

Inferential Statistics

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Steps in Inferential Analyses

- **VassarStats:**
<http://faculty.vassar.edu/lowry/VassarStats.html>
- In any inferential statistic, the first step is always to examine the p-value to determine if the result is significant
 - If not significant, analysis stops
 - If significant, then conduct post-hoc analyses if more than 2 groups are being compared
 - Examine descriptive statistics (mean, frequencies, correlation) to interpret the meaning of a significant result

t-test

- **t-test:** Used when comparing two groups on a dependent variable
 - **Independent samples:** Two unique groups
 - **Correlated samples:** Groups are created by matched assignment or the same participants are compared on two variables
- Report the means and standard deviations for the two groups, the t, df, and two-tailed p

t-test Example:

Comparison of Christian (Group A) to Muslim (Group B) on Number of Traumatic Experiences

	A	B	Total
n	210	21	231
$\sum X$	58.1299999	7.68	65.8099999
$\sum X^2$	23.1461000	3.592	26.7381000
SS	7.0552	0.7833	7.9894
mean	0.2768	0.3657	0.2849

Mean _a - Mean _b	t	df	p	one-tailed	two-tailed
-0.0889	-2.1	229		0.0184115	0.036823

t-Test Example

Comparison of Christian (Group A) to Muslim (Group B) on Degree of Community Support

Data Summary			
	A	B	Total
n	208	21	229
ΣX	137.049999	14.9299999	151.979999
ΣX^2	106.401699	12.2579000	118.659599
SS	16.1002	1.6434	17.7953
mean	0.6589	0.711	0.6637

Results				
Mean _a -Mean _b	t	df	p	
-0.0521	-0.81	227	one-tailed	0.209394
			two-tailed	0.418788

Analysis of Variance (ANOVA)

- ANOVA: Compare three or more groups on one dependent variable
- One-way ANOVA: Compares multiple groups on the same DV
 - Significant p means that there is a significant difference between groups somewhere, NOT that there is a significant difference between all groups
 - A post-hoc test such as Tukey's HSD (Honestly Significant Difference) is needed to determine which differences are significant
 - Report means and standard deviations for all groups, ANOVA summary table, and the results of Tukey's HSD
- Factorial ANOVA: Compare the effect of multiple Ivs on one DV
 - Interpretation is more complex

One-Way ANOVA Example

Comparison of Pentecostal (A), Catholic (B), and Mainline Christian (C) on Degree of Community Support

Data Summary						
	Samples					Total
	1	2	3	4	5	
N	75	53	80			208
ΣX	50.97	35.65	50.43			137.05
Mean	0.6796	0.672642	0.630375			0.658894
ΣX^2	39.6067	27.4241	39.3709			106.4017
Variance	0.067128	0.066239	0.095963			0.077779
Std.Dev.	0.259091	0.257369	0.309779			0.278889
Std.Err.	0.029917	0.035352	0.034634			0.019337

standard weighted-means analysis						
ANOVA Summary Independent Samples k=3						
Source	SS	df	MS	F	P	
Treatment [between groups]	0.107239	2	0.053619	0.69	0.502737	
Error	15.993007	205	0.078015			
Ss/Bl						Graph Maker
Total	16.100246	207				

One-Way ANOVA Example

Comparison of Pentecostal (A), Catholic (B), and Mainline Christian (C) on Traumatic Events Experienced. **NOTE: This Data was Falsified.**

Data Summary						
	Samples					Total
	1	2	3	4	5	
N	75	60	82			217
ΣX	17.86	19.66	24.81			62.33
Mean	0.238133	0.327667	0.302561			0.287235
ΣX^2	6.4658	9.4942	9.7061			25.6661
Variance	0.029902	0.051733	0.027155			0.035939
Std.Dev.	0.172922	0.22745	0.164788			0.189575
Std.Err.	0.019967	0.029364	0.018198			0.012869

standard weighted-means analysis						
ANOVA Summary Independent Samples k=3						
Source	SS	df	MS	F	P	
Treatment [between groups]	0.298167	2	0.149083	4.27	0.015192	
Error	7.464574	214	0.034881			
Ss/Bl						Graph Maker
Total	7.762741	216				

