                     daded12 |  -.0548368  _b[dadmarital:daded12]
                       _cons |   2.070718  _b[dadmarital:_cons]
-----------------------------+-----------------------------------------------------------
             var(e.kidmarital)|   .3091381  _b[var(e.kidmarital):_cons]
             var(e.mommarital)|   .3161529  _b[var(e.mommarital):_cons]
             var(e.dadmarital)|   .2938981  _b[var(e.dadmarital):_cons]
-----------------------------+-----------------------------------------------------------
cov(e.kidmarital,e.mommarital)|   .0380059  _b[cov(e.kidmarital,e.mommarital):_cons]
cov(e.kidmarital,e.dadmarital)|   .0761007  _b[cov(e.kidmarital,e.dadmarital):_cons]
cov(e.mommarital,e.dadmarital)|   .0839167  _b[cov(e.mommarital,e.dadmarital):_cons]
-------------------------------------------------------------------------------------------
LR test of model vs. saturated: chi2(6)   =     10.93, Prob > chi2 = 0.0906


.    sem, standardized                     // Print fully standardized solution, too
-------------------------------------------------------------------------------------------
 Standardized Solution:      |                 OIM
 All variables M=0, SD=1     |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------------------+-------------------------------------------------------------
Structural                   |
  kidmarital <-              |
                      kidboy |   .2306503   .0770785     2.99   0.003     .0795792    .3817214
                     kided12 |  -.0090898   .0834042    -0.11   0.913    -.1725591    .1543794
                     daded12 |  -.0023406   .0861915    -0.03   0.978    -.1712728    .1665916
                       _cons |   2.645964   .2466043    10.73   0.000     2.162628    3.129299
  ---------------------------+-------------------------------------------------------------
  mommarital <-              |
                     momed12 |  -.0782303   .1019932    -0.77   0.443    -.2781333    .1216728
                     daded12 |  -.0083038   .1023122    -0.08   0.935     -.208832    .1922244
                       _cons |   3.433518   .2280257    15.06   0.000     2.986595     3.88044
  ---------------------------+-------------------------------------------------------------
  dadmarital <-              |
                     daded12 |  -.2716069   .0768234    -3.54   0.000     -.422178   -.1210357
                       _cons |   3.676054   .2200636    16.70   0.000     3.244738    4.107371
-----------------------------+-------------------------------------------------------------
             var(e.kidmarital)|   .9463698   .0355442                      .8792068    1.018663
             var(e.mommarital)|   .9930701   .0139521                      .9660976    1.020796
             var(e.dadmarital)|   .9262297   .0417315                      .8479448    1.011742
-----------------------------+-------------------------------------------------------------
cov(e.kidmarital,e.mommarital)|     .12157   .0835428     1.46   0.146    -.0421709    .2853109
cov(e.kidmarital,e.dadmarital)|   .2524724   .0792209     3.19   0.001     .0972022    .4077426
cov(e.mommarital,e.dadmarital)|   .2752969   .0801933     3.43   0.001     .1181209     .432473
-------------------------------------------------------------------------------------------

.    estat gof, stats(all)                  // Print fit statistics
-------------------------------------------------------------------------------
Fit statistic        |      Value   Description (from STATA!)                Notes from Lesa:
---------------------+---------------------------------------------------------
Likelihood ratio     |
          chi2_ms(6) |     10.929   model vs. saturated                      This is -2ΔLL for our H0-H1
            p > chi2 |      0.091                                            Test of exact fit: NS is good!
         chi2_bs(15) |     52.998   baseline vs. saturated                   This is -2ΔLL for H0-H1 if
            p > chi2 |      0.000                                            H0 had no paths at all
---------------------+---------------------------------------------------------
Population error     |
               RMSEA |      0.077   Root mean squared error of approximation  Should be < .08 or so
 90% CI, lower bound |      0.000
         upper bound |      0.148
              pclose |      0.229   Probability RMSEA <= 0.05                Test of exact fit: NS is good!
---------------------+---------------------------------------------------------
Information criteria |
                 AIC |   2778.964   Akaike's information criterion          Does not match Mplus
                 BIC |   2823.089   Bayesian information criterion          Does not match Mplus
---------------------+---------------------------------------------------------
Baseline comparison  |
                 CFI |      0.870   Comparative fit index                   Should be > .9 or so
                 TLI |      0.676   Tucker-Lewis index                     Should be > .9 or so
---------------------+---------------------------------------------------------
Size of residuals    |
                SRMR |      0.039   Standardized root mean squared residual  Should be < .05 or so
                  CD |      0.132   Coefficient of determination            Like an overall R2 across DVs
-------------------------------------------------------------------------------
```

These standardized <- paths are standardized regression coefficients.

These standardized covariances are residual correlations (in RCORR).

