

Practice with Main Effects in General Linear Models (as estimated using restricted maximum likelihood in MIXED)

The models for this example come from Hoffman (2014) chapter 2. We will be examining the extent to which cognition (as measured by an information test outcome) can be predicted from age (centered at 85 years) grip strength (centered at 9 pounds), sex (with men as the reference group) and dementia status (none, future, current, with none as the reference) in a sample of 550 older adults. SPSS syntax and output as well as SAS syntax are given below; STATA syntax and output is available online.

SPSS Syntax for Data Manipulation and Data Description:

```
* Define location of files used in code below -- change this to your directory.
FILE HANDLE filesave /NAME = "C:\Dropbox\PilesOfVariance\Chapter2\SPSS".
* Import chapter 2 example data.
GET FILE = "filesave/SPSS_Chapter2.sav".
DATASET NAME Chapter2 WINDOW=FRONT.

* Center continuous predictors.
COMPUTE age85 = age - 85.
COMPUTE grip9 = grip - 9.
* Re-coding sex so women are reference (unnecessary).
IF (sexMW=0) sexwm=1.
IF (sexMW=1) sexwm=0.
* Creating contrasts for dementia groups.
DO IF (demgroup=1).
COMPUTE demNF=0.
COMPUTE demNC=0.
END IF.
DO IF (demgroup=2).
COMPUTE demNF=1.
COMPUTE demNC=0.
END IF.
DO IF (demgroup=3).
COMPUTE demNF=0.
COMPUTE demNC=1.
END IF.
* Labeling new variables.
VARIABLE LABELS
age85 "age85: Age in Years (0=85)"
grip9 "grip9: Grip Strength in Pounds (0=9)"
sexwm "sexwm: Sex (0=Women, 1=Men)"
demNF "demNF: Dementia Contrast for None=0 vs Future=1"
demNC "demNC: Dementia Contrast for None=0 vs Current=1".
EXECUTE.

ECHO "Chapter 2: Descriptive Statistics for Example Variables".
DESCRIPTIVES VARIABLES= age grip cognition.
CROSSTABS TABLES= sexMW BY demgroup.
CORRELATIONS VARIABLES age grip sexMW cognition.
```

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
age: Age in Years	550	80	97	84.93	3.430
grip: Grip Strength in Pounds	550	0	19	9.11	2.983
cognition: Information Test Cognitive Outcome	550	0	44	24.82	10.989
Valid N (listwise)	550				

Crosstabulation

		demgroup: Dementia Diagnosis (1=None, 2=Future, 3=Current)			Total
		1	2	3	
sexMW: Sex (0=Men, 1=Women)	0	168	40	19	227
	1	231	69	23	323
Total		399	109	42	550

Correlations

		age: Age in Years	grip: Grip Strength in Pounds	sexmw: Sex (0=Men, 1=Women)	cognition: Information Test Cognitive Outcome
age: Age in Years	Pearson Correlation	1	-.184	.046	-.170
	Sig. (2-tailed)		.000	.286	.000
	N	550	550	550	550
grip: Grip Strength in Pounds	Pearson Correlation	-.184	1	-.403	.242
	Sig. (2-tailed)	.000		.000	.000
	N	550	550	550	550
sexMW: Sex (0=Men, 1=Women)	Pearson Correlation	.046	-.403	1	-.236
	Sig. (2-tailed)	.286	.000		.000
	N	550	550	550	550
cognition: Information Test Cognitive Outcome	Pearson Correlation	-.170	.242	-.236	1
	Sig. (2-tailed)	.000	.000	.000	
	N	550	550	550	550

SAS Syntax and Output for Data Manipulation and Data Description:

```

* Defining global variable for file location to be replaced in code below;
%LET filesave= C:\Dropbox\PilesOfVariance\Chapter2\SAS;
* Location for SAS files for these models (uses macro variable filesave);
LIBNAME filesave "&filesave.";

* Import chapter 2 example data into work library;
DATA work.Chapter2; SET filesave.SAS_Chapter2;
* Center continuous predictors;
age85 = age - 85;
grip9 = grip - 9;
* Re-coding sex so women are reference (unnecessary);
IF sexMW=0 THEN sexwm=1;
ELSE IF sexMW=1 THEN sexwm=0;
* Creating all possible contrasts for dementia groups;
IF demgroup=1 THEN DO; demNF=0; demNC=0; END;
ELSE IF demgroup=2 THEN DO; demNF=1; demNC=0; END;
ELSE IF demgroup=3 THEN DO; demNF=0; demNC=1; END;
* Labeling new variables;
LABEL
age85= "age85: Age in Years (0=85)"
grip9= "grip9: Grip Strength in Pounds (0=9)"
sexwm= "sexwm: Sex (0=Women, 1=Men)"
demNF= "demNF: Dementia Contrast for None=0 vs Future=1"
demNC= "demNC: Dementia Contrast for None=0 vs Current=1";
RUN;

