AGR5201
ADVANCED STATISTICAL METHODS

Orthogonal contrast

Topic outline

1.0 Mean comparison: Review

- Example - R codes and output, summary

1.1 Orthogonal Contrast

1.2 Contrast analysis

- Hypotheses
- Contrast coefficients
- ANOVA with contrast
- R codes and output
- Exercise
- Example of F test and contrast

1.0 Mean comparison :Review

Method of analysis after ANOVA

ANOVA can determine if there are differences among the treatments, but what is the nature of those differences?

1. Are the treatments measured on a continuous scale?
   - Look at response surfaces (linear regression, polynomials)
2. Is there an underlying structure to the treatments?
   - Compare groups of treatments using orthogonal contrasts or a limited number of preplanned mean comparison tests
3. Are the treatments unstructured?
   - Use appropriate multiple comparison tests

1.0 Mean comparison : Review

Example

We are interested to know whether there are differences types of fertilizer on yield of chilies per bed:

Treatments:

1. Control (no fertilizer)
2. Chicken dung (organic)
3. Goat dung (organic)
4. NPK green (inorganic)

Control	Chicken dung	Goat dung	NPK green
T1	**T2**	**T3**	**T4**
25	41	36	43
19	39	32	46
21	40	35	49
26	45	40	52

COMMON ANALYSIS:
We run ANOVA
If F test significant we do multiple comparisons of treatment means using LSD, Tukey or Duncan
Then we look at which treatments differ from each other

1.1 Mean comparison : Review

ANOVA R codes and output

R codes

set working directory and read the data

```
setwd("D:/GDrive/1.TEACHING/A-2019-20 - SEM 1/R")

fert <- read.csv ("contrast_fert.csv", sep = "," ,
header = TRUE )

str(fert)
```

fit anova

```
fit<- lm(y~trt, data=fert)

anova(fit)
```

mean comparison

```
library (agricolae)

(HSD.test(fit, "trt"))
```

R Output

```
> anova(fit)
Analysis of Variance Table

Response: y
          Df  Sum Sq Mean Sq F value    Pr(>F)
trt        3 1331.19  443.73  40.569 1.472e-06 ***
Residuals 12  131.25   10.94
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
' ' 1
```

Part of output from "HSD.test" code – mean comparison (Tukey)

```
$groups
       y groups
t4 47.50      a
t2 41.25     ab
t3 35.75      b
t1 22.75      c
```

1.1 Mean comparison : Review

Result Summary

Treatment	Yield (kg/bed)*
NPK green	47.50^{a}
Chicken dung	41.25^{ab}
Goat dung	35.75^{b}
Control	22.75^{c}

**Means with similar letters are not significantly different $P>0.05$ using Tukey's HSD*

Interpretation

1. Control (unfertilized) gave lower yields than fertilized treatments
2. NPK green gave higher yields than goat dung but was not different from chicken dung
3. Chicken dung and goat dung did not show significant difference in yield

1.1 Orthogonal Contrast

What is 'contrast'?

- Comparisons between **two groups of treatments** after ANOVA.
- The comparisons are **planned before** experiment is conducted.
- Opposite to multiple mean comparisons (*post hoc*), contrasts are *a priori* comparisons.
- Contrast analysis:
  - t-test
  - single degree of freedom F-test (partition the treatment SS in ANOVA)

Technical definition:

A **contrast** is a linear combination of 2 or more factor level means with coefficients that sum to zero → $\Sigma c_i = 0$, where c_i = coefficient for i^{th} mean

1.2 Contrast analysis

Hypothesis

T1=Control	T2 = Chicken dung	T3 = Goat dung	T4 = NPK green

We plan what to compare (=contrast) based on our null hypotheses:

1. H_{o1}: Unfertilized and fertilized treatments do not differ in yield (compare T1 vs T2, T3, T4)
2. H_{o2}: Organic and inorganic treatments do not differ in yield (compare T4 vs T2, T3)
3. H_{o3}: Chicken dung and goat dung do not differ in yield (T2 vs T3)

1.2 Contrast analysis

Contrast coefficient

- To make the comparisons we have to give coefficients:

Contrasts (C)	T1 Control	T2 Chicken dung	T3 Goat dung	T4 NPK green
C1: Unfertilized vs Fertilized	-3	1	1	1
C2: Organic vs Inorganic	0	-1	-1	2
C3: Chicken dung vs Goat dung	0	1	-1	0

- A **contrast** is a linear combination of 2 or more factor level means with coefficients that sum to zero → $\Sigma c_i = 0$, where c_i = coefficient for i^{th} mean. For example:
  - The coefficient for contrast 1 = c1=-3 , c2=1, c3=1, c4=1 → (-3+1+1+1 = 0)
- Two **contrasts** are **orthogonal** if the sum of the products of corresponding coefficients (i.e. coefficients for the same means) adds to zero. For example:
  - Contrast 1 and 2 → (-3*0) + (1*(-1)) + (1*(-1)) + (1*2) = 0 + (-1) + (-1) + 2 = 0

1.2 Contrast analysis

ANOVA with contrast partitioning of treatment

Source	df	SS	MS	F	Pr>F
Treatment	3	1331.19	443.73	40.57	<.0001
Unfertilized vs Fertilized	**1**	**1054.69**	**1054.69**	**96.43**	**<.0001**
Organic vs Inorganic	**1**	**216.00**	**216.00**	**19.75**	**0.0008**
Chicken dung vs Goat dung	**1**	**60.50**	**60.50**	**5.53**	**0.036**
Error	12	131.25	10.94		
Total	15	1462.44			

