Analysis of Covariance (ANCOVA)

PSY 5101: Advanced Statistics for
Psychological and Behavioral Research 1

Goals

⦿ When and Why do we use ANCOVA?
⦿ Partitioning Variance
⦿ Carrying out in SPSS
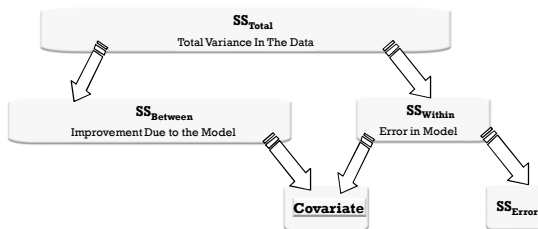⦿ Interpretation
  • Main Effects
  • Covariates

When And Why Do We Use ANCOVA?

⦿ To test for differences between group means when we know that an extraneous variable may have an impact on the outcome variable
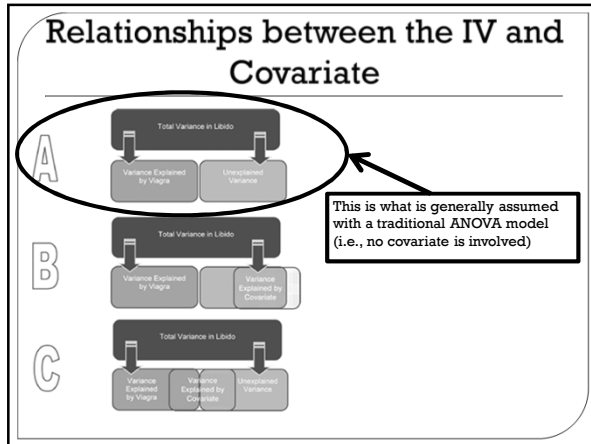⦿ Used to control known extraneous variables

Advantages of ANCOVA

◉ Reduces Error Variance
- The error variance in the model can be reduced by explaining some of the unexplained variance

◉ Greater Experimental Control
- By controlling known extraneous variables, we gain greater insight into the influence of the predictor variable(s)
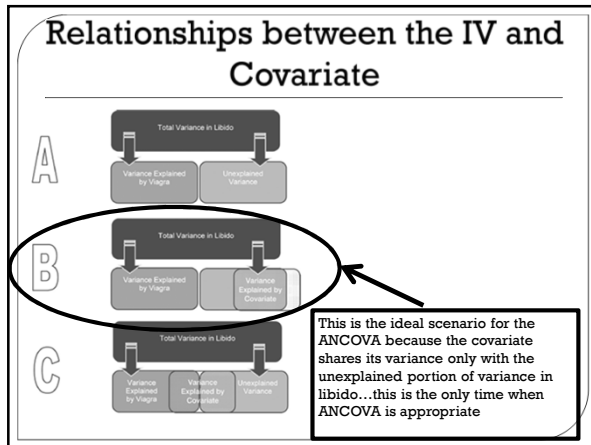

Partitioning of Variance

SS_{Total}
Total Variance In The Data

$SS_{Between}$
Improvement Due to the Model

SS_{Within}
Error in Model

Covariate

SS_{Error}

An Example

◉ Imagine that researchers wanted to test a new sexual stimulant drug called Viagra-2

◉ Three groups of men were given various doses of the drug and asked to report their sexual desire
- There are several possible extraneous variables such as the sexual desire of their partners

◉ We can conduct the same study but measure the libido of their partners over the same time period following the dose of Viagra-2
- DV = Participant's libido
- IV = Dose of Viagra (Placebo, Low Dose, & High Dose)
- Covariate = Partner's libido

Relationships between the IV and Covariate

A

B

C

This is what is generally assumed with a traditional ANOVA model (i.e., no covariate is involved)

Relationships between the IV and Covariate

A

B

C

This is the ideal scenario for the ANCOVA because the covariate shares its variance only with the unexplained portion of variance in libido…this is the only time when ANCOVA is appropriate

Relationships between the IV and Covariate

A

B

C

ANCOVA is commonly used in this scenario but it is not appropriate. In this scenario, the covariate shares variance with the IV which will be problematic for interpreting the ANCOVA

Dose	Participant's Libido	Partner's Libido
Placebo	3	4
	2	1
	5	5
	2	1
	2	2
	2	2
	7	7
	2	4
	4	5
Low Dose	7	5
	5	3
	3	1
	4	2
	4	2
	7	6
	5	4
	4	2
High Dose	9	1
	2	3
	6	5
	3	4
	4	3
	4	3
	4	2
	6	0
	4	1
	6	3
	2	0
	8	1
	5	0

Dose	Participant's Libido	Partner's Libido
Placebo	3.22 (1.79)	3.44 (2.07)
Low Dose	4.88 (1.46)	3.12 (1.73)
High Dose	4.85 (2.12)	2.00 (1.63)