```
.    estat eqgof                          // Print R2 per variable
Equation-level goodness of fit
------------------------------------------------------------------------------
             |            Variance            |
     depvars |    fitted  predicted   residual | R-squared        mc      mc2
-------------+--------------------------------+------------------------------
observed     |                                |
  kidmarital |  .3266568   .0175187   .3091381 |  .0536302   .231582  .0536302
  mommarital |  .3183591   .0022062   .3161529 |  .0069299  .0832462  .0069299
  dadmarital |  .3173058   .0234077   .2938981 |  .0737703  .2716069  .0737703
-------------+--------------------------------+------------------------------
     overall |                                |  .1323532
------------------------------------------------------------------------------
mc  = correlation between depvar and its prediction
mc2 = mc^2 is the Bentler-Raykov squared multiple correlation coefficient

.    estat residuals                      // Print how far off each predicted covariance is
Residuals of observed variables
  Mean residuals
                | kidmari~l  mommari~l  dadmari~l     kidboy    kided12    momed12    daded12
    ------------+-----------------------------------------------------------------------------
            raw |     0.000      0.000      0.000      0.000      0.000      0.000      0.000
    ------------------------------------------------------------------------------------------
```

Above: the means are recovered perfectly because each outcome has its own intercept (and predictor means are not part of the model). Below: the bolded covariances indicate the biggest sources of misfit—it looks like momed12 needs to predict each outcome!

```
  Covariance residuals
                | kidmari~l  mommari~l  dadmari~l     kidboy    kided12    momed12    daded12
    ------------+-----------------------------------------------------------------------------
      kidmarital |     0.002
      mommarital |     0.003      0.002
      dadmarital |     0.004      0.005      0.000
          kidboy |     0.004      0.015      0.014      0.000
         kided12 |    -0.001      0.016     -0.008      0.000      0.000
         momed12 |     0.068     -0.072     -0.280      0.000      0.000      0.000
         daded12 |    -0.000     -0.000     -0.000      0.000      0.000      0.000      0.000
    ------------------------------------------------------------------------------------------

.   estat mindices, minchi2(3.84) showpclass(all)  // Print voodoo to improve model fit at p<.05
Modification indices
-------------------------------------------------------------
                |                                  Standard
                |        MI     df   P>MI        EPC        EPC
----------------+--------------------------------------------
Structural      |
  dadmarital <- |
     mommarital |     9.061      1   0.00    3.68633   3.692443  This is already in the model as a cov
        momed12 |     9.061      1   0.00  -.0599371  -.2888608  This is MomEd → DadMarit
-------------------------------------------------------------
EPC = expected parameter change
```

Mplus Syntax and Output for Previous Model 3 as a Path Model (estimated with ML; no denominator DF):

```
!!!!!!!!!!!!!!!!!!!!!!!!! Mplus Lines Cannot Exceed 90 Characters !!!!!!!!!!!!!!!!!!!!
TITLE: Mplus Model 3: Own Education + Dad Education a Predictor of Each Attitude;

DATA:    FILE = Example4bWide.csv;  ! Can just list file name if in same folder;
         FORMAT = free;             ! FREE (default) or FIXED format;
         TYPE = individual;         ! Individual (default) or matrix data as input;

VARIABLE:
! List of ALL variables in original wide data file, in order;
! Mplus names must use 8 characters or fewer (so rename as needed);
  NAMES ARE FamilyID KidBoy KidEd12 MomEd12 DadEd12 KidMarit MomMarit DadMarit;
! List of ALL variables used in model;
  USEVARIABLES ARE KidBoy KidEd12 MomEd12 DadEd12 KidMarit MomMarit DadMarit;
! Missing data codes (here, -999);
  MISSING ARE ALL (-999);

ANALYSIS:    TYPE IS GENERAL;     ! Used for path models;
             ESTIMATOR IS ML;     ! Full-information maximum likelihood;
```

```
OUTPUT:     CINTERVAL;          ! Print confidence intervals;
            STDYX;              ! Print fully standardized solution, too;
            RESIDUAL;           ! Print how far off each predicted covariance is;
            MODINDICES (3.84);  ! Print voodoo to improve our model fit at p<.05;

