Stat 411/511

Extra SS F-test

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Quiz #3

Today noon - Monday noon

Same format, two sections, 30mins each

Short answer you need to be able to do exp(x)

The ANOVA table

a convenient way to lay the calculations out

Display 5.10 **p. 127**

Analysis of variance table: a test for equal mean percents of women in venires of seven judges; Spock data

4 *Subtract the "Within" from the "Total "*

5 *A mean square is the ratio of a sum-of-squares to its degrees of freedom*

6 *The F-statistic is the ratio of the Between MS to the Within MS*

Source of Variation		Sum of Squares	df	Mean Square	F-Statistic	p-value
Between Groups						
Within Groups	Full model	1,864.45	39			
Total	Reduced model	3,791.53	45			

n-I

n-1

1 *Sum of squared residuals from fitting the full (separate-means) model*

2 *Sum of squared residuals from fitting the reduced (equal-means) model*

3 *degrees of freedom*

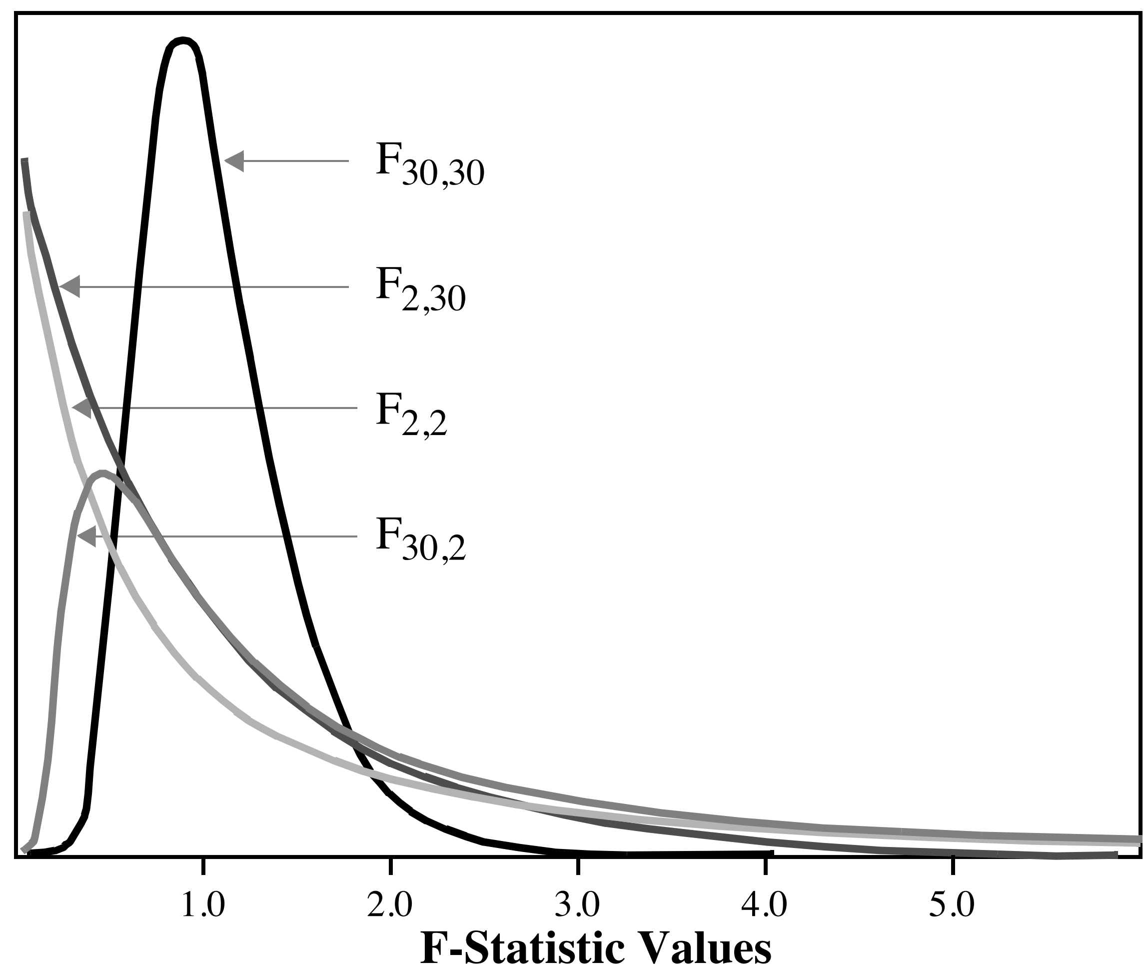
7 *The p-value comes from an F-distribution with and df*

***NOTE**: This is s_p^2*

The p-value is always one-sided for the F-test

Display 5.9 **p. 126**

Four F-distributions, having different degrees of freedom



Large F stats give evidence against the null hypothesis.

