Statistics One

Lecture 17
Factorial ANOVA

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Two segments

- Factorial ANOVA
- Example

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Lecture 17 ~ Segment 1

Factorial ANOVA

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Factorial ANOVA

- Two Independent Variables (IVs)
- One Dependent Variable (DV)

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Example

- Suppose an experiment is conducted to examine the effect of talking on a mobile phone while driving
  - IV1: Driving difficulty
  - IV2: Conversation demand

  - DV: Driving errors

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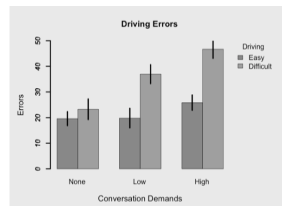
Example



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Factorial ANOVA

- Three hypotheses can be tested:
  - More errors in the difficult simulator?
  - More errors with more demanding conversation?
  - More errors due to the interaction of driving difficulty and conversation demand?

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Factorial ANOVA

- Three F ratios
  - F_A
  - F_B
  - F_{AxB}

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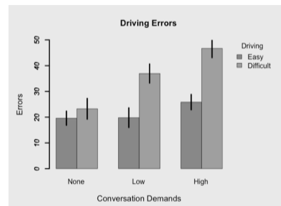
Factorial ANOVA

- *Main effect*: the effect of one IV averaged across the levels of the other IV

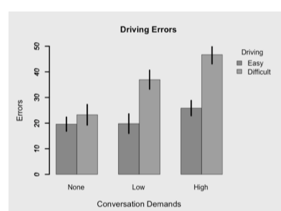
Example



Factorial ANOVA

- *Interaction effect*: the effect of one IV depends on the other IV (the simple effects of one IV change across the levels of the other IV)

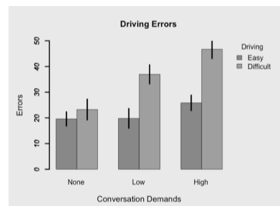
Example



Factorial ANOVA

- *Simple effect*: the effect of one IV at a particular level of the other IV

Example



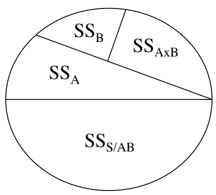
Factorial ANOVA

- Main effects and interaction effect are independent from one another

Factorial ANOVA

- Remember, factorial ANOVA is just a special case of multiple regression
  - It is a multiple regression with perfectly independent predictors (IVs)

Partition SS in the DV



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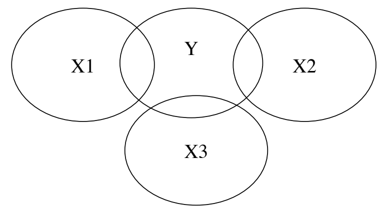
Independent predictor variables



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Remember, GLM

- General Linear Model (GLM)
  - $Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + e$
  - Y = DV
  - X1 = A
  - X2 = B
  - X3 = (A*B)

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F ratios

- $F_A = MS_A / MS_{S/AB}$
- $F_B = MS_B / MS_{S/AB}$
- $F_{AxB} = MS_{AxB} / MS_{S/AB}$

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MS

- $MS_A = SS_A / df_A$
- $MS_B = SS_B / df_B$
- $MS_{AxB} = SS_{AxB} / df_{AxB}$
- $MS_{S/AB} = SS_{S/AB} / df_{S/AB}$

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df

- $df_A = a - 1$
- $df_B = b - 1$
- $df_{AxB} = (a -1)(b - 1)$
- $df_{S/AB} = ab(n - 1)$
- $df_{Total} = abn - 1 = N - 1$

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Follow-up tests

- Main effects
  - Post-hoc tests
- Interaction
  - Analysis of simple effects
    - Conduct a series of one-way ANOVAs (or t-tests)

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Effect size

- Complete η^2
  - $\eta^2 = SS_{effect} / SS_{total}$
- Partial η^2
  - $\eta^2 = SS_{effect} / (SS_{effect} + SS_{S/AB})$

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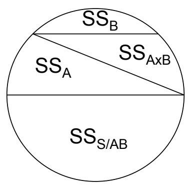
Effect size (complete)

η^2 for the interaction = SS_{AxB} / SS_{Total}



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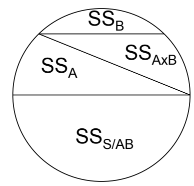
Effect size (partial)