MODEL: ! * --> Estimated parameter (all listed below for clarity);

! All residual variances estimated separately (by default);
  KidMarit* MomMarit* DadMarit*;

! All possible pairwise residual covariances (not estimated by default);
  KidMarit MomMarit DadMarit WITH KidMarit* MomMarit* DadMarit*;

! All intercepts estimated separately (by default);
  [KidMarit* MomMarit* DadMarit*];

! Regressions: y outcomes ON x predictors (label to do math on later);
  KidMarit ON KidBoy* KidEd12*;
  MomMarit ON MomEd12*;
  KidMarit MomMarit DadMarit ON DadEd12* (DadEd2K DadEd2M DadEd2D);

! Getting differences in effect of DadEd for each person;
  MODEL CONSTRAINT:
  NEW (KvMDadEd KvDDadEd MvDDadEd); ! List names of linear combinations here;
  KvMDadEd = DadEd2M - DadEd2K;     ! Kid v. Mom: Dad Educ Effect Diff;
  KvDDadEd = DadEd2D - DadEd2K;     ! Kid v. Dad: Dad Educ Effect Diff;
  MvDDadEd = DadEd2D - DadEd2M;     ! Mom v. Dad: Dad Educ Effect Diff;
```

```
THE MODEL ESTIMATION TERMINATED NORMALLY
MODEL FIT INFORMATION

Number of Free Parameters                       15   Notes from Lesa:
Loglikelihood
          H0 Value                        -337.106   For our model: Larger is better
          H1 Value                        -331.641   For model with all possible paths estimated
Information Criteria
          Akaike (AIC)                     704.211   For our model: Smaller is better
          Bayesian (BIC)                   748.336
          Sample-Size Adjusted BIC         700.878
            (n* = (n + 2) / 24)
Chi-Square Test of Model Fit
          Value                             10.929   This is -2ΔLL for our H0-H1
          Degrees of Freedom                     6   This is counting the covariances between X's and Y's too
          P-Value                           0.0906   Test of exact fit: Nonsignificant is good!
RMSEA (Root Mean Square Error Of Approximation)
          Estimate                           0.077   Should be < .08 or so
          90 Percent C.I.                0.000  0.148
          Probability RMSEA <= .05           0.229   Test of close fit: Nonsignificant is good!
CFI/TLI
          CFI                                0.870   Should be > .9 or so
          TLI                                0.676   Should be > .9 or so
Chi-Square Test of Model Fit for the Baseline Model
          Value                             52.998   This is -2ΔLL for H0-H1 if H0 had no paths at all
          Degrees of Freedom                    15
          P-Value                           0.0000
SRMR (Standardized Root Mean Square Residual)
          Value                              0.046   Should be < .05 or so
```

MODEL RESULTS (**UNSTANDARDIEZD SOLUTION;** Mplus reorders them to list paths first)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	**IN MIXED**
KIDMARIT ON					
KIDBOY	0.264	0.091	2.886	0.004	B11
KIDED12	-0.003	0.024	-0.109	0.913	B31
DADED12	0.000	0.018	-0.027	0.978	B21
MOMMARIT ON					
MOMED12	-0.016	0.021	-0.767	0.443	B42
DADED12	-0.002	0.021	-0.081	0.935	B22
DADMARIT ON					
DADED12	-0.055	0.016	-3.339	0.001	B20
KIDMARIT WITH					
MOMMARIT	0.038	0.027	1.424	0.154	UN(2,1)
DADMARIT	0.076	0.026	2.893	0.004	UN(3,1)
MOMMARIT WITH					
DADMARIT	0.084	0.027	3.066	0.002	UN(3,2)
Intercepts					
KIDMARIT	1.512	0.099	15.290	0.000	B01
MOMMARIT	1.937	0.063	30.949	0.000	B02
DADMARIT	2.071	0.057	36.154	0.000	B00
Residual Variances					
KIDMARIT	0.309	0.037	8.365	0.000	UN(1,1)
MOMMARIT	0.316	0.038	8.339	0.000	UN(2,2)
DADMARIT	0.294	0.035	8.367	0.000	UN(3,3)
New/Additional Parameters (FROM MODEL CONSTRAINT, like ESTIMATE or LINCOM)					
KVMDADED	-0.001	0.026	-0.046	0.963	B22 - B21
KVDDADED	-0.054	0.021	-2.586	0.010	B20 - B21
MVDDADED	-0.053	0.023	-2.279	0.023	B20 - B22

These unstandardized ON paths are the fixed slopes from MIXED.

These unstandardized WITH covariances are residual covariances (in R).

Note that because we are using ML, the residual variances are smaller than in MIXED (that used REML instead to avoid this downward bias).

STANDARDIZED MODEL RESULTS – ALL VARIABLES HAVE MEAN=0, SD=1

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
KIDMARIT ON				
KIDBOY	0.231	0.078	2.950	0.003
KIDED12	-0.009	0.083	-0.109	0.913
DADED12	-0.002	0.086	-0.027	0.978
MOMMARIT ON				
MOMED12	-0.078	0.102	-0.766	0.444
DADED12	-0.008	0.102	-0.081	0.935
DADMARIT ON				
DADED12	-0.272	0.078	-3.470	0.001
KIDMARIT WITH				
MOMMARIT	0.122	0.084	1.455	0.146
DADMARIT	0.252	0.079	3.187	0.001
MOMMARIT WITH				
DADMARIT	0.275	0.080	3.433	0.001
Intercepts				
KIDMARIT	2.646	0.247	10.723	0.000
MOMMARIT	3.434	0.228	15.057	0.000
DADMARIT	3.676	0.221	16.659	0.000
Residual Variances				
KIDMARIT	0.946	0.036	26.246	0.000
MOMMARIT	0.993	0.014	71.055	0.000
DADMARIT	0.926	0.043	21.782	0.000

These standardized ON paths are standardized regression coefficients.

These standardized WITH covariances are residual correlations (in RCORR).

R-SQUARE

Observed Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
KIDMARIT	0.054	0.036	1.487	0.137
MOMMARIT	0.007	0.014	0.496	0.620
DADMARIT	0.074	0.043	1.735	0.083

ESTIMATED MODEL AND RESIDUALS (OBSERVED - ESTIMATED)

The means are recovered perfectly because each outcome has its own intercept (and predictor means are not part of the model).

Residuals for Means

KIDMARIT	MOMMARIT	DADMARIT	KIDBOY	KIDED12	MOMED12	DADED12
0.000	0.000	0.000	0.000	0.000	0.000	0.000

