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Section 1

MANE 6313

Subsection 1

Week 4, Module E

Student Learning Outcome

Analyze simple comparative experiments and experiments with a single factor.

Module Learning Outcome

Interpret multiple comparisons of treatments and treatments to a control.

Contrasts

- A hypothesis from a linear combination of the parameters $C = \sum_{i=1}^{a} c_i y_{i.}$ with the constraint that $\sum_{i=1}^{a} c_i = 0$
- Can be extended to multiple comparisons using orthogonal contrasts

Multiple Comparisons

- Used to test $H_0 : \mu_i = \mu_j$ for all $i \neq j$
- Only used if H_0 is rejected
- There are four methods presented in the textbook
  - LSD method
  - Duncan's multiple range test
  - Newman-Keuls test
  - Tukey's test
- All methods control family-wise error rate not individual error rate
- Read the section on "which method do I use?"

Tukey Multiple Comparison Example

$a = 4$

Mortar Problem – Tukey's

Tukey's pairwise comparisons

Family error rate = 0.0500
Individual error rate = 0.0126

Critical value = 4.53

Intervals for (column level mean) - (row level mean)

	OCM	PCM	PIM
PCM	-3.08 11.16		
PIM	-102.46 -88.23	-106.50 -92.27	
RM	-88.99 -74.76	-93.03 -78.80	6.35 20.58

← output

Calculate $T_\alpha = q_\alpha(a, f)\sqrt{\frac{MS_E}{n}}$

$= q_{.05}(4, 8)\sqrt{\frac{7.40}{3}}$

$= 4.53(1.571)$

$= 7.115$

Consider OCM, PCM comparison

$(33.96 - 29.92) - 7.115 \le \mu_{OCM} - \mu_{PCM} \le (33.96 - 29.92) + 7.115$

$-3.075 \le \mu_{OCM} - \mu_{PCM} \le 11.155$

Since C.I. contains zero, no difference in means.

$\bar{y}_{PCM}$ 29.92 — $\bar{y}_{OCM}$ 33.96 — $\bar{y}_{RM}$ 115.84 — $\bar{y}_{PIM}$ 129.30

Comparison to a Control - Dunnett's Test

- In many experiments, one of the treatments is a control and the analysis is interested in comparing the other treatments to the control

12.30 Ott (1993: 787, 788) considers an experiment in which 10 specimens were obtained from the centers of each of three lakes at a depth of 1 foot. The mean dissolved oxygen contents (in ppm) were then calculated for each of the 30 specimens and the following data were obtained.

Lake					
A		*B*		*C*	
0	2	1	7	14	22
2	3	3	5	26	21
1	4	4	3	25	16
3	1	6	4	18	20
1	5	8	5	19	30

Source: Data from R. Lyman Ott, 1993. *An Introduction to Statistical Methods and Data Analysis.* 4th ed. Belmont, CA: Wadsworth. Reprinted with permission of the publisher.

12.10 Twenty-five (relatively homogeneous) plots of ground were prepared in an identical fashion and planted with the same grain. Randomly selected plots received fertilizer treatments (in pounds per plot) as shown in the accompanying table. Tabled values indicate plot yields (in bushels per acre).

control	Fertilizer Levels			
0	10	20	30	40
20	25	36	35	43
25	29	37	39	40
23	31	29	31	36
27	30	40	42	48
19	27	33	44	47

Problem 12.10

One-way ANOVA: yield versus fertilizer

```
Analysis of Variance for yield
Source     DF      SS      MS      F      P
fertiliz    4  1256.6   314.1  18.07  0.000
Error      20   347.6    17.4
Total      24  1604.2

                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level      N    Mean   StDev  ------+---------+---------+---------
 0         5  22.800   3.347  (----*---)
10         5  28.400   2.408       (---*----)
20         5  35.000   4.183             (----*----)
30         5  38.200   5.263                  (----*----)
40         5  42.800   4.970                       (---*----)
                               ------+---------+---------+---------
Pooled StDev =    4.169             24.0      32.0      40.0

Dunnett's comparisons with a control

    Family error rate = 0.0500
Individual error rate = 0.0153

Critical value = 2.65

Control = level (0) of fertiliz

Intervals for treatment mean minus control mean

Level      Lower   Center    Upper --+---------+---------+---------+-----
10        -1.390    5.600   12.590 (--------*--------)
20         5.210   12.200   19.190          (--------*--------)
30         8.410   15.400   22.390                 (--------*--------)
40        13.010   20.000   26.990                        (--------*--------)
                              --+---------+---------+---------+-----
                              0.0       8.0      16.0      24.0
```

Minitab Demonstration

- Multiple comparisons for mortar problem
- Dunnett's procedure for problem 12.10

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Means

mortar	N	Mean	StDev	95% CI
OCM	3	33.960	1.703	(30.338, 37.582)
PCM	3	29.920	0.896	(26.298, 33.542)
PIM	3	129.30	4.76	(125.68, 132.93)
RM	3	115.84	1.81	(112.21, 119.46)

Pooled StDev = 2.72075

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

mortar	N	Mean	Grouping		
PIM	3	129.30	A		
RM	3	115.84		B	
OCM	3	33.960			C
PCM	3	29.920			C

Means that do not share a letter are significantly different.