We have convincing evidence that at least one judge has a different mean percentage of women on their venires (one-way Anova F test on 6 and 39 degrees of freedom, p-value = 0.00006).

One way anova in R

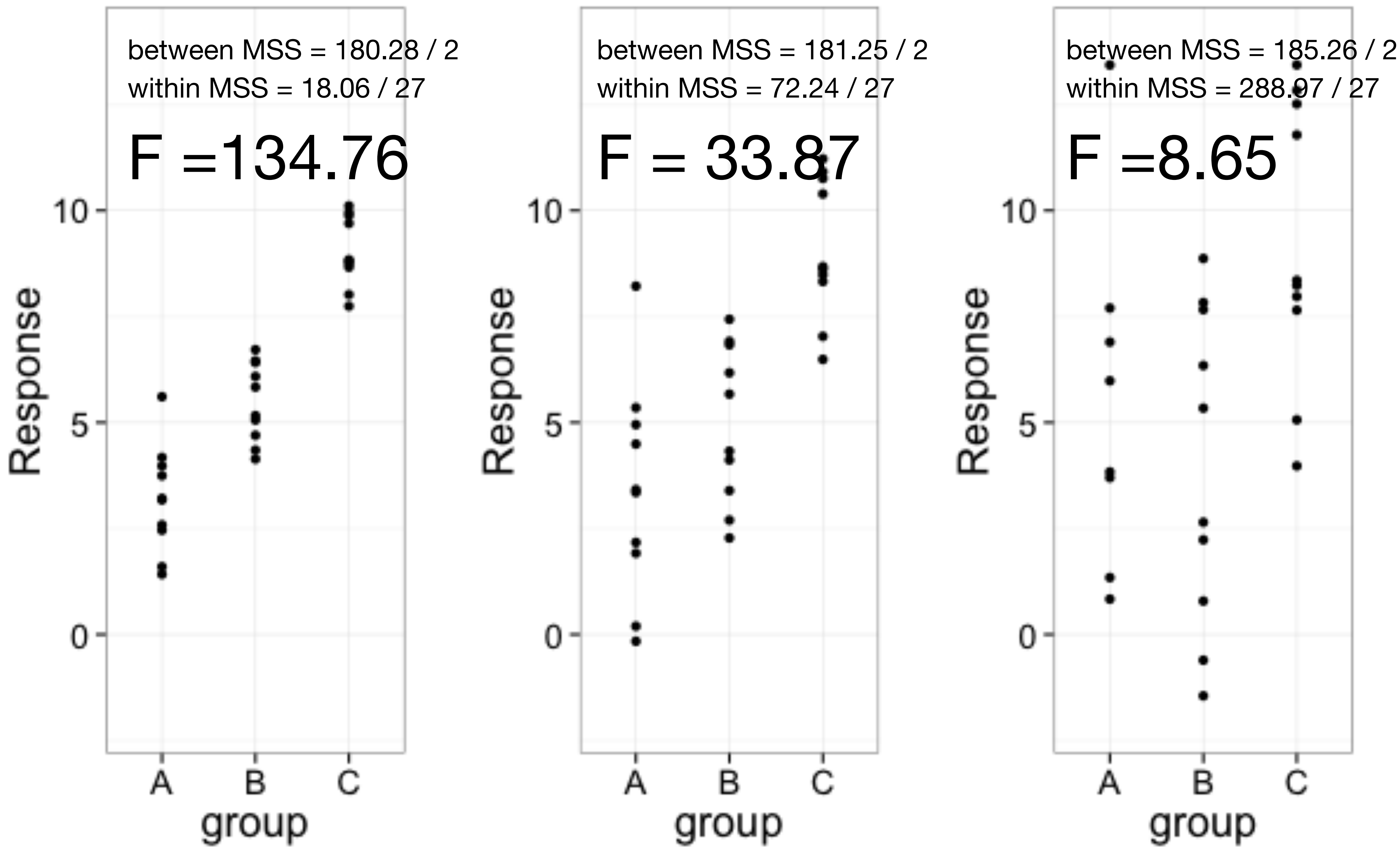
```
anova(lm(Percent ~ Judge, data = case0502))
```