```
 Residuals for Covariances
              KIDMARIT   MOMMARIT   DADMARIT   KIDBOY     KIDED12    MOMED12    DADED12
              ________   ________   ________   ________   ________   ________   ________
 KIDMARIT       0.002
 MOMMARIT       0.003      0.002
 DADMARIT       0.004      0.005      0.000
 KIDBOY         0.004      0.015      0.014      0.000
 KIDED12       -0.001      0.016     -0.008      0.000      0.000
 MOMED12        0.068     -0.072     -0.280      0.000      0.000      0.000
 DADED12        0.000      0.000      0.000      0.000      0.000      0.000      0.000
```

After shutting off the MODEL CONSTRAINT code and running it again, we get these "helpful" suggestions for how to improve model fit:

The bolded covariances indicate the biggest sources of misfit—it looks like momed12 needs to predict each outcome!

```
Minimum M.I. value for printing the modification index     3.840
                           M.I.     E.P.C.  Std E.P.C.  StdYX E.P.C.

ON Statements
DADMARIT ON MOMMARIT       9.062     3.687      3.687       3.693  This is already in the model as a cov
DADMARIT ON MOMED12        9.061    -0.060     -0.060      -0.289  This is MomEd → DadMarit

WITH Statements
MOMED12  WITH DADMARIT     9.336    -0.294     -0.294      -0.200  This is MomEd ←→ DadMarit
DADED12  WITH DADMARIT     8.134     0.491      0.491       0.324  This is already in the model as a path
```

Model 4: DV-Specific Intercept Version adding Mom Education as Predictor of Each

$$\widehat{Marital}_{fi} = \beta_{00}(Dad_{fi}) + \beta_{01}(Kid_{fi}) + \beta_{02}(Mom_{fi}) + \beta_{10}(Dad_{fi})(KidBoy_f)$$
$$+\beta_{20}(Dad_{fi})(DadEd_f - 12) + \beta_{31}(Kid_{fi})(KidEd_f - 12) + \beta_{42}(Mom_{fi})(MomEd_f - 12)$$
$$+\beta_{21}(Kid_{fi})(DadEd_f - 12) + \beta_{22}(Mom_{fi})(DadEd_f - 12)$$
$$+\beta_{41}(Kid_{fi})(MomEd_f - 12) + \beta_{40}(Dad_{fi})(MomEd_f - 12)$$

