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	189	185	183	195
184	204	183	193	197
189	190	186	184	194
189	190	183	186	202
188	189	179	194	200
186	207	191	199	211
195	203	188	196	203
186	193	196	188	206
183	181	189	193	202
188	206	194	196	195

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

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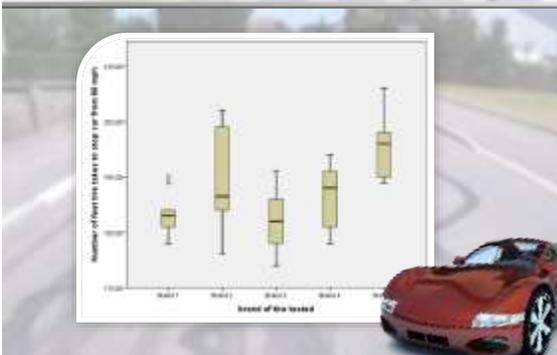
They look similar. Why don't we just do a bunch of t-tests?

- **t test =** $\dfrac{\text{difference b/t sample means}}{\text{variability within distribution(s)}}$

- **F test =** $\dfrac{\text{"average" difference among sample means}}{\text{"average" variability among distributions}}$

> Conducting 7 t tests from the same sampling distribution (under the same hypothesis) using $\alpha = 0.05$ each time would result in overall Type 1 error of about .35

Hypotheses Words & Symbols

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

$$\mu_1 = \mu_2 = \ldots = \mu_k$$
or
$$\bar{x}_1 = \bar{x}_2 = \ldots = \bar{x}_5$$

> k = total number of groups

- **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

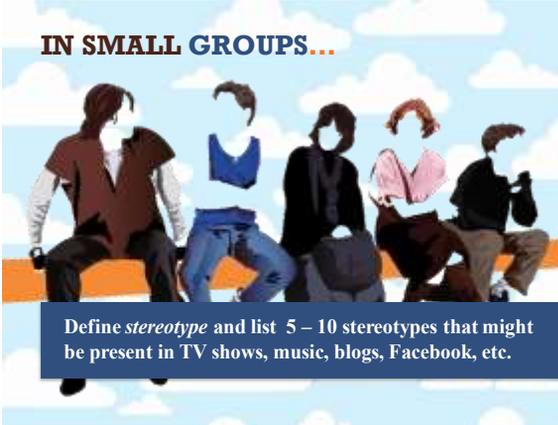## Different Sources of Variance

- **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	$k-1$	$MSB = \dfrac{SSB}{k-1}$	$F = \dfrac{MSB}{MSW}$
Within Samples	SSW	$N-k$	$MSW = \dfrac{SSW}{N-k}$	
Total	$SST = SSB+SSW$	$N-1$		

df: degrees of freedom **k: number of groups**

SS: sum of squares **N: total # scores**

MS: mean squared **F: F_{comp}**

One-Way ANOVA Example

"You see us as you want to see us."

CRIMINAL   ATHLETE   BASKET CASE   PRINCESS

BRAIN

Dear Mr. Vernon,

We accept the fact that we had to sacrifice a whole Saturday in detention for whatever it was we did wrong. What we did WAS wrong, but we think you're crazy to make us write an essay telling you who we think we are. You see us as you want to see us—in the simplest terms and the most convenient definitions. But what we found out is that each one of us is...a brain...and an athlete...and a basket case...a princess...and a criminal. Does that answer your question?

Sincerely yours,

The Breakfast Club

Social Cognition

Don't kid yourself WE ALL do it!

He probably knows the scores of last night's game.

I bet that he has taken a trip to the Italian Riviera.

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. TV scores: 11, 12, 10, 10, 9, 8

Source	DF	SS	MS	F	P
Between	?	148	?	?	?
Within	?	?	?		
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 FOR SIGNIFICANT F

a. "A one-way ANOVA was conducted to determine…"
b. "There was sufficient evidence to reject the null hypothesis…F(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

- **F_{comp} shows sig diff somewhere among group averages**
- **However, must use post-hoc tests to determine specific "pairwise" diffs**
  - **Protection from Type I error**
  - **_Fisher's least significant difference_ (LSD) method**
    - **LSD: smallest stat sig diff between two group averages**

LSD Table of Mean Differences

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	SIG.	95% CI	
					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

CONCLUSIONS FOR LSD

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…

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