Tukey HSD Test	
HSD[.05]=0.07; HSD[.01]=0.09	
M1 vs M2 P<.05	
M1 vs M3 nonsignificant	
M2 vs M3 nonsignificant	

M1 = mean of Sample 1
 M2 = mean of Sample 2
 and so forth.
 HSD = the absolute [unsigned] difference between any two sample means required for significance at the designated level. HSD[.05] for the .05 level; HSD[.01] for the .01 level.

Interpreting Factorial ANOVA

- **Interaction Effect:** The effect of one independent variable depends on the level of the other independent variable
- **Main Effect:** Comparison of each independent variable separately
 - Main effects are the same as t-tests or one-way ANOVAs for each independent variable separately

Interpreting Factorial ANOVA

- Examine the interaction first.
 - If significant, proceed by comparing each individual group via Tukey's HSD
 - Main effects are generally not examined, because main effects are superseded by the interaction
 - If the interaction is not significant, examine the main effects, which are interpreted just like a one-way ANOVA
 - Follow up significant results with Tukey's HSD
 - If nothing is significant, analysis stops.

Factorial ANOVA Example

3x2: Gender by Christian Denomination on Community Support

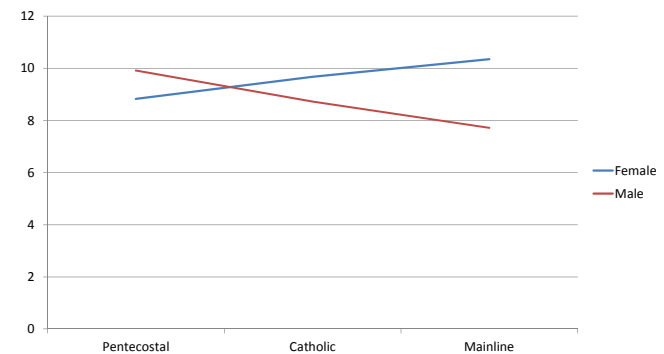
ANOVA Summary					
Source	SS	df	MS	F	P
Rows	0.2	1	0.2	2.64	0.1058
Columns	0.05	2	0.03	0.33	0.7193
r x c	0.66	2	0.33	4.36	0.0141
Error	14.61	193	0.08		
Total	15.52	198			

Critical Values for the Tukey HSD Test

	HSD[.05]		HSD[.01]	
	Rows	Columns	Rows	Columns
Rows	2	0.08	0.1	
Columns	3	0.12	0.14	
Cells	6	0.2	0.24	

HSD=the absolute [unsigned] difference between any two means (row means, column means, or cell means) required for significance at the designated level: HSD[.05] for the .05 level; HSD[.01] for the .01 level. The HSD test between row means can be meaningfully performed only if the row effect is significant; between column means, only if the column effect is significant; and between cell means, only if the interaction effect is significant.

Community Support: Interaction Effect



Factorial ANOVA Example

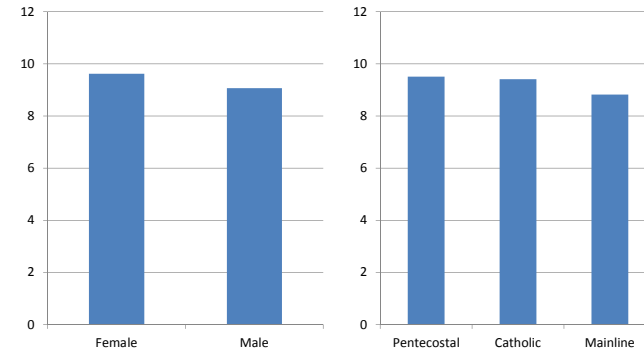
3x2: Gender by Christian Denomination on Community Support

	Pentecostal	Catholic	Mainline	Total
Female	0.63	0.69	0.75	0.69
Male	0.71	0.62	0.55	0.65
Total	0.68	0.67	0.63	

Interaction was significant. Tukey's HSD was 0.2 for the interaction at .05 significance.