```
display as result "STATA DV-Specific Intercept Version -- Add Mom Educ (Control for Own Educ)"
mixed marital c.kid c.mom c.dad c.kid#c.kidboy c.kid#c.kided12 c.mom#c.momed12 ///
              c.dad#c.daded12 c.kid#c.daded12 c.mom#c.daded12 ///
              c.kid#c.momed12 c.dad#c.momed12,  ///
         noconstant /// Remove fixed intercept
         || familyid: , noconstant variance reml residuals(unstructured,t(DV)) ///
         dfmethod(satterthwaite) dftable(pvalue)
  estat wcorrelation, covariance,  // R matrix
  estat wcorrelation,              // RCORR matrix
  predict pred, xb  // Add column pred of predicted outcomes to data
  lincom c.kid#c.daded12*-1 + c.mom#c.daded12*1, small // Kid vs. Mom: Dad Educ Effect Diff
  lincom c.kid#c.daded12*-1 + c.dad#c.daded12*1, small // Kid vs. Dad: Dad Educ Effect Diff
  lincom c.mom#c.daded12*-1 + c.dad#c.daded12*1, small // Mom vs. Dad: Dad Educ Effect Diff
  lincom c.kid#c.momed12*-1 + c.mom#c.momed12*1, small // Kid vs. Mom: Mom Educ Effect Diff
  lincom c.kid#c.momed12*-1 + c.dad#c.momed12*1, small // Kid vs. Dad: Mom Educ Effect Diff
  lincom c.mom#c.momed12*-1 + c.dad#c.momed12*1, small // Mom vs. Dad: Mom Educ Effect Diff

 // Get correlation of actual and predicted outcomes to form R2
    pwcorr marital pred if DV==1, sig
    pwcorr marital pred if DV==2, sig
    pwcorr marital pred if DV==2, sig

TITLE "SAS DV-Specific Intercept Version -- Add Mom Educ (Controlling for Own+Dad Educ)";
PROC MIXED DATA=work.Example4b NOCLPRINT COVTEST NAMELEN=100 METHOD=REML;
     CLASS FamilyID DV;
     MODEL marital = kid mom dad kid*KidBoy kid*KidEd12 mom*MomEd12 dad*DadEd12
                     kid*DadEd12 mom*DadEd12 kid*MomEd12 dad*MomEd12
                      / NOINT SOLUTION DDFM=Satterthwaite OUTPM=work.PredFinal;
     REPEATED DV / R RCORR TYPE=UN SUBJECT=FamilyID;
     ESTIMATE "Kid vs. Mom: Dad Educ Effect Diff"  kid*DadEd12 -1 mom*DadEd12 1;
     ESTIMATE "Kid vs. Dad: Dad Educ Effect Diff"  kid*DadEd12 -1 dad*DadEd12 1;
     ESTIMATE "Mom vs. Dad: Dad Educ Effect Diff"  mom*DadEd12 -1 dad*DadEd12 1;
     ESTIMATE "Kid vs. Mom: Mom Educ Effect Diff"  kid*MomEd12 -1 mom*MomEd12 1;
     ESTIMATE "Kid vs. Dad: Mom Educ Effect Diff"  kid*MomEd12 -1 dad*MomEd12 1;
     ESTIMATE "Mom vs. Dad: Mom Educ Effect Diff"  mom*MomEd12 -1 dad*MomEd12 1;
RUN; TITLE;
```

SAS Output for Model 4 (estimated with REML and using Satterthwaite denominator degrees of freedom): Parameters would go in Table 1 for results

Estimated R Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	0.3193	0.04017	0.08212
2	0.04017	0.3220	0.08159
3	0.08212	0.08159	0.2842

Estimated R Correlation Matrix for FAMILYID 3996

Row	Col1	Col2	Col3
1	1.0000	0.1253	0.2726
2	0.1253	1.0000	0.2697
3	0.2726	0.2697	1.0000

Fit Statistics

-2 Res Log Likelihood	722.90
AIC (Smaller is Better)	734.9
AICC (Smaller is Better)	735.1
BIC (Smaller is Better)	752.6

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|	
kid	1.5221	0.1003	140	15.17	<.0001	Kid intercept B01
mom	1.9508	0.06321	137	30.86	<.0001	Mom intercept B02
dad	2.1232	0.05938	137	35.76	<.0001	Dad intercept B00
kid*KidBoy	0.2578	0.09226	135	2.79	0.0060	girl vs boy for Kid B11
kid*KidEd12	-0.01067	0.02508	135	-0.43	0.6711	Kid Ed for kid B31
mom*MomEd12	-0.03077	0.02151	137	-1.43	0.1547	Mom Ed for mom B42
dad*DadEd12	-0.02354	0.01966	137	-1.20	0.2333	Dad Ed for dad B20
kid*DadEd12	-0.00725	0.02109	136	-0.34	0.7315	Dad Ed for kid B21
mom*DadEd12	0.006376	0.02093	137	0.30	0.7611	Dad Ed for mom B22
kid*MomEd12	0.01513	0.02191	136	0.69	0.4910	Mom Ed for kid B41
dad*MomEd12	-0.05640	0.02020	137	-2.79	0.0060	Mom Ed for dad B40

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|	
Kid vs. Mom: Dad Educ Effect Diff	0.01363	0.02781	138	0.49	0.6249	B22 - B21
Kid vs. Dad: Dad Educ Effect Diff	-0.01629	0.02465	137	-0.66	0.5099	B20 - B21
Mom vs. Dad: Dad Educ Effect Diff	-0.02991	0.02455	137	-1.22	0.2250	B20 - B22
Kid vs. Mom: Mom Educ Effect Diff	-0.04590	0.02876	140	-1.60	0.1127	B42 - B41
Kid vs. Dad: Mom Educ Effect Diff	-0.07153	0.02554	139	-2.80	0.0058	B40 - B41
Mom vs. Dad: Mom Educ Effect Diff	-0.02562	0.02523	137	-1.02	0.3115	B40 - B42