```

```
TITLE1 "Chapter 2: Descriptive Statistics for Example Variables";
PROC MEANS DATA=work.Chapter2; VAR age grip cognition; RUN;
PROC FREQ DATA=work.Chapter2; TABLE sexMW*demgroup; RUN;
PROC CORR DATA=work.Chapter2; VAR age grip sexMW cognition; RUN;
TITLE1;
```

SPSS and SAS MIXED Syntax and SPSS Output for Empty Model in Equation 2.3

$$\text{Cognition}_i = \beta_0 + e_i$$

```
DATASET ACTIVATE Chapter2 WINDOW=FRONT.
ECHO 'Eq 2.3: Empty Means Model'.
MIXED cognition
  /METHOD = REML
  /PRINT = SOLUTION TESTCOV
  /FIXED = .
```

```
TITLE1 'Eq 2.3: Empty Means Model';
PROC MIXED DATA=work.Chapter2 COVTEST NOCLPRINT NAMELEN=100 IC METHOD=REML;
  MODEL cognition = / CHISQ SOLUTION CL DDFM=BW;
  ODS OUTPUT CovParms=CovEmpty;
RUN; TITLE1;
```

Information Criteria^a

-2 Restricted Log Likelihood	4196.098
Akaike's Information Criterion (AIC)	4198.098
Hurvich and Tsai's Criterion (AICC)	4198.105
Bozdogan's Criterion (CAIC)	4203.406
Schwarz's Bayesian Criterion (BIC)	4202.406

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	24.821818	.468574	549	52.973	.000	23.901401	25.742235

Estimates of Covariance Parameters^a

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	120.758722	7.288654	16.568	.000	107.285837	135.923522

Intercept $\beta_0 =$

Descriptive Statistics (repeated from before)

	N	Minimum	Maximum	Mean	Std. Deviation
age: Age in Years	550	80	97	84.93	3.430
grip: Grip Strength in Pounds	550	0	19	9.11	2.983
cognition: Information Test Cognitive Outcome	550	0	44	24.82	10.989
Valid N (listwise)	550				

SPSS and SAS MIXED Syntax and SPSS Output for Age Model in Equation 2.4

$$\text{Cognition}_i = \beta_0 + \beta_1 (\text{Age}_i - 85) + e_i$$

```

DATASET ACTIVATE Chapter2 WINDOW=FRONT.
ECHO 'Eq 2.4: Adding Age 0=85'.
MIXED cognition WITH age85
  /METHOD = REML
  /PRINT = SOLUTION TESTCOV
  /FIXED = age85.

TITLE1 'Eq 2.4: Adding Age 0=85';
PROC MIXED DATA=work.Chapter2 COVTEST NOCLPRINT NAMELEN=100 IC METHOD=REML;
  MODEL cognition = age85 / CHISQ SOLUTION CL DDFM=BW;
  ODS OUTPUT CovParms=CovAge;
RUN; TITLE1;
* Call macro to calculate R2 for overall model;
  %ModelR2(CovBase=CovEmpty, CovFewer=CovEmpty, CovMore=CovAge);

```

Information Criteria^a

-2 Restricted Log Likelihood	4182.081
Akaike's Information Criterion (AIC)	4184.081
Hurvich and Tsai's Criterion (AICC)	4184.088
Bozdogan's Criterion (CAIC)	4189.387
Schwarz's Bayesian Criterion (BIC)	4188.387

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	24.781837	.462243	548	53.612	.000	23.873852	25.689822
age85	-.546091	.134856	548	-4.049	.000	-.810988	-.281194

Estimates of Covariance Parameters^a

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	117.464155	7.096269	16.553	.000	104.347583	132.229490

From SAS:

R2 (% Reduction) Overall and for CovEmpty vs. CovAge

Name	CovParm	Estimate	StdErr	ZValue	ProbZ	R2_from_	R2_Increment
CovEmpty	Residual	120.76	7.2887	16.57	<.0001	Base	.
CovAge	Residual	117.46	7.0963	16.55	<.0001	0.027282	0.027282

