TOPIC: MULTIPLE COMPARISONS: BONFERRONI

The Bonferroni Test

- Recall: ANOVA compares 3+ means. If H_0 is rejected, **Post-hoc** tests can tell you *which* means are different.
  - Post-Hoc Tests, like **Bonferroni**, test ____________ of means against each other.

Recall *(Two Means t-Test)*

$$t = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

EXAMPLE

In an ANOVA test on mean weekly study time for different grade levels, you reject H_0: Students in grades 10-12 study for the same amount of time. Determine which pair(s) of means are different with $\alpha = 0.05$.

$\text{MSE} =$ ________

$N =$ ______, $k =$ _____, $df =$ ______

Grade	Weekly Study Times (hrs)										$\bar{x}$	n
10	3	4	4	2	1	0	3	6	5	2	3	10
11	4	5	6	3	7	8	2	3	1	4	4.3	10
12	7	5	8	3	6	7	8	5	9	2	6	10

10th & 11th Grade

H_0:

H_a:

$$t = \frac{\_\_ - \_\_}{\sqrt{\_\_\left(\frac{}{\_\_} + \frac{}{\_\_}\right)}}$$

P-value = _______

\# of pairs = _______

P-val · # pairs = _______

P-val · # pairs [< | >] α

[REJECT | FTR] H_0.

11th & 12th Grade

$H_0: \mu_{11} = \mu_{12}$

$H_a: \mu_{11} \neq \mu_{12}$

$$t = \frac{\_\_ - \_\_}{\sqrt{4.448 \cdot \left(\frac{1}{10} + \frac{1}{10}\right)}}$$

P-value = _______

\# of pairs = 3

P-val · # pairs = _______

P-val · # pairs [< | >] α

[REJECT | FTR] H_0.

10th & 12th Grade

$H_0: \mu_{10} = \mu_{12}$

$H_a: \mu_{10} \neq \mu_{12}$

$$t = \frac{\_\_ - \_\_}{\sqrt{4.448 \cdot \left(\frac{1}{10} + \frac{1}{10}\right)}}$$

P-value = _______

\# of pairs = 3

P-val · # pairs = _______

P-val · # pairs [< | >] α

[REJECT | FTR] H_0.

HOW TO: Perform Bonferroni Test on TI-84

1) Verify: ANOVA H_0 was rejected? ☐

2) Get MSE from ANOVA readout

`One-way ANOVA`

(V) `Error`

`MS=`

For each pair of groups:

3) $H_0: \mu_1 = \mu_2$, $H_a: \mu_1 \neq \mu_2$

4) Calculate t (use $s^2 = \textbf{MSE}$)

5) P-value: use $df = N - k$

$N =$ # of total obs. $k =$ # of groups

6) Multiply P-value by # of __________

To find on calc: MATH > PROB

(V) `3:nCr`, Enter ${}_kC_2$

7) State Conclusion

New

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 \cdot \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$s^2 = $ MSE from one-way ANOVA

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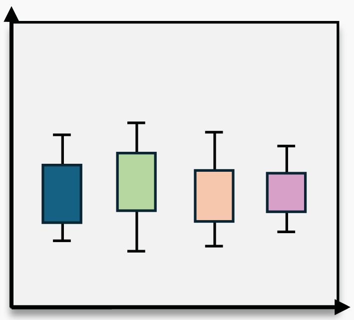
PRACTICE

A researcher is comparing mean cholesterol levels across 4 diet plans (A, B, C, D) in a One-Way ANOVA test. If H_0 was rejected and the researcher were to use a Bonferroni Test, how many pairs of comparisons would they do?

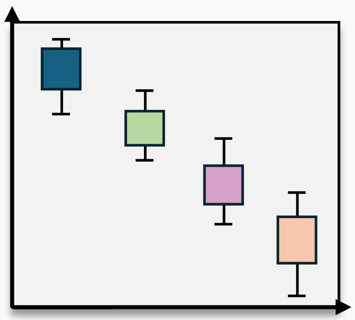
PRACTICE

For which of the following scenarios would it be most appropriate to run a Bonferroni Test to see which mean(s) are significantly different from the rest?

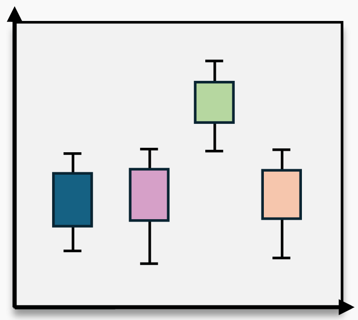
A)



B)



C)



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EXAMPLE

A cereal brand evaluates 3 different cereals to determine which is best appealing based on taste ratings (1-10) from customers. Their initial findings reject H_0: the mean taste ratings of the cereals are the same. The table below shows taste ratings from random samples of participants. Use a Bonferroni Test to compare Cereal A vs. C. If A vs. B and B vs. C yield P-values of 0.0014 & 0.0004 respectively, what can you conclude about Cereal B?

Cereal	Taste Rating						$\bar{x}$	n
A	7	8	6	9	7	9	7.67	6
B	5	6	5	6	4	5	5.17	6
C	8	9	7	9	8	7	8.00	6

HOW TO: Perform Bonferroni Test on TI-84

1) Verify: ANOVA H_0 was rejected? ☐

2) Get MSE from ANOVA readout

`One-way ANOVA`

[V] `Error`

`MS=`

For each pair of groups:

3) $H_0: \mu_1 = \mu_2, \quad H_a: \mu_1 \neq \mu_2$

4) Calculate t (use $s^2 = \mathbf{MSE}$)

5) P-value: use $df = N - k$

$N =$ # of total obs. $k =$ # of groups

6) Multiply P-value by # of ________

To find on calc: [MATH] [>] `PROB`

[V] `3:nCr`, Enter ${}_kC_2$

7) State Conclusion

Recall

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 \cdot \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$s^2 =$ MSE from one-way ANOVA