```
* Get R2 per outcome condition (prediction by old and yrs65);
PROC SORT DATA=work.PredFinal; BY DV FamilyID; RUN;
PROC CORR DATA=work.PredFinal; BY DV; VAR marital; WITH pred; RUN;
```

DV=1.Kid → R^2 = .0627		DV=2.Mom → R^2 = .0175		DV=2.Dad → R^2 = .1236	
	marital		marital		marital
Pred	0.25049	Pred	0.13215	Pred	0.35159
Predicted Mean	0.0028	Predicted Mean	0.1196	Predicted Mean	<.0001

STATA Syntax for Model 4 as a Path Model (estimated with ML; no denominator DF):

```
display as result "STATA Model 4: Own + Dad & Mom Education a Predictor of Each Attitude"
sem                                          ///
   (kidmarit mommarit dadmarit <- _cons)     /// All intercepts estimated (by default)
   (kidmarit <- kidboy kided12)              /// Regressions: y outcomes ON x predictors
   (kidmarit mommarit dadmarit <- daded12)   ///
   (kidmarit mommarit dadmarit <- momed12),  /// New effects go here
    var(e.kidmarit e.mommarit e.dadmarit)    /// All residual variances estimated (by default)
    covariance(e.kidmarit*e.mommarit         /// All pairwise residual covariances (not default)
               e.mommarit*e.dadmarit         ///
               e.kidmarit*e.dadmarit)        ///
    method(mlmv)                              // Full-information ML
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    lincom _b[mommarital:daded12] - _b[kidmarital:daded12] // Kid v. Mom: Dad Educ Effect Diff
    lincom _b[mommarital:momed12] - _b[kidmarital:momed12] // Kid v. Mom: Mom Educ Effect Diff
    lincom _b[mommarital:momed12] - _b[kidmarital:momed12] // Kid v. Mom: Mom Educ Effect Diff
    lincom _b[mommarital:momed12] - _b[kidmarital:momed12] // Kid v. Mom: Mom Educ Effect Diff
    sem, coeflegend                       // Print parameter labels, too (to use in lincom)
    sem, standardized                     // Print fully standardized solution, too
    estat gof, stats(all)                 // Print fit statistics
    estat eqgof                           // Print R2 per variable
    estat residuals                       // Print how far off each predicted covariance is
    estat mindices, minchi2(3.84) showpclass(all) // Print voodoo to improve model fit at p<.05
```

Mplus Syntax and Output for Model 4 as a Path Model (estimated with ML; no denominator DF):

```
!!!!!!!!!!!!!!!!!!!!!!!!!! Mplus Lines Cannot Exceed 90 Characters !!!!!!!!!!!!!!!!!!!!
TITLE: Mplus Model 4: Own Education + Dad & Mom Education a Predictor of Each Attitude;
```

DATA, VARIABLE, ANALYSIS, and OUTPUT are all the same as Model 3.

