ANCOVA Example #1—Covariate Choice Matters!

Each person who came to the clinic was screened for depression. Those who were diagnosed as "moderately depressed" were invited to participate in a treatment comparison study we were conducting. The IV is whether patients received cognitive-behavioral therapy or a "support group control". Because of ethical concerns, patients were not randomly assigned to treatment conditions. Rather, each was permitted to choose which treatment they would receive. In addition, each patient was permitted to decide when they would begin treatment. In addition to collecting the DV score (rating of depression – bigger scores – more depression = "poorer") after 18 weeks of therapy, the researchers also recorded the number of weeks between diagnosis and beginning treatment as well as initial depression score for each patient.

First get the ANOVAs for the DV and the Covariates/Confounds

Descriptives

		N	Mean	Std. Deviation
rating of depression -- bigger scores are poorer	support group	20	4.4000	1.81804
	cog-beh group	20	4.0000	2.00000
	Total	40	4.2000	1.89737
time between diagnosis and rating of depression - in weeks	support group	20	20.2000	2.26181
	cog-beh group	20	14.2500	3.00657
	Total	40	17.2250	3.99671
INITDEP	support group	20	5.0000	2.22427
	cog-beh group	20	13.2500	2.57263
	Total	40	9.1250	4.80485

If we analyzed only the DV we would conclude that there is "no treatment effect"

However, there is a between group difference in both "delay" and "initial depression" – suggesting that we should include these variables in the statistical analysis.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
rating of depression -- bigger scores are poorer	Between Groups	1.600	1	1.600	.438	.512
	Within Groups	138.800	38	3.653		
	Total	140.400	39			
time between diagnosis and rating of depression - in weeks	Between Groups	354.025	1	354.025	50.020	.000
	Within Groups	268.950	38	7.078		
	Total	622.975	39			
INITDEP	Between Groups	680.625	1	680.625	117.696	.000
	Within Groups	219.750	38	5.783		
	Total	900.375	39			

Both delay and initial depression are "confounds" – variables other than the IV that differ (on average) between the IV groups.

Correlations

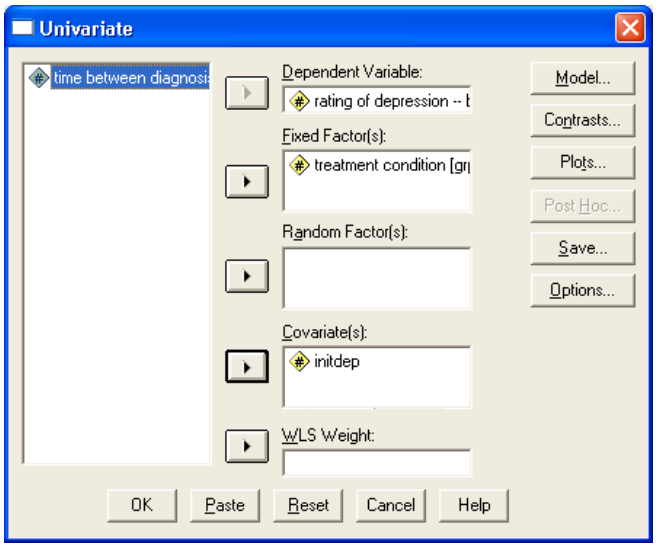
		rating of depression -- bigger scores are poorer	time between diagnosis and rating of depression - in weeks	INITDEP
rating of depression -- bigger scores are poorer	Pearson Correlation	1	.569**	.188
	Sig. (2-tailed)	.	.000	.244
	N	40	40	40
time between diagnosis and rating of depression - in weeks	Pearson Correlation	.569**	1	-.466**
	Sig. (2-tailed)	.000	.	.002
	N	40	40	40
INITDEP	Pearson Correlation	.188	-.466**	1
	Sig. (2-tailed)	.244	.002	.
	N	40	40	40