Main Effects for Community Support

No differences are significant



Factorial ANOVA Example

3x2: Gender by Christian Denomination on PTSD Re-Experiencing

standard weighted-means analysis

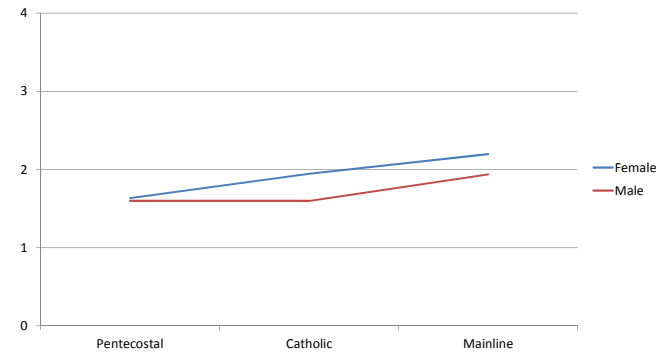
ANOVA Summary					
Source	SS	df	MS	F	P
Rows	1.94	1	1.94	2.28	0.1327
Columns	7.29	2	3.65	4.29	0.015
r x c	0.83	2	0.42	0.49	0.6134
Error	163.2	192	0.85		
Total	173.26	197			

Critical Values for the Tukey HSD Test			
	HSD[.05]	HSD[.01]	
Rows	2	0.26	0.34
Columns	3	0.39	0.48
Cells	6	0.67	0.79

HSD=the absolute [unsigned] difference between any two means (row means, column means, or cell means) required for significance at the designated level; HSD[.05] for the .05 level; HSD[.01] for the .01 level. The HSD test between row means can be meaningfully performed only if the row effect is significant; between column means, only if the column effect is significant; and between cell means, only if the interaction effect is significant.

Factorial ANOVA Example

3x2: Gender by Christian Denomination on PTSD Re-Experiencing



Factorial ANOVA Example

3x2: Gender by Christian Denomination on PTSD Re-Experiencing

	Pentecostal	Catholic	Mainline	Total
Female	1.64	1.95	2.19	1.89
Male	1.60	1.60	1.94	1.71
Total	1.62	1.80	2.01	

Main effect of column was significant. Tukey's HSD was 0.26 for the row at .05 significance.

Analysis of Covariance (ANCOVA)

- **ANCOVA:** Compares post-test scores with pre-test scores factored out
 - *Concomitant variable (CV)* is the variable that should be controlled for (e.g., pre-test)
 - *Observed Means:* Actual means for the dependent variable (post-test).
 - *Adjusted Means:* Means that have been statistically manipulated based on the concomitant variable (pre-test)
- Report both the Observed and Adjusted Means as well as ANCOVA summary table
 - Present any figures with the Adjusted Means with a note so that readers are clear that these are Adjusted Means.

ANCOVA Example

Effect of Treatment on PTSD Symptoms. **NOTE: Data is fabricated**

Dependent Variable		
Sample		
A	B	Total
n		
240	240	480
Observed Means		
1.3304	1.8107	1.5706
Adjusted Means		
1.8663	1.2748	1.5706

Pre-test Scores
 Group A: 0.28
 Group B: 1.74

Aggregate Correlation within Samples: CV vs DV

r =	0.53	r ² =	0.28
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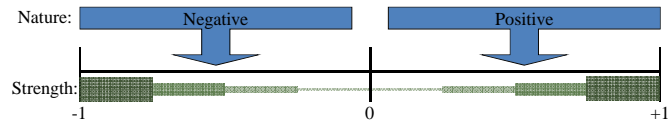
ANCOVA Summary

Source	SS	df	MS	F	P
adjusted means	17.12	1	17.12	33.58	<.0001
adjusted error	243.16	477	0.51		
adjusted total	260.28	478			

