

Inferential Statistics

Analysis of Variance ANOVA, Part 2

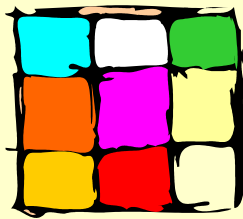


What We Will Cover in This Section

- Introduction.
- Overview.
- Factorial ANOVA
- Repeated Measures ANOVA.



Factorial ANOVA, Two-way Design



Definition

Experimental design in which there are two or more independent variables and one dependent variable.

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Problem #1 Effects of Music on Mood

A student was researching the influence of music on mood. She hypothesized that tone of the music (aggressive vs. calm) would influence a person's mood but that the type of music (classical vs. popular) would not affect mood.

She randomly divided 60 volunteers into one of four groups: classical-aggressive, classical-calm, popular-aggressive, or popular-calm. Then she played a six-minute musical selection for the person then had them rate their mood.

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Music Study Descriptive Statistics

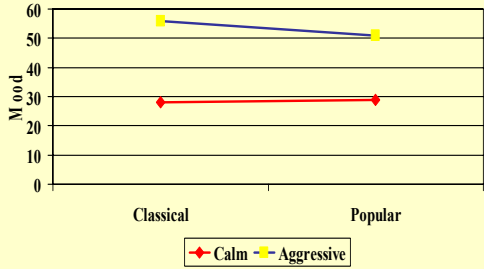
	Music Type		
	Aggressive	Calm	
Classical	56.00	28.27	42.14
Popular	51.29	29.73	40.51
	53.64	29.00	41.32

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Relationship between music type and mood



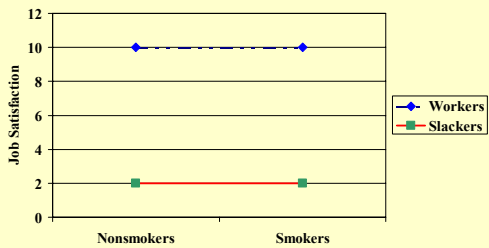
Main Effect

The independent influence that one independent variable alone has on the dependent variable.

Job Satisfaction Study

	Smoker?		
	Smoker	Non Smoker	
Worker	10	10	10
Slacker	2	2	2
	6	6	

Factorial ANOVA: One Main Effect



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Teacher Satisfaction Study

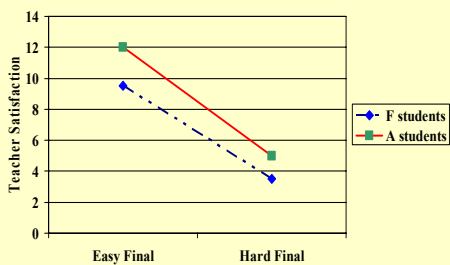
	Final Type		
	Easy	Hard	
A Student	12.00	5.00	8.50
F Student	10.00	4.00	7.00
	11.00	4.5	

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Factorial ANOVA: Main Effects



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Interaction

The combined effects of two or more independent variables on the dependent variable.

- Is the combined effect of a tranquilizer and alcohol stronger than either taken alone?
- Is exercise and healthy diet better than either alone?
- Is distributed studying and studying with a classmate more effective than either one alone.

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Job Satisfaction #2

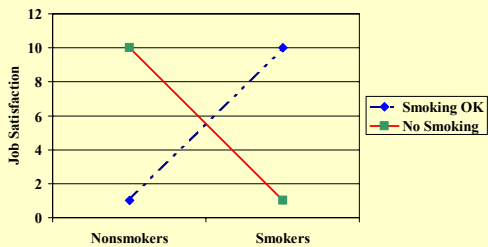
	Smokers		
	No	Yes	
Smoking Not Allowed	10	1	5.5
Smoking Allowed	1	10	5.5
	5.5	5.5	

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Factorial Graphs: Interaction

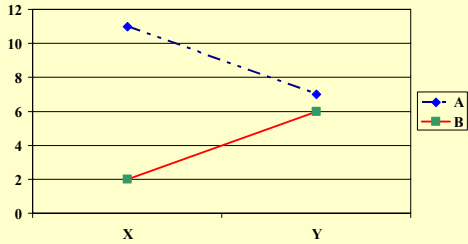


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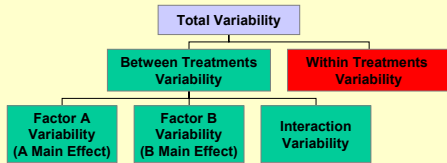
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Another Interaction



Partitioning Sources of Variability



Problem 2*

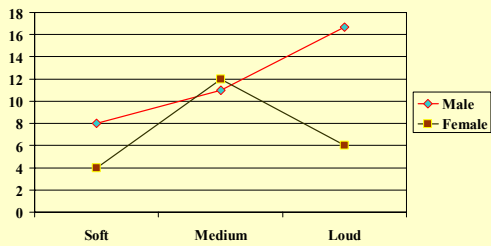
Vera Loude was convinced that the volume of commercials would make the commercials more persuasive. She also felt that this effect would be different for males and females.