Interpret each fixed effect:Intercept $\beta_0 =$ Main effect of Age $\beta_1 =$

Calculate $R^2 = (\text{old} - \text{new}) / (\text{old}) = (120.76 - 117.46) / (120.76) = .027$

SPSS and SAS MIXED Syntax and SPSS Output for Grip Strength Model in Equation 2.6

$$\text{Cognition}_i = \beta_0 + \beta_1 (\text{Age}_i - 85) + \beta_2 (\text{Grip}_i - 9) + e_i$$

```

DATASET ACTIVATE Chapter2 WINDOW=FRONT.
ECHO 'Eq 2.6: Adding Grip 0=9'.
MIXED cognition WITH age85 grip9
  /METHOD = REML
  /PRINT = SOLUTION TESTCOV
  /FIXED = age85 grip9
  /TEST = "Model R2 Test" age85 1; grip9 1.

TITLE1 'Eq 2.6: Adding Grip 0=9';
PROC MIXED DATA=work.Chapter2 COVTEST NOCLPRINT NAMELEN=100 IC METHOD=REML;
MODEL cognition = age85 grip9 / CHISQ SOLUTION CL DDFM=BW;
CONTRAST "Model R2 F-Test" age85 1, grip9 1 / CHISQ;
ODS OUTPUT CovParms=CovGrip;
RUN; TITLE1;
* Call macro to calculate R2 for overall model;
  %ModelR2(CovBase=CovEmpty, CovFewer=CovAge, CovMore=CovGrip);

```

Information Criteria^a

-2 Restricted Log Likelihood	4157.480
Akaike's Information Criterion (AIC)	4159.480
Hurvich and Tsai's Criterion (AICC)	4159.487
Bozdogan's Criterion (CAIC)	4164.784
Schwarz's Bayesian Criterion (BIC)	4163.784

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	24.700784	.451880	547	54.662	.000	23.813152	25.588415
age85	-.417585	.134046	547	-3.115	.002	-.680893	-.154278
grip9	.802482	.154136	547	5.206	.000	.499710	1.105253

Estimates of Covariance Parameters^a

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	112.122824	6.779776	16.538	.000	99.591914	126.230405

Test of Contrasts^a

Source	Numerator df	Denominator df	F	Sig.
Model R2 Test	2	547	22.142	.000

From SAS:

Label	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
Model R2 F-Test	2	547	44.28	22.14	<.0001	<.0001

F* df = χ^2 (as will show instead in STATA)

R2 (% Reduction) Overall and for CovAge vs. CovGrip

Name	CovParm	Estimate	StdErr	ZValue	ProbZ	R2_from_Base	R2_Increment
CovEmpty	Residual	120.76	7.2887	16.57	<.0001	-0.000000	.
CovAge	Residual	117.46	7.0963	16.55	<.0001	0.027282	.
CovGrip	Residual	112.12	6.7798	16.54	<.0001	0.071514	0.044231

Interpret each fixed effect:Intercept $\beta_0 =$ Main effect of Age $\beta_1 =$ Main effect of Grip Strength $\beta_2 =$ Calculate $R^2 = (\text{old} - \text{new}) / (\text{old}) = (117.46 - 112.12) / (117.46) = .044$ **SPSS and SAS MIXED Syntax and SPSS Output for Sex (0=M, 1=W) Model in Equation 2.7**

$$\text{Cognition}_i = \beta_0 + \beta_1 (\text{Age}_i - 85) + \beta_2 (\text{Grip}_i - 9) + \beta_3 (\text{SexMW}_i) + e_i$$

```

DATASET ACTIVATE Chapter2 WINDOW=FRONT.
ECHO 'Eq 2.7: Adding Sex 0=M 1=W'.
MIXED cognition WITH age85 grip9 sexMW
  /METHOD = REML
  /PRINT = SOLUTION TESTCOV
  /FIXED = age85 grip9 sexMW
  /TEST = "Intercept for Women" intercept 1 sexMW 1
  /TEST = "Model R2 Test" age85 1; grip9 1; sexMW 1.

TITLE1 'Eq 2.7: Adding Sex 0=M 1=W';
PROC MIXED DATA=work.Chapter2 COVTEST NOCLPRINT NAMELEN=100 IC METHOD=REML;
  MODEL cognition = age85 grip9 sexMW / CHISQ SOLUTION CL DDFM=BW;
  CONTRAST "Model R2 F-Test" age85 1, grip9 1, sexMW 1 / CHISQ;
  ODS OUTPUT CovParms=CovSex;
  ESTIMATE "Intercept for Women" intercept 1 sexMW 1 / CL;
RUN; TITLE1;
  * Call macro to calculate R2 for overall model;
  %ModelR2(CovBase=CovEmpty, CovFewer=CovGrip, CovMore=CovSex);