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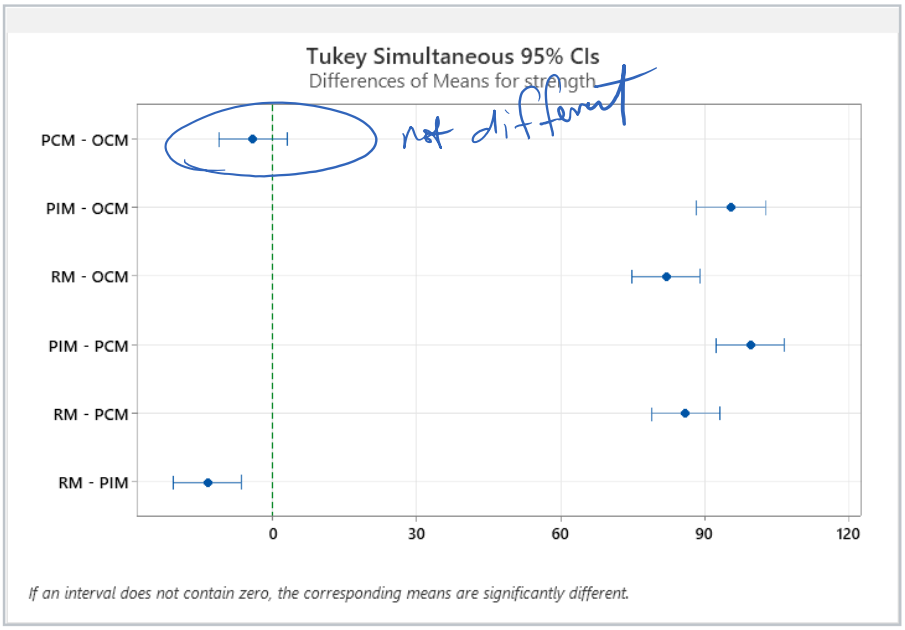

$\binom{4}{2} = \frac{4!}{2!(4-2)!} = 6$

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Dunnett Simultaneous Tests for Level Mean - Control Mean

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
10 - 0	5.60	2.64	(-1.39, 12.59)	2.12	0.140
20 - 0	12.20	2.64	(5.21, 19.19)	4.63	0.001
30 - 0	15.40	2.64	(8.41, 22.39)	5.84	0.000
40 - 0	20.00	2.64	(13.01, 26.99)	7.59	0.000

Individual confidence level = 98.47%

no difference statistically significant

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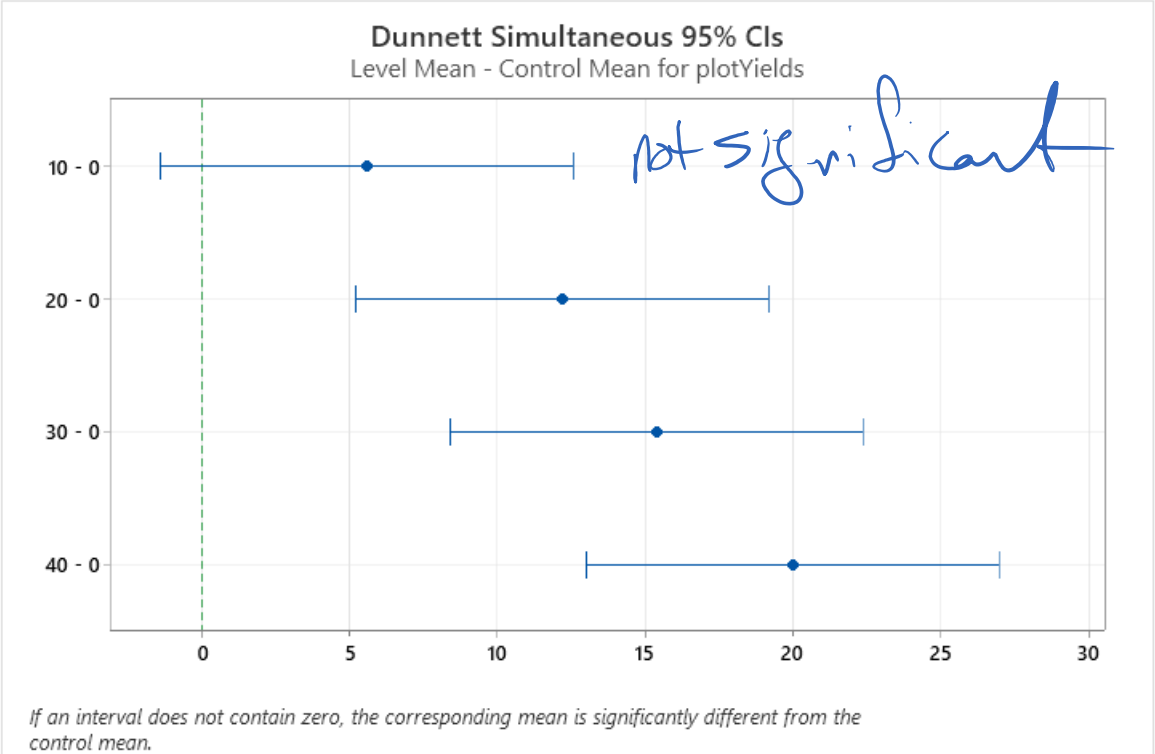

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