Independent One-Way Analysis of Variance

... comparing two or more means among independent groups

Objectives

- Understand when and why we use independent, one-way ANOVA
- Be able to interpret an ANOVA table
- Interpret post hoc tests after a significant ANOVA

Which Tire Is The Best?

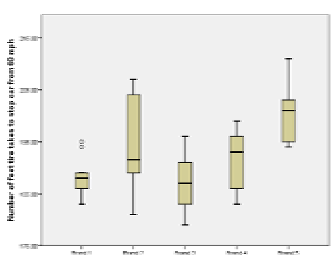
Does distance it takes to stop car at 60 mph depend on tire brand?

Brand1	Brand2	Brand3	Brand4	Brand5
194	[illegible]	[illegible]	[illegible]	[illegible]
184	204	[illegible]	[illegible]	197
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	179	[illegible]	[illegible]
[illegible]	207	191	[illegible]	211
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	193	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Sample Descriptive Statistics

Brand	N	MEAN	SD
1	10	188.20	3.88
2	10	195.20	9.02
3	10	187.40	5.27
4	10	191.20	5.55
5	10	200.50	5.44

Visualizing The Tire Data



ANOVA Table…Reject!

ANOVA

Number of feet tire takes to stop car from 60 mph

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1174.800	4	293.700	7.954	.000
Within Groups	1661.700	45	36.927		
Total	2836.500	49			

Multiple Comparisons

Dependent Variable: Number of feet tire takes to stop car from 60 mph

LSD

(I) Brand of tire tested	(J) Brand of tire tested	Mean Difference (I-J)	[illegible]	Sig.	[illegible]	[illegible]
Brand 1	Brand 2	-7.20000*	[illegible]	.013	[illegible]	[illegible]
	Brand 3	.80000	[illegible]	.770	[illegible]	[illegible]
	Brand 4	-3.00000	[illegible]	.275	[illegible]	[illegible]
	Brand 5	-12.30000*	[illegible]	.000	[illegible]	[illegible]
Brand 2	Brand 1	7.20000*	[illegible]	.013	[illegible]	[illegible]
	Brand 3	[illegible]	[illegible]	.009	[illegible]	[illegible]
	Brand 4	4.20000	[illegible]	.148	[illegible]	[illegible]
	Brand 5	-5.10000	[illegible]	.067	[illegible]	[illegible]
Brand 3	Brand 1	-.80000	[illegible]	.770	[illegible]	[illegible]
	Brand 2	[illegible]	[illegible]	.009	[illegible]	[illegible]
	Brand 4	-3.80000	[illegible]	.169	[illegible]	[illegible]
	Brand 5	-13.10000*	[illegible]	.000	[illegible]	[illegible]
Brand 4	Brand 1	3.00000	[illegible]	.275	[illegible]	[illegible]
	Brand 2	-4.20000	[illegible]	.148	[illegible]	[illegible]
	Brand 3	3.80000	[illegible]	.169	[illegible]	[illegible]
	Brand 5	-9.30000*	[illegible]	.001	[illegible]	[illegible]
Brand 5	Brand 1	12.30000*	[illegible]	.000	[illegible]	[illegible]
	Brand 2	5.10000	[illegible]	.067	[illegible]	[illegible]
	Brand 3	13.10000*	[illegible]	.000	[illegible]	[illegible]
	Brand 4	9.30000*	[illegible]	.001	[illegible]	[illegible]

* The mean difference is significant at the 0.05 level.

Hypothesis Testing With ANOVA

They look similar. Why don't we just do a bunch of t-tests?

- **t test =** $\frac{\text{difference b/t sample means}}{\text{variability within distribution(s)}}$
- **F test =** $\frac{\text{"average" difference among sample means}}{\text{"average" variability among distributions}}$

Conducting 7 t tests from the same sampling distribution (under the same hypothesis) using α = 0.05 each time would result in overall Type I error of about .35

Hypotheses Words & Symbols

- **H_0: sample (population) averages are all equal**

$$\mu_1 = \mu_2 = \ldots = \mu_k$$

or

$$\bar{x}_1 = \bar{x}_2 = \ldots = \bar{x}_5$$

- **H_1: at least one sample (population) mean differs significantly from one other**
  - **H_1: at least one μ differs significantly from one other μ**