Correlation

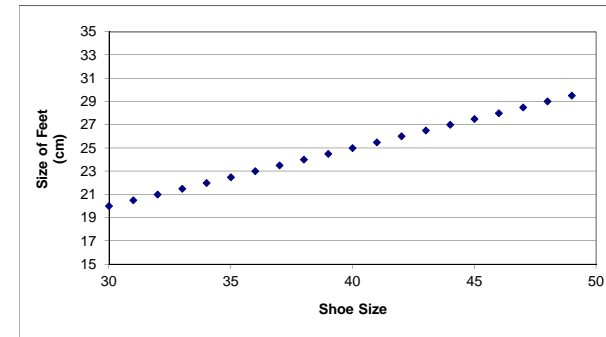
- **Correlation:** Examine the relationship between two variables within the same group of participants
 - Examine the p to determine if the correlation is significant
 - If this is significant, then the next step is to look at the correlation itself, symbolized by r.
- Report the means and standard deviations for the two variables, the t, df, two-tailed p, and r

Interpreting Correlations

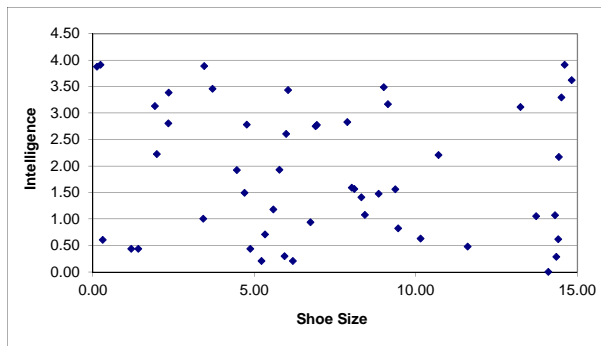


- Nature
 - **Positive:** Two variables increase together
 - **Negative:** As one variable increases, the other decreases
- Strength
 - Closer to -1 or +1 is stronger relationship
 - 0 is no relationship

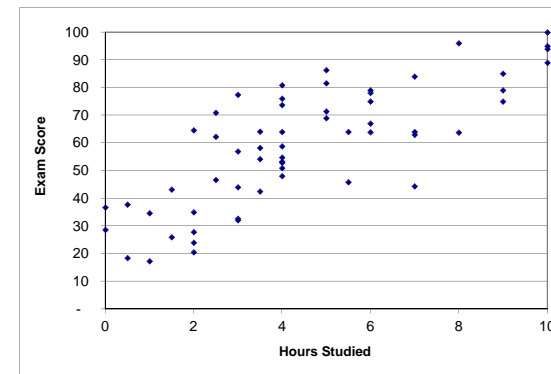
Correlation = 1.00

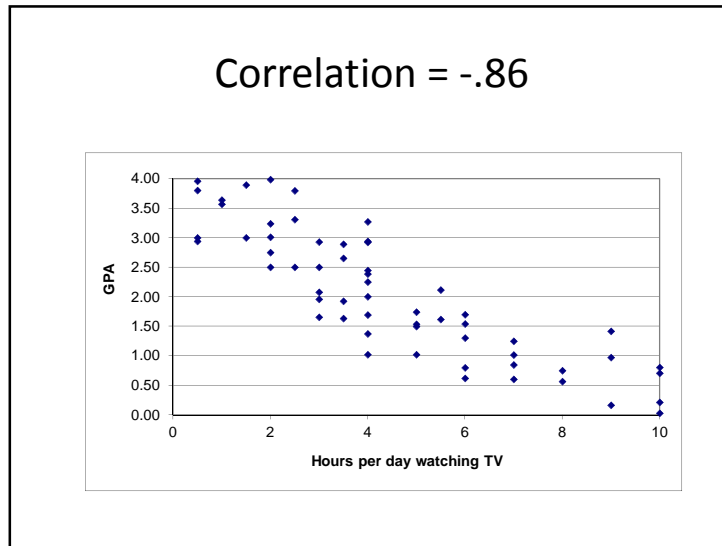


Correlation = .04



Correlation = .78





Correlation Example

Relationship between Number of Traumatic Experiences and PTSD Re-Experiencing Symptoms