To test her belief Vera recorded an advertisement and played it to a group of male and female volunteers at one of three levels: Soft, Medium, and Loud.

After listening to the advertisement the volunteers were asked to rate its persuasiveness.

* From Helman, G. W. (2003) *Basic Statistics for the Behavioral Sciences*. Houghton Mifflin: Boston

Graph of Vera's Data



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Vera's Data

	Soft	Medium	Loud	Mean
Male	9 4 11 <small>(M=8.00)</small>	8 12 13 <small>(M=11.00)</small>	18 17 15 <small>(M=16.67)</small>	M=11.89
Female	2 6 4 <small>(M=4.00)</small>	9 10 17 <small>(M=12.00)</small>	6 8 4 <small>(M=6.00)</small>	M=7.33
Mean	M=6.00	M=11.50	M=11.33	M_G=9.611

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Where Do the Numbers Come From?

	Soft	Medium	Loud	Mean
Male	$\begin{pmatrix} 9 \\ 4 \\ 11 \end{pmatrix}$ M= 8.0	$\begin{pmatrix} 8 \\ 12 \\ 13 \end{pmatrix}$ M= 11.0	$\begin{pmatrix} 18 \\ 17 \\ 15 \end{pmatrix}$ M= 16.67	M=11.89
Female	$\begin{pmatrix} 2 \\ 6 \\ 4 \end{pmatrix}$ M= 4.0	$\begin{pmatrix} 9 \\ 10 \\ 17 \end{pmatrix}$ M= 12.0	$\begin{pmatrix} 6 \\ 8 \\ 4 \end{pmatrix}$ M= 6.0	M=7.33
Mean	M=6.00	M=11.50	M=11.33	M _G =9.611

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Evaluating the Null Hypothesis

	F_{obt}	F_{crit}
Volume	$F_{(2,12)} = 7.14$	3.88
Gender	$F_{(1,12)} = 11.36$	4.75
Volume x Gender	$F_{(2,12)} = 6.25$	3.88

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Post Hoc Tests

- For Main effects conduct the regular Tukey HSD test.
- For Interactions
 - Make comparisons within
 - Each column.
 - Each row.
 - When using Tukey, adjust k when selecting the value for q.

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Effect Size

- Calculate Eta squared using the regular formula.

$$\eta^2 = \frac{93.39}{412.28} = .227$$

$$\eta^2 = \frac{117.45}{412.28} = .285$$

$$\eta^2 = \frac{102.77}{412.28} = .249$$

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Problem 2: Chocolate Chip Study

The Home for Retired College Professors (HRCP) wants to do a fund raiser using the expertise of its residents as business consultants. After a trial, the clients complained that the advice was too impractical and academic. The director, Gerry Atric, wants to see if feeding these oldsters with chocolate chips would increase the practicality of their recommendations.

Atric felt that teaching experience would also have an impact on the treatment effect, so she divided the group into those who taught more than 20 years and those who taught less than 20 years.

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Model

		Chocolate Chips	
Experience		No	Yes
Under 20 years		n=5	n=5
Over 20 years		n=5	n=5

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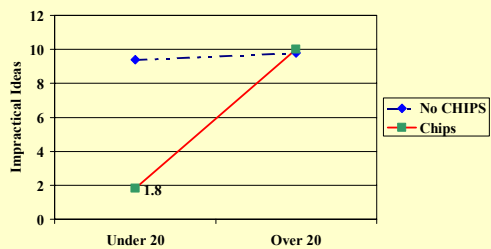
	No Chips	Chips	Mean
Under 20	9 10 8 9 11 M= 9.4	2 3 2 1 1 M= 1.8	5.6
Over 20	10 11 9 9 10 M= 9.8	9 12 10 9 10 M= 10.0	9.9
Mean	9.6	5.9	7.75

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Chocolate Chip Study



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2x2 Factorial ANOVA

Chocolate and experience study summary table

Source	SS	df	MS	F
Between Group				
Experience	92.45	1	92.45	88.05*
Chocolate Chips	68.45	1	68.45	65.19*
AXB	76.05	1	76.05	72.43*
Within Group	16.80	16	1.05	
Total	253.75	19		

* p < .01

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Effect Size

	η^2
Experience	.338
Chips	.250
Experience x Chips	.278

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Factorial ANOVA: Notation

Number of independent variables

4 x 3 x 2 factorial ANOVA


Levels of each independent variable.