Table of Critical F Values

- **Go to your table of critical F values**
- **What do you notice about the table?**
- **If df = 4,45 and F_{comp} = 7.95, is there a statistically significant difference somewhere among your group averages? At .05? At .01?**
- **F IS NEVER NEGATIVE!**

The ANOVA Table

Different Sources of Variance

- **Between** comes from IV and **within** from error and random variation

Between Groups Variance + Within Groups Variance = Total Variance

Accounting for total variability in our study does not mean we understand where it all comes from

ANOVA Table Cheat Sheet

Source of Variation	SS	df	MS	F ratio
Between Samples	SSB	k - 1	$MSB = \frac{SSB}{k-1}$	$F = \frac{MSB}{MSW}$
Within Samples	SSW	n - k	$MSW = \frac{SSW}{n-k}$	
Total	SST = SSB+SSW	n - 1		

df: degrees of freedom

SS: sum of squares

MS: mean squared

k: number of groups

N: total # scores

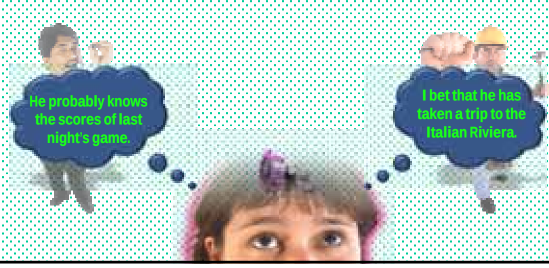
F: F_{comp}

One-Way ANOVA Example

“You see us as you want to see us.”

Social Cognition

Don’t kid yourself WE ALL do it!



IN SMALL GROUPS…

Define *stereotype* and list 5 – 10 stereotypes that might be present in TV shows, music, blogs, Facebook, etc.

Media Consumption & Stereotyping

The local parent-teacher association researched the impact of media on children's *level of stereotyping (DV).* As part of the research, child participants were assigned to increased exposure to either *popular music, television* or a *control group (IV).* The stereotyping scale went from 0 to 20 (0=low stereotyping, 20=high). Scores for each group are listed below. Use the steps of hypothesis testing and the ANOVA table to decide whether type of media has no impact on level of stereotyping.

1. Control scores: 6, 5, 4, 2, 1, 0
2. Pop music: 10, 8, 9, 7, 5, 3
3. Television scores: 11, 12, 10, 10, 9, 8

Source	DF	SS	MS	F	P
Between	?	148	?	?	?
Within	?	72	?	?	
Total	?	220			

Media Consumption & Stereotyping

Source	DF	SS	MS	F	P
Between	2	148	74	15.42	p<.05
Within	15	72	4.8		
Total	17	220			

CONCLUSIONS AT THIS POINT

a. "A one-way ANOVA was conducted to determine…"
b. "There was sufficient evidence to reject the null hypothesis…t(2, 15)…"
c. "These findings mean that…"
d. "Further post-hoc testing is necessary to determine which pairwise differences are statistically significant…"

Summary of ANOVA

- Easier than multiple t-tests
- Circumvents Type I error inflation
- Group means vs. grand mean
  - significant F if even one mean significantly different from grand mean
- ANOVA hypothesis is non-directional
  - need post-hoc testing if null rejected

Post-Hoc Testing: Finishing Off a Significant ANOVA

POST HOC TESTING

- Significant F does not pinpoint difference among groups
- Must use post-hoc tests to determine
  - Protection from Type I error
- *Fisher's least significant difference* method

LSD Table of Mean Differences

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	SIG.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Popular Music	-4.0*	1.26491	.006	-6.6961	-1.3039
	Television	-7.0*	1.26491	.000	-9.6961	-4.3039
Popular Music	Control	4.0*	1.26491	.006	1.3039	6.6961
	Television	-3.0*	1.26491	.032	-5.6961	-.3039
Television	Control	7.0*	1.26491	.000	4.3039	9.6961
	Popular Music	3.0*	1.26491	.032	.3039	5.6961

* The mean difference is significant at the 0.05 level.

Post-Hoc LSD Interpretation

7a. A Fisher's LSD, post-hoc test was conducted to determine which pairwise differences…

7b. Our LSD test revealed that average level of stereotyping for TV watchers is significantly…

7b. Given these findings, parents would be advised…activist groups should target…more education about pervasive stereotype influences…