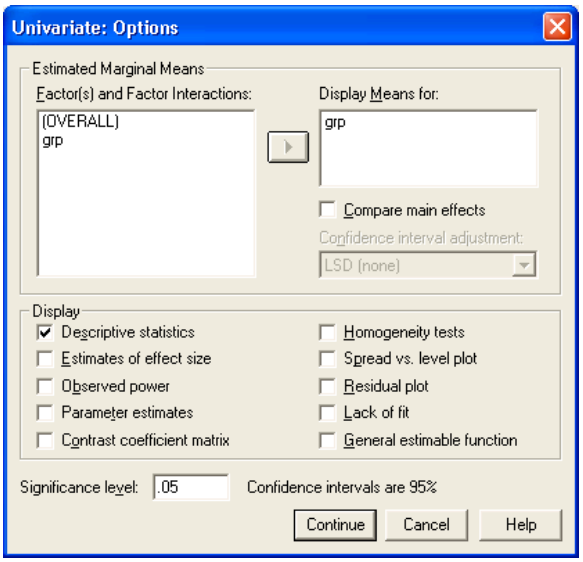
**. Correlation is significant at the 0.01 level (2-tailed).

Both delay and initial depression are also correlated with the DV. These are the kinds of covariates that will produce "important" differences between ANOVA and ANCOVA results – covariates that are correlated with both the IV and the DV.

Analysis ➔ General Linear Model ➔ Univariate

- As for ANOVA – specify the DV and the IV (Fixed Factors)
- Include the Covariate
- In the Options window check Descriptives and as for Estimated Marginal Means for the IV





Syntax for the results that follow

```
UNIANOVA depression   BY   group   WITH  delay
  /METHOD = SSTYPE(3)
  /EMMEANS = TABLES(group)   WITH  (delay  = mean)   COMPARE (group)
  /PRINT = DESCRIPTIVE
  /DESIGN = group   delay.
```

← dv BY iv WITH covariate

← corrects each effect for all others

← gets group mean difference at mean score for covariate

← descriptive stats

← specifies main effects covariate model

```
UNIANOVA depression   BY   group   WITH   initdep
  /METHOD = SSTYPE(3)
  /EMMEANS = TABLES(group)   WITH  (initdep  = mean)   COMPARE (group)
  /PRINT = DESCRIPTIVE
  /DESIGN = group   initdep.
```

```
UNIANOVA depression   BY   group   WITH   delay   initdep
  /METHOD = SSTYPE(3)
  /EMMEANS = TABLES(group)   WITH  (initdep  = mean  delay = mean)  COMPARE (group)
  /PRINT = DESCRIPTIVE
  /DESIGN = group   initdep.
```

ANCOVA using Delay as a Covariate

Descriptive Statistics

Dependent Variable: rating of depression -- bigger scores are poorer

treatment condition	Mean	Std. Deviation	N
support group	4.4000	1.81804	20
cog-beh group	4.0000	2.00000	20
Total	4.2000	1.89737	40

The "Descriptive Stats" are the uncorrected DV group means – same as from the ANOVA

Tests of Between-Subjects Effects

Dependent Variable: rating of depression -- bigger scores are poorer

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	79.129[a]	2	39.564	23.892	.000
Intercept	22.588	1	22.588	13.641	.001
DELAY	77.529	1	77.529	46.817	.000
GRP	33.716	1	33.716	20.360	.000
Error	61.271	37	1.656		
Total	846.000	40			
Corrected Total	140.400	39			

a. R Squared = .564 (Adjusted R Squared = .540)

Notice that the MSerror for this ANCOVA is about ½ that from the ANOVA -- by making the covariate "a predictor" variation attributed to it is taken away from the "error" and so the test of the IV is more powerful.

There is a significant effect for the covariate – suggests that including it will change the apparent group difference on the DV (remember this is the DV-Covariate relationship)

With Delay as a covariate there is a significant effect for the IV

treatment condition

Dependent Variable: rating of depression -- bigger scores are poorer

treatment condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
support group	2.803[a]	.371	2.052	3.553
cog-beh group	5.597[a]	.371	4.847	6.348

a. Evaluated at covariates appeared in the model: time between diagnosis and rating of depression - in weeks = 17.2250.

These are the "corrected means" – "corrected" for the covariate difference between groups. This is the mean difference that is tested by the "GRP" F-test above – the relationship between IV condition and the DV after correcting for (statistically controlling) group difference on the covariate.