Data Summary

$\sum X =$	68.63	$\sum X^2 =$	28.0123
$\sum Y =$	435.3	$\sum Y^2 =$	991.5978
$\sum XY =$	132.87		

	X	Y
N	242	
Mean	0.2836	1.7988
Variance	0.0355	0.8655
Std.Dev.	0.1883	0.9303
Std.Err.	0.0121	0.0598

r	r ²	Slope	Y Intercept	Std. Err. of Estimate
0.2231	0.0498	1.101987	1.486276	0.9088
t	df	p		one-tailed
3.55	240			0.0002315
				two-tailed
				0.000463

Correlation Example

Relationship between Age and Degree of Community Support

Data Summary

$\sum X =$	156.11	$\sum X^2 =$	121.9003
$\sum Y =$	5428	$\sum Y^2 =$	128784
$\sum XY =$	3641.06		

	X	Y
N	233	
Mean	0.67	23.2961
Variance	0.0746	10.0542
Std.Dev.	0.2731	3.1708
Std.Err.	0.0179	0.2077

r	r ²	Slope	Y Intercept	Std. Err. of Estimate
0.0214	0.0005	0.24846	23.129632	3.177
t	df	p		one-tailed
0.33	231			0.3708495
				two-tailed
				0.741699

Correlation Example

Relationship between PTSD Arousal Symptoms and Academic Achievement. **NOTE: Data is fabricated**

Data Summary

$\sum X =$	421.25	$\sum X^2 =$	902.3475
$\sum Y =$	12532	$\sum Y^2 =$	668964
$\sum XY =$	20773.15		

	X	Y
N	242	
Mean	1.7407	51.7851
Variance	0.7016	82.9578
Std.Dev.	0.8376	9.1081
Std.Err.	0.0538	0.5855

r	r ²	Slope	Y Intercept	Std. Err. of Estimate
-0.5664	0.3208	-6.158946	62.505977	7.522
t	df	p		one-tailed
-10.65	240			<.0001
				two-tailed
				<.0001

Chi-Square

- **Chi-Square (χ^2):** Compares the frequencies of responses between two (or more) independent groups
 - Determine whether distributions of categorical variables differ from one another
- **BE CAREFUL NOT TO ARTIFICIALLY DIVIDE CONTINUOUS VARIABLES INTO DISCRETE VARIABLES!**

Chi-Square Example

Frequency of Smokers/Non-Smokers by Gender **NOTE: Data is fabricated**

Select the number of rows:

Select the number of columns:

Data Entry

	B ₁	B ₂	B ₃	B ₄	B ₅	Totals
A ₁	90	10	.....	.....	.....	100
A ₂	10	90	.....	.....	.....	100
A ₃	.....	.....	.....	.....	.....	.....
A ₄	.....	.....	.....	.....	.....	.....
A ₅	.....	.....	.....	.....	.....	.....
Totals	100	100	.....	.....	.....	200

Chi-Square	df	P
124.82	1	<.0001

Cramer's V = 0.8

Note that for df=1 the chi-square value reported is the Yates chi-square, corrected for continuity. The Pearson chi-square, uncorrected for continuity, is 128
 P = <.0001

Chi-Square Example

Political Party Affiliation by Gender **NOTE: Data is fabricated**

Select the number of rows:

Select the number of columns:

Data Entry

	B ₁	B ₂	B ₃	B ₄	B ₅	Totals
A ₁	12	15	.....	.....	.....	27
A ₂	14	12	.....	.....	.....	26
A ₃	13	13	.....	.....	.....	26
A ₄	.....	.....	.....	.....	.....	.....
A ₅	.....	.....	.....	.....	.....	.....
Totals	39	40	.....	.....	.....	79

Chi-Square	df	p
0.47	2	0.7906

No message for this analysis.