Factorial ANOVA Assumptions

1. The observations within each treatment condition are independent.
2. The population distribution is relatively normal.
3. The variances within each treatment condition are equal.

Assignment

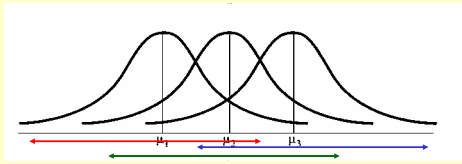
Homework #13



Repeated Measures ANOVA

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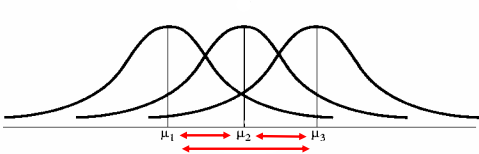
Sources of Within Group Variability



1. Measurement error.
2. Individual differences among the subjects.
3. Random error.

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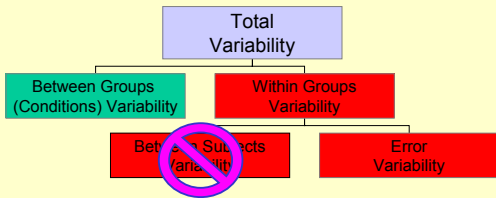
Sources of Between Group Variability



1. **TREATMENT EFFECT.**
2. Individual differences among the subjects.
3. Measurement Error.
4. Random error.

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Partitioning the Variance



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The F-test

$$F_{(k-1)(n-1)} = \frac{MS_{\text{Treatment}}}{MS_{\text{Error}}}$$

Note that this is "n", not N or N-k.

Error has random subject error removed.

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Example: Relaxation Therapy

Nine migraine sufferers were asked to document the strength of their headaches. There was a two-week baseline period followed by three weeks of relaxation therapy.

The therapists wanted to determine if the therapy was effective.

1. What is the research hypothesis?
2. What is H_0 ?
3. What is the statistical hypothesis?

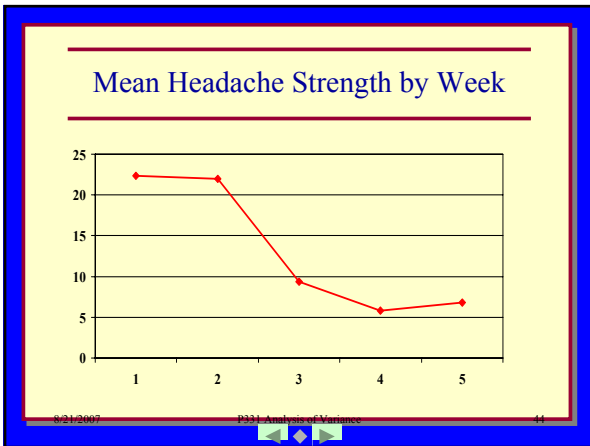
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Subject	Baseline weeks		Treatment Weeks			Subject
	1	2	3	4	5	Total
1	21	22	8	6	6	63
2	20	19	10	4	4	47
3	17	15	5	4	5	46
4	25	30	13	12	17	97
5	30	27	13	8	6	84
6	19	27	8	7	4	65
7	26	16	5	2	5	54
8	17	18	8	1	5	49
9	26	24	14	8	9	81
Mean	22.33	22.00	9.33	5.78	6.78	13.24

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Summary Table

Source	df	SS	MS	F
Between Weeks	4	2449.20	612.30	85.04
Within Between Subjects	8	486.71		} Error
Error	32	230.40	7.20	
Total	44	3166.31		

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Post hoc Tests

- Tukey's HSD
 - Replace MS_{within} with MS_{error}
 - Replace df_{within} with df_{error}

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Effect Size

$$\eta^2 = \frac{SS_{\text{between}}}{SS_{\text{total}}}$$

$$\eta^2 = \frac{2449.2}{3166.31}$$

$$\eta^2 = .774$$

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Assignment

Homework #14

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