η^2 for the interaction = SS_{AxB} / (SS_{AxB} + $SS_{S/AB}$)



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Assumptions

- Assumptions underlying factorial ANOVA
  - DV is continuous (interval or ratio variable)
  - DV is normally distributed
  - Homogeneity of variance

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Segment summary

- Factorial ANOVA
  - Three F-tests (F_A, F_B, F_{AxB})
  - Main effects
  - Interaction effect
  - Simple effects

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Segment summary

- Factorial ANOVA
  - Effect size (complete and partial eta-squared)
  - Post-hoc tests (follow main effects)
  - Simple effects analyses (follow interaction)
  - Homogeneity of variance assumption
    - Levene's test

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END SEGMENT

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Lecture 17 ~ Segment 2

Factorial ANOVA
Example

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Example

- Strayer and Johnson (2001) conducted an experiment to examine the effect of talking on a mobile phone while driving
- They tested subjects in a driving simulator

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Example

- To manipulate driving difficulty, they simply made the driving course in the simulator more or less difficult

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Example

- To manipulate conversation demand, they included two “talking” conditions:
  - In one condition the subject simply had to repeat what they heard on the other line of the phone

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Example

- To manipulate conversation demand, they included two “talking” conditions:
  - In the other condition the subject had to think of and then say a word beginning with the last letter of the last word spoken on the phone
  - For example, if you hear “ship”, say a word that begins with the letter “p”, such as “peach”

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Example

- IV1 = driving difficulty (easy, difficult)
- IV2 = conversation demand (none, low, high)
- DV = errors in driving simulator

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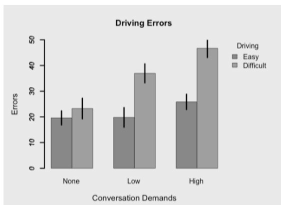
Example



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Results: Levene's test

```
> leveneTest(df$errors ~ df$driving * df$conversation)
Levene's Test for Homogeneity of Variance (center = median)
       Df F value Pr(>F)
group   5  0.5206 0.7602
      114
```

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Results: Factorial ANOVA

```
> summary(anova <- aov(df$errors ~ df$driving * df$conversation))
                            Df Sum Sq Mean Sq F value   Pr(>F)    
df$driving                   1   5782    5782   94.64  < 2e-16 ***
df$conversation              2   4416    2208   36.14 6.98e-13 ***
df$driving:df$conversation   2   1639     820   13.41 5.86e-06 ***
Residuals                  114   6965      61                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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Results: Simple effects

- Simple effect of A at each level of B
  - Effect of driving difficulty at each level of conversation demand
- Simple effect of B at each level of A
  - Effect of conversation demand at each level of driving difficulty

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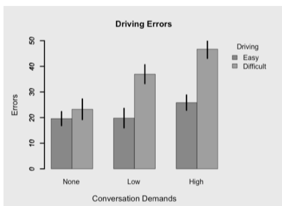
Example



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Results: Simple effects

```
> t.test(none.easy, none.diff, var.equal=T)

 Two Sample t-test

data:  none.easy and none.diff
t = -1.5052, df = 38, p-value = 0.1405
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -8.55906  1.25906
sample estimates:
mean of x mean of y
    19.60     23.25

> cohensD(none.easy, none.diff)
[1] 0.475981
```

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Results: Simple effects

```
> t.test(low.easy, low.diff, var.equal=T)

 Two Sample t-test

data:  low.easy and low.diff
t = -6.4625, df = 38, p-value = 1.324e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -22.52228 -11.77772
sample estimates:
mean of x mean of y
    19.80     36.95

> cohensD(low.easy, low.diff)
[1] 2.043623
```

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Results: Simple effects

```
> t.test(high.easy, high.diff, var.equal=T)

 Two Sample t-test

data:  high.easy and high.diff
t = -8.9664, df = 38, p-value = 6.467e-11
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -25.55742 -16.14258
sample estimates:
mean of x mean of y
    25.85     46.70

> cohensD(high.easy, high.diff)
[1] 2.835426
```

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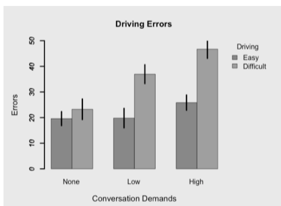
Segment summary



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END SEGMENT

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END LECTURE 17

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