response groups

```
Analysis of Variance Table

Response: Percent
          Df Sum Sq Mean Sq F value    Pr(>F)    
Judge      6 1927.1  321.18  6.7184 6.096e-05 ***
Residuals 39 1864.5   47.81                      
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

This will test the separate means model against the equal means model



$p < 1 \times 10^{-14}$ $p < 1 \times 10^{-7}$ $p = 0.0012$

Which would you say gives more evidence of the groups coming from populations with different means?

Spock's trial

There is evidence that at least one judge has a different mean percent of women. a one-way anova conclusion

But what we really want to argue is that Spock's judge has a different mean percent of women compared to all the other judges.

We argue this in two steps:

Argument #1. There's no evidence the other judges (A-F) have different mean percentage of women from each other. That means it makes sense to imagine they are all drawing venires at random from a population with mean percentage of women, $\mu_{0.}$

Argument #2. There is evidence that Spock's judge has mean percentage of women that is not the same as the other judges, i.e. it is not, μ_0.

These aren't one-way anova conclusions, we still use the extra SS F-test to reach them, but with different full and reduced models.

An extra Sums of Squares F-test compares **two models**

Full model: a model that fully describes the set of alternatives.

fit and find RSS and df

Restricted model: a restriction of the full model imposed by the null hypothesis.

fit and find RSS and df

Extra SS F-statistic

$$F = \frac{\text{Extra Sum of Squares/Extra degrees of freedom}}{\hat{\sigma}^2_{\text{full}}}$$

squared pooled sd from full model
find it from SS/df for full model

Extra Sum of Squares =

RSS from reduced model **-** RSS from full model =

reduction in residual sum of squares

Extra degrees of freedom =

df in reduced model **-** df in full model =

reduction in degrees of freedom

or how many **more** parameters does the full model have?

Under the **null** hypothesis (reduced model is true) the F-statistic has an F-distribution with v_1 and v_2 degrees of freedom.

v1 = extra df, v2 = df of full model

Argument #1

Null: the population mean percentage of women is the same for all the **other** judges.

$\mu_{Spock} = \mu_1$, $\mu_A = \mu_B = \mu_C = \mu_D = \mu_E = \mu_F = \mu_0$

Alternative: at least one “other” judge has a different mean.

Full model: separate means for all judges.

Null model: two means, one for Spock, one for everyone else.

```
> # create new Spock or Not variable
> case0502$two_groups <- ifelse(case0502$Judge == "Spock's", "Spock's", "Other")

> # find two group averages
> case0502$two_group_average <- with(case0502, ave(Percent, two_groups))

> # sum of squared residuals
> with(case0502, sum((Percent - two_group_average)^2))
[1] 2190.903
```

Argument #1 **Null**: the population mean percentage of women is the same for all the **other** judges.

ANOVA Table

		Sum of squared residuals	d.f.
Full model	separate means model	1864.46	
Reduced model	two means model	2190.9	

n = 46

n - # parameters

Argument #1 **Null**: the population mean percentage of women is the same for all the **other** judges.

Your turn: Find the F-statistic

		Sum of squared residuals	d.f.	MSS	F	p-value
	Extra	C: subtract A from B	F: subtract D from E	G: divide C by F	I: divide G by H	use R: `1- pf(I, F, D)`
Full model	separate means model	A 1864.46	D 39	H: divide A by D		
Reduced model	two means model	B 2190.9	E 44			

Argument #1

We have evidence that any of the **other** six judges have a different mean percentage of women on their venires (extra sum of squares F-test on and degrees of freedom, p-value =).

Argument #2

Null: the population mean percentage of women for Spock is the same as the mean for all the other judges.

$\mu_1 = \mu_0$

Reduced model: there is **one** parameter, the mean for everyone.

equal means model

Full model: there are **two** parameters, the mean for Spock's judge, the mean of all the other judges.

two means model

Argument #2 the population mean percentage of women for Spock is the same as the mean for all the other judges

ANOVA Table

		Sum of squared residuals	d.f.
Full model	two means model	2190.9	44
Reduced model	equal means model	3791.53	45

Argument #2 the population mean percentage of women for Spock is the same as the mean for all the other judges

		Sum of squared residuals	d.f.	MSS	F	p-value
	what's left?	C: subtract A from B	F: subtract D from E	G: divide C by F	I: divide G by H	<0.0001
Full model	two means model	2190.9	44	H: divide A by D		
Reduced model	equal means model	3791.53	45			

Argument #2

We have evidence that Spock's judge has a different mean percentage of women on his venires than all the other judges (extra sum of squares F-test on and degrees of freedom, p-value =).

Anova in R

To test the full model against another model

A variable I made

```
> # full model
> m1 <-  lm(Percent ~ Judge, data = case0502)

> # all other judges equal
> m2 <-  lm(Percent ~ two_groups, data = case0502)

> # gives the anova table for two means versus full model
> anova(m1, m2)

Analysis of Variance Table

Model 1: Percent ~ Judge
Model 2: Percent ~ two_groups
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1     39 1864.5
2     44 2190.9 -5   -326.46 1.3658 0.2582
```