```
MODEL: ! * --> Estimated parameter (all listed below for clarity);

! All residual variances estimated separately (by default);
  KidMarit* MomMarit* DadMarit*;

! All possible pairwise residual covariances (not estimated by default);
  KidMarit MomMarit DadMarit WITH KidMarit* MomMarit* DadMarit*;

! All intercepts estimated separately (by default);
  [KidMarit* MomMarit* DadMarit*];

! Regressions: y outcomes ON x predictors (label to do math on later);
  KidMarit ON KidBoy* KidEd12*;
  KidMarit MomMarit DadMarit ON DadEd12* (DadEd2K DadEd2M DadEd2D);
  KidMarit MomMarit DadMarit ON MomEd12* (MomEd2K MomEd2M MomEd2D); ! New effects here;

! Getting differences in effect of DadEd for each person;
  MODEL CONSTRAINT: ! List names of linear combinations here;
  NEW (KvMDadEd KvDDadEd MvDDadEd KvMMomEd KvDMomEd MvDMomEd);
  KvMDadEd = DadEd2M - DadEd2K;     ! Kid v. Mom: Dad Educ Effect Diff;
  KvDDadEd = DadEd2D - DadEd2K;     ! Kid v. Dad: Dad Educ Effect Diff;
  MvDDadEd = DadEd2D - DadEd2M;     ! Mom v. Dad: Dad Educ Effect Diff;
  KvMMomEd = MomEd2M - MomEd2K;     ! Kid v. Mom: Mom Educ Effect Diff;
  KvDMomEd = MomEd2D - MomEd2K;     ! Kid v. Dad: Mom Educ Effect Diff;
  MvDMomEd = MomEd2D - MomEd2M;     ! Mom v. Dad: Mom Educ Effect Diff;
```

```
THE MODEL ESTIMATION TERMINATED NORMALLY
MODEL FIT INFORMATION

Number of Free Parameters                       17   Notes from Lesa:
Loglikelihood
          H0 Value                        -332.158   For our model: Larger is better
          H1 Value                        -331.641   For model with all possible paths estimated
Information Criteria
          Akaike (AIC)                     698.316   For our model: Smaller is better
          Bayesian (BIC)                   748.324
          Sample-Size Adjusted BIC         694.538
            (n* = (n + 2) / 24)
```

```
Chi-Square Test of Model Fit
          Value                              1.034   This is -2ΔLL for our H0-H1
          Degrees of Freedom                     4   This is counting the covariances between X's and Y's too
          P-Value                           0.9047   Test of exact fit: Nonsignificant is good!
RMSEA (Root Mean Square Error Of Approximation)
          Estimate                           0.000   Should be < .08 or so
          90 Percent C.I.                0.000  0.052
          Probability RMSEA <= .05           0.947   Test of close fit: Nonsignificant is good!
CFI/TLI
          CFI                                1.000   Should be > .9 or so
          TLI                                1.000   Should be > .9 or so
Chi-Square Test of Model Fit for the Baseline Model
          Value                             52.998   This is -2ΔLL for H0-H1 if H0 had no paths at all
          Degrees of Freedom                    15
          P-Value                           0.0000
SRMR (Standardized Root Mean Square Residual)
          Value                              0.020   Should be < .05 or so

MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value  IN MIXED
KIDMARIT ON
    KIDBOY             0.258      0.091      2.839      0.005  B11
    KIDED12           -0.011      0.025     -0.433      0.665  B31
    DADED12           -0.007      0.021     -0.350      0.726  B21
    MOMED12            0.015      0.022      0.703      0.482  B41
 MOMMARIT ON
    DADED12            0.006      0.021      0.308      0.758  B42
    MOMED12           -0.031      0.021     -1.447      0.148  B22
 DADMARIT ON
    DADED12           -0.024      0.019     -1.210      0.226  B20
    MOMED12           -0.056      0.020     -2.822      0.005  B40
 KIDMARIT WITH
    MOMMARIT           0.039      0.027      1.478      0.139  UN(2,1)
    DADMARIT           0.080      0.026      3.124      0.002  UN(3,1)
 MOMMARIT WITH
    DADMARIT           0.080      0.026      3.081      0.002  UN(3,2)
 Intercepts
    KIDMARIT           1.522      0.099     15.418      0.000  B01
    MOMMARIT           1.951      0.063     31.199      0.000  B02
    DADMARIT           2.123      0.059     36.146      0.000  B00
 Residual Variances
    KIDMARIT           0.308      0.037      8.363      0.000  UN(1,1)
    MOMMARIT           0.315      0.038      8.367      0.000  UN(2,2)
    DADMARIT           0.278      0.033      8.367      0.000  UN(3,3)
New/Additional Parameters (FROM MODEL CONSTRAINT, like ESTIMATE or LINCOM)
    KVMDADED           0.014      0.027      0.497      0.619  B22 - B21
    KVDDADED          -0.016      0.024     -0.671      0.502  B20 - B21
    MVDDADED          -0.030      0.024     -1.232      0.218  B20 - B22
    KVMMOMED          -0.046      0.028     -1.620      0.105  B42 - B41
    KVDMOMED          -0.072      0.025     -2.845      0.004  B40 - B41
    MVDMOMED          -0.026      0.025     -1.027      0.304  B40 - B42