Summary:

- There is no apparent difference between group on the DV (from ANOVA)
- Those in the cog-beh Tx waited a significantly shorter average time to begin treatment than did the support Tx
- After correcting for delay, those in the cog-beh Tx has significantly higher depression scores than those in the support Tx – the support Tx worked better!

ANCOVA with Initial Depression as the Covariate

Descriptive Statistics

Dependent Variable: rating of depression -- bigger scores are poorer

treatment condition	Mean	Std. Deviation	N
support group	4.4000	1.81804	20
cog-beh group	4.0000	2.00000	20
Total	4.2000	1.89737	40

Tests of Between-Subjects Effects

Dependent Variable: rating of depression -- bigger scores are poorer

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	47.106[a]	2	23.553	9.341	.001
Intercept	5.599E-03	1	5.599E-03	.002	.963
INITDEP	45.506	1	45.506	18.048	.000
GRP	42.121	1	42.121	16.705	.000
Error	93.294	37	2.521		
Total	846.000	40			
Corrected Total	140.400	39			

a. R Squared = .336 (Adjusted R Squared = .300)

Notice that the MSerror for this ANCOVA is less that from the ANOVA -- by making the covariate "a predictor" variation attributed to it is taken away from the "error" and so the test of the IV is more powerful.

There is a significant effect for the covariate – suggests that including it will change the apparent group difference on the DV (remember this is the DV-Covariate relationship)

With Initial depression as a covariate there is a significant effect for the IV

treatment condition

Dependent Variable: rating of depression -- bigger scores are poorer

			95% Confidence Interval	
treatment condition	Mean	Std. Error	Lower Bound	Upper Bound
support group	6.277[a]	.567	5.129	7.426
cog-beh group	2.123[a]	.567	.974	3.271

a. Evaluated at covariates appeared in the model: INITDEP = 9.1250.

These are the "corrected means" – "corrected" for the covariate difference between groups. This is the mean difference that is tested by the "GRP" F-test above – the relationship between IV condition and the DV after correcting for (statistically controlling) group difference on the covariate.

Summary:

- There is no apparent difference between group on the DV (from ANOVA)
- Those in the cog-beh Tx has significantly higher initial depression scores than did the support Tx
- After correcting for initial depression, those in the cog-beh Tx has significantly lower depression scores than those in the support Tx – the cog-beh Tx worked better!

ANCOVA with both Delay and Initial Depression as Covariates

Tests of Between-Subjects Effects

Dependent Variable: rating of depression -- bigger scores are poorer

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	83.065[a]	3	27.688	17.385	.000
Intercept	22.657	1	22.657	14.226	.001
INITDEP	3.936	1	3.936	2.472	.125
DELAY	35.959	1	35.959	22.578	.000
GRP	.750	1	.750	.471	.497
Error	57.335	36	1.593		
Total	846.000	40			
Corrected Total	140.400	39			

a. R Squared = .592 (Adjusted R Squared = .558)

With all three variables in the model (IV, Delay, Initial Depression) only Delay has an "independent contribution" to the model.

treatment condition	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
support group	3.741[a]	.699	2.324	5.157
cog-beh group	4.659[a]	.699	3.243	6.076

a. Evaluated at covariates appeared in the model: INITDEP = 9.1250, time between diagnosis and rating of depression - in weeks = 17.2250.

After correcting for both of the covariates simultaneously, there is no DV (depression) mean difference between the groups.

This example highlights the "advantages" and "dangers" of ANCOVA…

Advantages:

- Experimental control is often impossible – ANCOVA allows the application of statistical control
- Statistical control allows the inclusion of specific covariates into the analysis – if there are data
- ANCOVA may provide more "accurate" results because of including these covariates
    - Correcting for initial nonequivalences
    - Increasing the statistical power (reducing the error term)

Dangers:

- Only "controls" for covariates that are included in the analysis (not "all subject variables" as does RA)
- Results can "depend up" which covariate(s) are included in the analysis
- Remember that we got different "results" from each of the three ANCOVAs included here