

ANCOVA to "Control Confounds"

Although originally designed to help reduce within-group variation that was "masking" between group effects, the ANCOVA is more often used to help "control for" between group variation on uncontrolled variables that may be "masking" between groups on the DV. Here are some examples.

```
data list free / grp dv1 dv2 cov1 cov2 cov3.
variable labels dv1 'grp1 mean 4 larger than grp0 mean'
                dv2 'grp1 mean = grp0 mean'
                cov1 'grp1 cov = grp0'
                cov2 'grp1 cov > grp0'
                cov3 'grp1 cov < grp0'.
```

```
means dv1 dv2 cov1 cov2 cov3 by grp / statistics 1. ← let's check-out all the variables involved
```

```
Summaries of DV1          grp1 mean 4 larger than grp0 mean
By levels of GRP

Value Mean Source Sum of Squares D.F. Mean Square F Sig.
.00 19.5 Between Groups 48.0000 1 48.0000 1.4159 .2616
1.00 23.5 Within Groups 339.0000 10 33.9000
```

```
Summaries of DV2          grp1 mean = grp0 mean
By levels of GRP

Value Mean Source Sum of Squares D.F. Mean Square F Sig.
.00 23.5000 Between Groups .0000 1 .0000 .0000 1.0000
1.00 23.5000 Within Groups 355.0000 10 35.5000
```

```
Summaries of COV1        grp1 cov = grp0
By levels of GRP

Value Source Sum of Squares D.F. Mean Square F Sig.
.00 30.5000 Between Groups .0000 1 .0000 .0000 1.0000
1.00 30.5000 Within Groups 883.0000 10 88.3000
```

```
Summaries of COV2        grp1 cov > grp0
By levels of GRP

Value Source Sum of Squares D.F. Mean Square F Sig.
.00 30.5000 Between Groups 645.3333 1 645.3333 7.5714 .0204
1.00 45.1667 Within Groups 852.3333 10 85.2333
```

```
Summaries of COV3        grp1 cov < grp0
By levels of GRP

Value Source Sum of Squares D.F. Mean Square F Sig.
.00 30.5000 Between Groups 675.0000 1 675.0000 7.6444 .0200
1.00 15.5000 Within Groups 883.0000 10 88.3000
```

Let's look at the effect of applying each covariate to DV1 ← group 1 has higher mean on DV1 than group 0

anova dv1 by grp(0,1) with cov1 ← no group difference on cov1
 /dv1 by grp(0,1) with cov2 ← group 1 had higher mean on cov2 than group 0
 /dv1 by grp(0,1) with cov3. ← group 0 has higher mean on cov3 than group 1

DV1 grp1 mean 4 larger than grp0 mean
 BY GRP
 WITH COV1 grp1 cov = grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV1	314.529	1	314.529	115.678	.000
GRP	48.000	1	48.000	17.653	.002
Residual	24.471	9	2.719		
Total	387.000	11	35.182		

- COV1 is acting to reduce error variance only. GRP SS same as in ANOVA (Repeated from earlier handout)

DV1 grp1 mean 4 larger than grp0 mean
 BY GRP
 WITH COV2 grp1 cov > grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV2	323.447	1	323.447	133.820	.000
GRP	41.800	1	41.800	17.294	.002
Residual	21.753	9	2.417		
Total	387.000	11	35.182		

- COV2 is acting to "control for" non-GRP differences **in same direction as the DV1 effect**
- notice the SSgrp is lower than in ANOVA, indicating that part of GRP dif in DV is due to GRP dif in COV
- even with SSgrp lowered, the error variance reduction "action" of COV2 leads to a significant GRP effect for DV1 (but one that is smaller than the ANOVA estimate)

DV1 grp1 mean 4 larger than grp0 mean
 BY GRP
 WITH COV3 grp1 cov < grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV3	77.284	1	77.284	28.424	.000
GRP	285.245	1	285.245	104.907	.000
Residual	24.471	9	2.719		
Total	387.000	11	35.182		

- COV3 acting as a "control" for the group difference opposite the direction of the DV1 effect.
- notice that the SSgrp is higher than in ANOVA, indicating that the GRP effect was being offset by the COV
- When this is "corrected for," the DV1 group difference is much larger -- there is also a error variance reduction aspect in this analysis.

Let's look at the effect of applying each covariate to DV2 ← no group difference

anova dv2 by grp(0,1) with cov1 ← no group difference on cov1
 /dv2 by grp(0,1) with cov2 ← group 1 had higher mean on cov2 than group 0
 /dv2 by grp(0,1) with cov3. ← group 0 has higher mean on cov3 than group 1

DV2 grp1 mean = grp0 mean
 BY GRP
 WITH COV1 grp1 cov = grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV1	325.364	1	325.364	98.806	.000
GRP	.000	1	.000	.000	1.000
Residual	29.636	9	3.293		
Total	355.000	11	32.273		

- With no GRP difference on DV2, error variance reduction doesn't change anything!

DV2 grp1 mean = grp0 mean
 BY GRP
 WITH COV2 grp1 cov > grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV2	186.851	1	186.851	63.039	.000
GRP	141.472	1	141.472	47.729	.000
Residual	26.677	9	2.964		
Total	355.000	11	32.273		

- COV2 "correction" yields a significant GRP effect for DV2
- Why? Seems that the initial COV2 difference exactly offset the GRP effect on DV2 (grp1 < grp0), leading to the null results with the ANOVA. With ANCOVA, the GRP effect becomes apparent.
- Again, there is also an error variance reduction component.

DV2 grp1 mean = grp0 mean
 BY GRP
 WITH COV3 grp1 cov < grp0

Source	Sum of Squares	DF	Mean Square	F	Signif of F
COV3	184.401	1	184.401	55.999	.000
GRP	140.963	1	140.963	42.808	.000
Residual	29.636	9	3.293		
Total	355.000	11	32.273		

- Same as above, but in the opposite direction (grp1 > grp0, for DV2).

the "model" for ANCOVA is = $\frac{IV_{\text{effect}} + COV_{\text{effect}}}{\text{ind. dif.} + \text{error variance corr with COV}}$

← The covariate can "inflate" or "work against" the IV effect (ANCOVA can help or can hurt)

← reducing error variance can only increase the effect, because always reduced error term