```

Information Criteria^a

-2 Restricted Log Likelihood	4141.117
Akaike's Information Criterion (AIC)	4143.117
Hurvich and Tsai's Criterion (AICC)	4143.125
Bozdogan's Criterion (CAIC)	4148.420
Schwarz's Bayesian Criterion (BIC)	4147.420

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	26.959431	.738873	546	36.487	.000	25.508049	28.410812
age85	-.433772	.132464	546	-3.275	.001	-.693973	-.173571
grip9	.546002	.166277	546	3.284	.001	.219382	.872622
sexMW	-3.798780	.990359	546.000	-3.836	.000	-5.744161	-1.853399

Estimates of Covariance Parameters^a

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	109.380697	6.620021	16.523	.000	97.145710	123.156616

Contrast Estimates^{a,b}

Contrast	Estimate	Std. Error	df	Test Value	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
L1	23.160651	.600349	546	0	38.579	.000	21.981374	24.339928

a. Intercept for Women

Test of Contrasts^a

Source	Numerator df	Denominator df	F	Sig.
Model R2 Test	3	546	20.036	.000

From SAS:

R2 (% Reduction) Overall and for CovGrip vs. CovSex

Name	CovParm	Estimate	StdErr	ZValue	ProbZ	R2_from_Base	R2_Increment
CovEmpty	Residual	120.76	7.2887	16.57	<.0001	-0.000000	.
CovGrip	Residual	112.12	6.7798	16.54	<.0001	0.071514	.
CovSex	Residual	109.38	6.6200	16.52	<.0001	0.094221	0.022707

Interpret each fixed effect:

Intercept $\beta_0 =$

Main effect of Age $\beta_1 =$

Main effect of Grip Strength $\beta_2 =$

Main effect of Sex $\beta_3 =$

The intercept for women is calculated from:

Calculate $R^2 = (\text{old} - \text{new}) / (\text{old}) = (112.12 - 109.38) / (112.12) = .023$

SPSS and SAS MIXED Syntax and SPSS Output for Dementia Group Model in Equation 2.8

$$\text{Cognition}_i = \beta_0 + \beta_1(\text{Age}_i - 85) + \beta_2(\text{Grip}_i - 9) + \beta_3(\text{SexMW}_i) + \beta_4(\text{DemNF}_i) + \beta_5(\text{DemNC}_i) + e_i$$

We can use the model equation to calculate the **dementia group means** for predicted cognition:

$$\begin{aligned} \text{Cognition for None} &= \beta_0 \\ \text{Cognition for Future} &= \beta_0 + \beta_4 \\ \text{Cognition for Current} &= \beta_0 + \beta_5 \end{aligned}$$

We can determine the **differences between the dementia group means** as follows:

$$\begin{aligned} \text{None vs. Future} &= \text{Future} - \text{None} = (\beta_0 + \beta_4) - (\beta_0) = \beta_4 \\ \text{None vs. Current} &= \text{Current} - \text{None} = (\beta_0 + \beta_5) - (\beta_0) = \beta_5 \\ \text{Future vs. Current} &= \text{Current} - \text{Future} = (\beta_0 + \beta_5) - (\beta_0 + \beta_4) = \beta_5 - \beta_4 = -\beta_4 + \beta_5 \end{aligned}$$

