Graduate Statistics

Multivariate Analysis of Variance (MANOVA)

What We Will Cover in This Section

- Introduction to Multivariate Statistics.
- Multivariate Analysis of Variance, Overview.
- MANOVA, Example.
- Multivariate Analysis of Covariance (MANCOVA).
- Key Learning Principles.

A Problem

A group of students wanted to know if there were significant differences in performance between a group of dyslexic and non-dyslexic students in a simple visual-motor skills task. Volunteers were asked to perform on a mirror-tracing apparatus. The number of errors and time to trace the design was recorded for each person.

Multivariate Statistics

- In experimental research.
  - Inferential statistical techniques used to assess the differences between means when there is more than one dependent variable.
- In correlational research.
  - Inferential statistical techniques used to assess the degree of association between more than two variables.

t-test vs. ANOVA vs. MANOVA

Test	Number of independent variables	Number of dependent variables
t- test	One	One
ANOVA	Multiple	One
MANOVA	Multiple	Multiple

Correlational Examples

Test	Number of predictors	Number of criterion variables
Simple Correlation	One	One
Multiple Regression	Multiple	One
Canonical Correlation	Multiple	Multiple

Multivariate Analysis of Variance: MANOVA

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Why Have Several DVs?

1. From a validity point of view, multiple dependent measures are better than a single dependent measure.
2. A strong treatment will affect people in many ways.
3. It is more efficient to do one study assessing the impact of the independent variable(s) three things than three studies assessing their impact on one thing.

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Benefits of MANOVA

1. Opportunity to use multiple measures.
2. May not find differences between two correlated dependent variables if assessed in separate studies.
3. Multiple ANOVAs will lead to inflated Type I error rate.

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Concept: How it is Done

- **Simple MANOVA develops a linear combination of the dependent variables.**
  - This equation has the following format.

$$V_{new} = a_1V_1 + a_2V_2 + a_3V_3 + \ldots + a_nV_n$$

  - This combination takes into account any possible correlation between the variables.
  - This equation is designed in such a way as to provide maximum differences between the treatment groups on V_{new}.

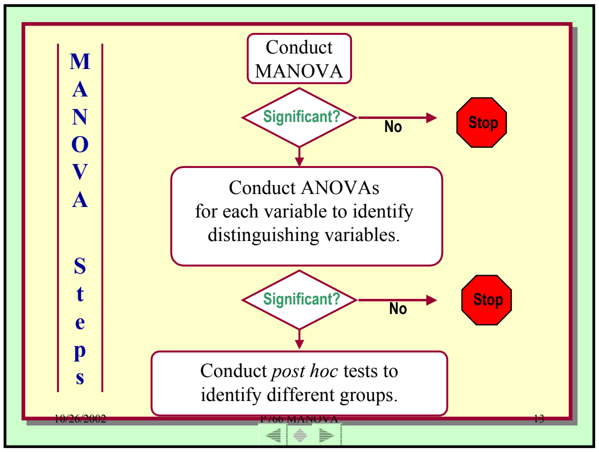
MANOVA Null Hypothesis

$$ANOVA \quad H_o : \mu_1 = \mu_2 = \mu_3 = \ldots = \mu_k$$

$$MANOVA \quad H_o : \mu_{V1} = \mu_{V2} = \mu_{V3} = \ldots = \mu_{Vk}$$

Usual Statistical Test

ANOVA F Test	$F = \frac{SS_{Between}}{SS_{Within}}$	Larger indicates larger differences.
MANOVA Wilkes Lambda	$\Lambda = \frac{\lvert W \rvert}{\lvert T \rvert}$	**SMALLER** indicates larger variability between the vector of means.



Correcting the Alpha Level

Conducting multiple ANOVAs increases the probability of a Type 1 Error.

To correct divide " by the number of dependent variables. This equalizes the probability across the variables.

This is called the *Bonferroni* adjustment.

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Bonferroni Example

If there are two dependent variables, then the Bonferroni corrected level would be .05/2 or .025.

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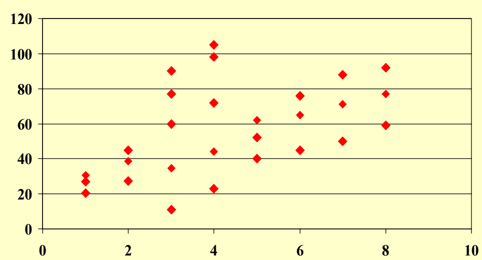
MANOVA Assumptions

1. The observations within each sample are random and independent of each other.
2. The dependent variables are multivariate normal.
3. The covariance matrices for the dependent variables are equal.
4. The relationship between the dependent variables is linear.

Homogeniety of Variance



Total: Sum of Squares, Sum of Cross Products

	V1	V2	V3
V1	SS_{V1}	SCP_{V1xV2}	SCP_{V1xV3}
V2	SCP_{V1xV2}	SS_{V2}	SCP_{V2xV3}
V3	SCP_{V1xV3}	SCP_{V2xV3}	SS_{V3}

Comparing: ANOVA vs. MANOVA

$$ANOVA: \quad SS_{Total} = SS_{Between} + SS_{Within}$$

$$MANOVA: \quad SSCP_{Total} = SSCP_{Between} + SSCP_{Within}$$

$$T = B + W$$

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MANOVA Computation

$$\Lambda = \frac{|W|}{|T|} = \frac{|W|}{|B + W|}$$

$$\eta^2 = 1 - \Lambda$$

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Example

A researcher was interested in the possibility that a new type of therapy would influence the cognitive levels of people with disabilities. To control for severity of the disability she divided the group into three levels of disability: Mild, Moderate, and Severe. The dependent variable in this study was the influence of the therapy on three cognitive skills tests: WRAT-R, WRAT-A, and IQ.

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Design

	Mild		Moderate		Severe	
	WRAT-R	WRAT-A	WRAT-R	WRAT-A	WRAT-R	WRAT-A
Treatment	106.6	103.6	100.0	99.3	93.0	86.0
Control	85.0	89.3	76.6	76.7	72.3	68.3

Step 1. MANOVA

Source	Wilks' Lambda	Df_1	Df_2	F
Treatment	.13772	2	11	34.43**
Disability	.25526	4	22	5.38*
T X D	.90807	4	22	.27

* p< .05, ** p<.01

Step 2. ANOVA

	SS	df	MS	F
Treatment				
WRAT-R	2090.88	1	2090.88	46.1
WRAT-A	1494.22	1	1494.22	33.2
Disability				
WRAT-R	520.77	2	260.38	5.7
WRAT-A	1126.77	2	563.38	12.5
T X D				
WRAT-R	2.11	2	1.056	.023
WRAT-A	52.78	2	26.38	.587
Error				
WRAT-R	544.00	12	45.33	
WRAT-A	539.33	12	44.94	

Step 3. Post hoc Tests

Too damn many to show you.

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THE END

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