1.2 Contrast analysis

R codes

```
# set working directory and read the data
setwd("D:/GDrive/1.TEACHING/A-2019-20 - SEM 1/R")
fert <- read.csv ("contrast_fert.csv", sep = "," ,
header = TRUE )
str(fert)
#set the trt column as factor (required for aov analysis)
fert$trt <- as.factor (fert$trt)


# fit anova
fit<- lm(y~trt, data=fert)
anova(fit)
# set contrast coefficients
c1 = c(-3, 1,  1, 1)
c2 = c(0, -1, -1, 2)
c3 = c(0, 1, -1, 0)
```

The coefficients are set before the analysis

```
# combine the contrast coefficient matrix
mat <- cbind(c1,c2,c3)

# tell R that the matrix gives the contrasts you want
contrasts(fert$trt) <- mat

# these lines give you your results
model1 <- aov(y ~ trt, data = fert)
summary(model1)
summary.aov(model1, split=list(trt=list("unfertilized
vs. fertilized"=1, "org vs. inorg" = 2, "chic vs. goat
manure"=3)))
```

1.2 Contrast analysis

Exercise:

A researcher is interested to know whether corn silage as a feed is superior to Napier grass for daily gain of feedlot cattle with and without PKC. He is planning to use contrast to compare between the feeds. Determine the contrast coefficients for each hypothesis:

Treatments:

T1 Corn silage 100%

T2 Corn silage 80% PKC 20%

T3 Napier grass 100%

T4 Napier silage 100%

T5 Napier silage 80% PKC 20%

Hypotheses:

1. Corn silage is no different from Napier
2. Napier silage is no different from Napier grass
3. Adding PKC to corn silage has no effect
4. Adding PKC to Napier silage has no effect

1.2 Contrast analysis

Exercise:

A researcher is interested to know whether corn silage as a feed is superior to Napier grass for daily gain of feedlot cattle with and without PKC:

Contrast coefficients:

	Comparison	T1	T2	T3	T4	T5
C1	Corn vs Napier	3	3	-2	-2	-2
C2	Napier silage vs Napier grass	0	0	-2	1	1
C3	Corn silage + PKC vs Corn silage -PKC	-1	1	0	0	0
C4	Napier silage + PKC vs Napier silage -PKC	0	0	0	-1	1

Treatments:

T1 Corn silage 100%
T2 Corn silage 80% PKC 20%
T3 Napier grass 100%
T4 Napier silage 100%
T5 Napier silage 80% PKC 20%

1.2 Contrast analysis

F test for a pre-planned comparison (contrast)

- When contrasts are pre-planned, there is no need to compute the overall F-test for treatments. Indeed, this test is of no value when making contrasts, because it tells nothing about the significance level of the specific hypotheses of interest. Because the hypotheses of interest were created prior to the initiation of the experiment, their type I error rates are consistent with tabular values.

1.2 Contrast analysis

Example: F test

Three creeping bentgrass varieties were tested for survival in turfplots on a simulated golf-course putting green. The varieties represented three levels of inherent resistance to summer patch (HR = high, MR = medium, and LR = low). Each variety was represented as an inoculated and a non-inoculated treatment (in factorial combination). Inoculation was with a fungicide to inhibit development of the summer patch fungus. Percent non-diseased ground cover was determined.

	Block				
Treatment	1	2	3	4	Mean
1 (Inoculated, HR)	75	80	92	86	83.3
2 (Inoculated, MR)	70	81	99	91	85.3
3 (Inoculated, LR)	79	83	89	94	86.3
4 (Not Inoc, HR)	85	83	74	88	82.5
5 (Not Inoc, MR)	70	85	83	80	79.5
6 (Not Inoc, LR)	70	71	66	82	72.3
Mean	74.8	80.5	83.8	86.8	81.5

The initial ANOVA gave the following results.

Source	df	SS	MS	F	P
Block	3	476.00	158.67	3.54	0.0407
Treatment	5	521.00	104.20	2.32	0.0945
B x T	15	673.00	44.87		
Total	23	1670.00			

Note the F-test for treatments. Ready to give up on this experiment???

1.2 Contrast analysis

Example: Contrast

	Treatment number					
Contrast	1	2	3	4	5	6
Inoc. vs. Not	1	1	1	-1	-1	-1
Inoc: LR vs. others	1	1	-2	0	0	0
Inoc: HR vs. MR	1	-1	0	0	0	0
Not: LR vs. others	0	0	0	1	1	-2
Not: HR vs. MR	0	0	0	1	-1	0

Source	df	SS	MS	F	P
Block	3	476.00	158.67	3.54	0.0407
Inoc. vs. Not	1	280.17	280.17	6.24	0.0246
Inoc: LR vs. others	1	10.67	10.67	0.24	0.6329
Inoc: HR vs. MR	1	8.00	8.00	0.18	0.6788
Not: LR vs. others	1	204.17	204.17	4.55	0.0498
Not: HR vs. MR	1	18.00	18.00	0.40	0.5360
B x T	15	673.00	44.87		
Total	23	1670.00			

Inoculated (85%) vs. not (78%) and LR (72%) vs. others (81%) without inoculation both had $P<0.05$. If this researcher worried about overall treatment F-tests, this information would not have been discovered.