These values are then requested via the SPSS TEST and SAS ESTIMATE statements below...

```

DATASET ACTIVATE Chapter2 WINDOW=FRONT.
ECHO 'Eq 2.8: Adding Dementia Group'
  + ', Using Manual Group Contrasts so Reference=None'.
MIXED cognition WITH age85 grip9 sexMW demNF demNC
  /METHOD = REML
  /PRINT = SOLUTION TESTCOV
  /FIXED = age85 grip9 sexMW demNF demNC
  /TEST = "Model R2 F-Test" age85 1; grip9 1; sexmw 1; demNF 1; demNC 1
  /TEST = "Omnibus F-Test for Dementia Group" demNF 1; demNC 1
  /TEST = "Intercept for None Group" intercept 1 demNF 0 demNC 0
  /TEST = "Intercept for Future Group" intercept 1 demNF 1 demNC 0
  /TEST = "Intercept for Current Group" intercept 1 demNF 0 demNC 1
  /TEST = "None vs Future Group" demNF 1 demNC 0
  /TEST = "None vs Current Group" demNF 0 demNC 1
  /TEST = "Future vs Current Group" demNF -1 demNC 1.

TITLE1 'Eq 2.8: Adding Dementia Group';
TITLE2 'Using Manual Group Contrasts so Reference=None';
PROC MIXED DATA=work.Chapter2 COVTEST NOCLPRINT NAMELEN=100 IC METHOD=REML;
  MODEL cognition = age85 grip9 sexMW demNF demNC / CHISQ SOLUTION CL DDFM=BW;
  ODS OUTPUT CovParms=CovDem;
  CONTRAST "Model R2 F-Test" age85 1, grip9 1, sexmw 1, demNF 1, demNC 1 / CHISQ;
  CONTRAST "Omnibus F-Test for Dementia Group" demNF 1, demNC 1 / CHISQ;
  * Request group means (hold age=85, grip=9, men);
  ESTIMATE "Intercept for None Group" intercept 1 demNF 0 demNC 0 / CL;
  ESTIMATE "Intercept for Future Group" intercept 1 demNF 1 demNC 0 / CL;
  ESTIMATE "Intercept for Current Group" intercept 1 demNF 0 demNC 1 / CL;
  * Request group differences;
  ESTIMATE "None vs. Future Group" demNF 1 demNC 0 / CL;
  ESTIMATE "None vs. Current Group" demNF 0 demNC 1 / CL;
  ESTIMATE "Future vs. Current Group" demNF -1 demNC 1 / CL;
RUN; TITLE1; TITLE2;
  * Call macro to calculate R2 for overall model;
  %ModelR2(CovBase=CovEmpty, CovFewer=CovSex, CovMore=CovDem);

```

Information Criteria^a

-2 Restricted Log Likelihood	4016.269
Akaike's Information Criterion (AIC)	4018.269
Hurvich and Tsai's Criterion (AICC)	4018.276
Bozdogan's Criterion (CAIC)	4023.568
Schwarz's Bayesian Criterion (BIC)	4022.568

Estimates of Fixed Effects^a

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	29.264325	.698508	544	41.895	.000	27.892222	30.636428
age85	-.405734	.118897	544	-3.412	.001	-.639288	-.172180
grip9	.604226	.149776	544.000	4.034	.000	.310016	.898435
sexMW	-3.657374	.891433	544	-4.103	.000	-5.408446	-1.906303
demNF	-5.721971	1.019078	544	-5.615	.000	-7.723782	-3.720160
demNC	-16.479813	1.522754	544	-10.822	.000	-19.471010	-13.488616

Estimates of Covariance Parameters^a

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	88.070880	5.340082	16.492	.000	78.202505	99.184546

Test of Contrasts^a

Source	Numerator df	Denominator df	F	Sig.
Model R2 F-Test	5	544	41.753	.000

Source	Numerator df	Denominator df	F	Sig.
Omnibus F-Test for Dementia Group	2	544	67.056	.000

From SAS (SPSS version in all separate tables):

Label	Estimates		DF	t Value	Pr > t	Lower	Upper
	Estimate	Standard Error					
Intercept for None Group	29.2643	0.6985	544	41.90	<.0001	27.8922	30.6364
Intercept for Future Group	23.5424	1.0785	544	21.83	<.0001	21.4238	25.6609
Intercept for Current Group	12.7845	1.5302	544	8.35	<.0001	9.7787	15.7903
None vs. Future Group	-5.7220	1.0191	544	-5.61	<.0001	-7.7238	-3.7202
None vs. Current Group	-16.4798	1.5228	544	-10.82	<.0001	-19.4710	-13.4886
Future vs. Current Group	-10.7578	1.7080	544	-6.30	<.0001	-14.1128	-7.4028

R2 (% Reduction) Overall and for CovSex vs. CovDem

Name	CovParm	Estimate	StdErr	ZValue	ProbZ	R2_from_Base	R2_Increment
CovEmpty	Residual	120.76	7.2887	16.57	<.0001	-0.00000	.
CovSex	Residual	109.38	6.6200	16.52	<.0001	0.09422	.
CovDem	Residual	88.0709	5.3401	16.49	<.0001	0.27069	0.17647

Interpret each fixed effect:

Intercept $\beta_0 =$

Main effect of Age $\beta_1 =$

Main effect of Grip Strength $\beta_2 =$

Main effect of Sex $\beta_3 =$

Main effect of DemNF $\beta_4 =$

Main effect of DemNC $\beta_5 =$