STANDARDIZED MODEL RESULTS - ALL VARIABLES HAVE MEAN=0, SD=1
STDYX Standardization
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 KIDMARIT ON
    KIDBOY             0.225      0.078      2.895      0.004
    KIDED12           -0.037      0.085     -0.433      0.665
    DADED12           -0.035      0.101     -0.350      0.726
    MOMED12            0.072      0.102      0.704      0.481
 MOMMARIT ON
    DADED12            0.031      0.102      0.308      0.758
    MOMED12           -0.148      0.101     -1.457      0.145
 DADMARIT ON
    DADED12           -0.117      0.096     -1.216      0.224
    MOMED12           -0.272      0.094     -2.894      0.004
 KIDMARIT WITH
    MOMMARIT           0.126      0.083      1.514      0.130
    DADMARIT           0.274      0.078      3.503      0.000
 MOMMARIT WITH
    DADMARIT           0.270      0.078      3.442      0.001
 Intercepts
    KIDMARIT           2.664      0.245     10.891      0.000
    MOMMARIT           3.445      0.224     15.373      0.000
    DADMARIT           3.769      0.218     17.276      0.000
```

These unstandardized ON paths are the fixed slopes from MIXED.

These unstandardized WITH covariances are residual covariances (in R).

Note that because we are using ML, the residual variances are smaller than in MIXED (that used REML instead to avoid this downward bias).

These standardized ON paths are standardized regression coefficients.

These standardized WITH covariances are residual correlations (in RCORR).

```
 Residual Variances
    KIDMARIT           0.944      0.037     25.769      0.000
    MOMMARIT           0.983      0.022     44.766      0.000
    DADMARIT           0.876      0.052     16.826      0.000
R-SQUARE
    Observed                                           Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value
    KIDMARIT           0.056      0.037      1.529      0.126
    MOMMARIT           0.017      0.022      0.796      0.426
    DADMARIT           0.124      0.052      2.373      0.018

           Residuals for Covariances
              KIDMARIT   MOMMARIT   DADMARIT   KIDBOY     KIDED12    MOMED12    DADED12
              ________   ________   ________   ________   _______    ________   ________
 KIDMARIT       0.002
 MOMMARIT       0.004      0.000
 DADMARIT       0.003      0.000      0.000
 KIDBOY         0.005      0.015      0.015
 KIDED12        0.013      0.029      0.043      0.000      0.000
 MOMED12        0.000      0.000      0.000      0.000      0.000      0.000
 DADED12        0.000      0.000      0.000      0.000      0.000      0.000      0.000
```

Only the kid predictors on the mom and dad outcomes have leftover covariance, and no single added paths would help the model.

Example results section for Part 2 Models 3–4 (picking up from Part 1; using SAS and Mplus output):

Next, we examined whether father's education incrementally predicted the marital attitudes of the mother or adult child after controlling for their own education, but neither effect was significant (and the effect of father's education on his own attitudes was significantly larger). The effect of father's education on his own attitudes remained significant, while the effect of education own their own attitudes for the adult child and mother remained nonsignificant). Finally, we examined the incremental effects of mother's education on marital attitudes, and results from this final model are shown in Table 1. For every additional year of mother's education, father's attitudes were expected to be significantly less conservative by 0.01 (p = .006). The effect of mother's education of adult child attitudes was nonsignificant and significantly smaller than its effect of father's attitudes.

We re-estimated the final model as a path analysis in M*plus* (using maximum likelihood) in order to obtain indices of absolute model fit. The model had excellent fit, $\chi^2(4) = 1.03$, p = .90, RMSEA = .00 [CI = .00–.05], CFI = 1.00, indicating that no further paths were needed. This final model is depicted in Figure 1 below.

Figure 1 (line types used to help visually distinguish the paths; standardized coefficients may also be added)