ANCOVA on SPSS

Options
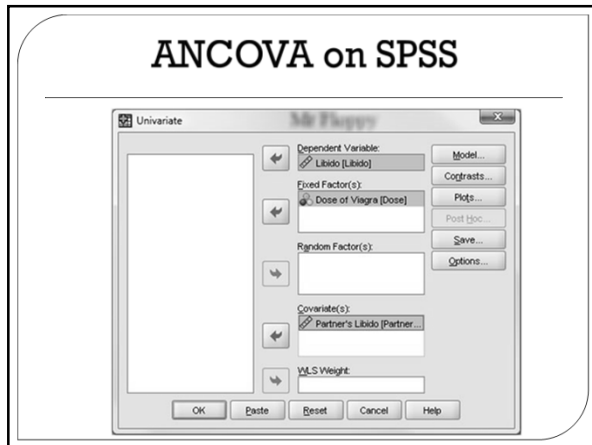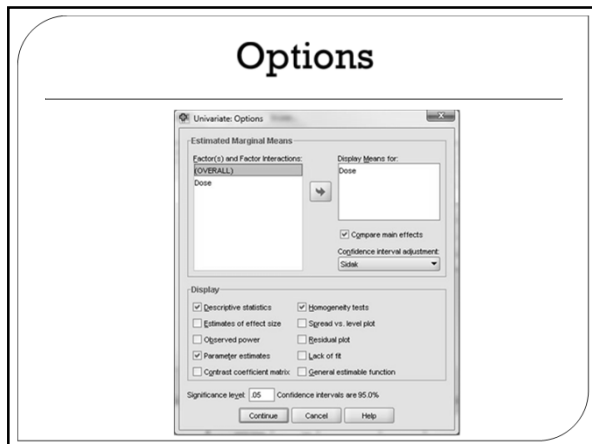
Results Without the Covariate

Tests of Between-Subjects Effects

Dependent Variable: Libido

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.844ᵃ	2	8.422	2.416	.108
Intercept	535.184	1	535.184	153.522	.000
DOSE	16.844	2	8.422	2.416	.108
Error	94.123	27	3.486		
Total	683.000	30			
Corrected Total	110.967	29			

a. R Squared = .152 (Adjusted R Squared = .089)

Without the partner's libido as a covariate, the dose of Viagra-2 does not have a significant effect on the sexual desire of the participants

Output

Levene's Test of Equality of Error Variances

Dependent Variable: Libido

F	df1	df2	Sig.
5.525	2	27	.010

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+PARTNER+DOSE

The Levene's Test shows that the variances between the groups are not equal. However, the ratio of the largest and smallest group variances are not terribly large so the ANCOVA would normally be used as it is

Tests of Between-Subjects Effects

Dependent Variable: Libido

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.750ᵃ	3	11.583	3.952	.019
Intercept	12.171	1	12.171	4.152	.052
PARTNER	17.906	1	17.906	6.109	.020
DOSE	28.337	2	14.169	4.833	.016
Error	76.216	26	2.931		
Total	683.000	30			
Corrected Total	110.967	29			

a. R Squared = .313 (Adjusted R Squared = .234)

Output

Levene's Test of Equality of Error Variances

Dependent Variable: Libido

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5.525	2	27	.010

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+PARTNER+DOSE

This shows that the libido of the partner is associated with the sexual desire reported by the participants

Tests of Between-Subjects Effects

Dependent Variable: Libido

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Corrected Model	34.750ᵃ	3	11.583	3.952	.019
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Dependent Variable: Libido

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5.525	2	27	.010

Tests the null hypothesis that the error variance of
the dependent variable is equal across groups.

a. Design: Intercept+PARTNER+DOSE

This shows that the dose of Viagra-2 has an impact on the sexual desire of the participants when the libido of the partner is included as a covariate

Tests of Between-Subjects Effects

Dependent Variable: Libido

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.750ᵃ	3	11.583	3.952	.019
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The covariate has an impact on the result of the analysis because its inclusion reduces the variance that is unexplained (i.e., error variance)

Output

Estimates

Dependent Variable:Libido

Dose of Viagra	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Placebo	2.926ᵃ	.596	1.701	4.152
Low Dose	4.712ᵃ	.621	3.436	5.988
High Dose	5.151ᵃ	.503	4.118	6.184

a. Covariates appearing in the model are evaluated at the following values:
Partner's Libido = 2.73.

Participants in the high dose group report higher levels of sexual desire than those in the placebo group…but participants in the low dose group do not differ from those in either the placebo group or the high dose group

Pairwise Comparisons

Dependent Variable:Libido

(I) Dose of Viagra	(J) Dose of Viagra	Mean Difference (I-J)	Std. Error	Sig.ᵃ	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Placebo	Low Dose	-1.786	.849	.130	-3.953	.381
	High Dose	-2.225*	.803	.030	-4.273	-.177
Low Dose	Placebo	1.786	.849	.130	-.381	3.953
	High Dose	-.439	.811	.932	-2.509	1.631
High Dose	Placebo	2.225*	.803	.030	.177	4.273
	Low Dose	.439	.811	.932	-1.631	2.509

Based on estimated marginal means

a. Adjustment for multiple comparisons: Sidak.

*. The mean difference is significant at the .05 level.

Unadjusted Means

Adjusted Means

$F(2, 26) = 4.14, p < .05$