Lecture 17
Segment 2

Mixed factorial ANOVA:

Example in R

Example

Phonological similarity effects in simple and complex span tasks
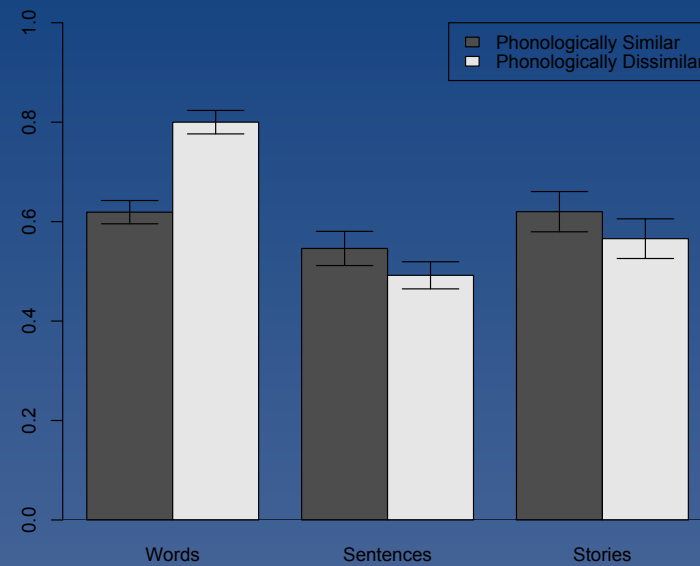
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Experimental design

- Mixed factorial design, 3x2, (Ax(BxS))
  - Between groups IV
    - Memory task (words, sentences, stories)
  - Within groups IV
    - Phonological similarity (similar, dissimilar)
  - DV
    - Percentage of words recalled

Results ~ Preview

Hypotheses

- Mixed factorial design, 3x2, (Ax(BxS))
  - Main effect of memory task?
    - Memory task (words, sentences, stories)
  - Main effect of similarity?
    - Phonological similarity (similar, dissimilar)
  - Interaction?

Hypotheses

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

R script

- This script is available on the course website
  - STATS1.EX.08.R
  - STATS1.EX.08.txt

R script

```
##########
# Macnamara, Moore, & Conway (2011), Experiment 1, Serial recall
##########

library(psych)
library(car)
source(file="eta_squared.R")

e1sr <- read.table("STATS1.EX.08.txt", header = T)
```

R script ~ Omnibus ANOVA

```
# Omnibus analysis is a 3x2 mixed factorial with task and stimuli as the independent variables and serial recall as the dependent variable.
The three levels of task are word span, reading span, and story span.  The two levels of stimuli are phonologically similar and
phonologically dissimilar.

stim = factor(e1sr$stim,levels=c("S","D"))  #reverse levels (for graphs like the article)

aov.e1sr = aov(e1sr$recall ~ (e1sr$task*e1sr$stim) + Error(factor(e1sr$subject)/e1sr$stim))
summary(aov.e1sr)
eta.2(aov.e1sr, ret.labels=TRUE)


# Levene's test
leveneTest(e1sr$recall, e1sr$task, center="mean")
```

R script ~ Simple effects

```
# Simple effects analysis for simple span (i.e., word span)
aov.e1srw = aov(e1sr$recall[task=="W"] ~ e1sr$stim[task=="W"] +Error(factor(e1sr$subject[task=="W"])/e1sr$stim[task=="W"]))
summary(aov.e1srw)
eta.2(aov.e1srw, ret.labels=TRUE)
```

R script ~ Simple effects

```
# Simple effects analysis for complex span (this is a 2x2 mixed factorial)
aov.e1srnw = aov(e1sr$recall[task!="W"] ~ e1sr$task[task!="W"]*e1sr$stim[task!="W"] +
    Error(factor(e1sr$subject[task!="W"]) / e1sr$stim[task!="W"]))
summary(aov.e1srnw)
eta.2(aov.e1srnw, ret.labels=TRUE)
```

R script ~ Bar chart

```
# Bar plot

wspan = describe.by(recall[task=="W"], group = stim[task =="W"], mat = T)
rspan = describe.by(recall[task=="R"], group = stim[task =="R"], mat = T)
sspan = describe.by(recall[task=="S"], group = stim[task =="S"], mat = T)
graphme = cbind(Words = wspan$mean, Sentences = rspan$mean, Stories = sspan$mean)
rownames(graphme) = c("Phonologically Similar", "Phonologically Dissimilar")
se = cbind(wspan$se, rspan$se, sspan$se)

bp = barplot(graphme, beside = TRUE,
        ylim = c(0,1), space = c(0, .5), legend.text = TRUE,
        args.legend = c(x = "topright"))
abline(h=0)
for (ii in 1:3) {
  arrows(bp[1, ii], graphme[1,ii] - se[1, ii],
        y1 = graphme[1,ii] + se[1, ii], angle = 90, code = 3)
  arrows(bp[2, ii], graphme[2,ii] - se[2, ii],
    y1 = graphme[2,ii] + se[2, ii], angle = 90, code = 3)
    }
```

R script ~ Effect size function

```r
eta.2 = function(aov.mdl, ret.labels = FALSE){
  eta.2vector = c()
  labels = c()
  for (table in summary(aov.mdl)){    #each block of factors
    SS.vector = table[[1]]$"Sum Sq"   #table is a list with 1 entry, but you have to use [[1]] anyway
    last = length(SS.vector)
    labels = c(labels, row.names(table[[1]])[-last])   #all but last (error term)
    for (SS in SS.vector[-last]) { #all but last entry (error term)
      new.etaval = SS / (SS + SS.vector[last])
      eta.2vector = c(eta.2vector, new.etaval)
    }
  }
  if (ret.labels) return(data.frame(eta.2 = eta.2vector, row.names = labels))
  return(eta.2vector)
}
```

R output ~ Omnibus analysis

```
Error: factor(e1sr$subject)
          Df Sum Sq Mean Sq F value   Pr(>F)
e1sr$task  2 0.7384  0.3692   10.54 0.000124 ***
Residuals 58 2.0309  0.0350
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Error: factor(e1sr$subject):e1sr$stim
                  Df Sum Sq Mean Sq F value   Pr(>F)
e1sr$stim          1 0.0161 0.01607   1.956    0.167
e1sr$task:e1sr$stim 2 0.3716 0.18582  22.624 5.46e-08 ***
Residuals         58 0.4764 0.00821
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> eta.2(aov.e1sr, ret.labels=TRUE)
                    eta.2
e1sr$task         0.26663954
e1sr$stim         0.03262359
e1sr$task:e1sr$stim 0.43824551
```

R output ~ Levene's test

```
>
> # Levene's test
> leveneTest(e1sr$recall, e1sr$task, center="mean")
Levene's Test for Homogeneity of Variance (center = "mean")
        Df F value  Pr(>F)
group    2  3.4274 0.03571 *
       119
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
```

R output ~ Simple effects

```
Error: factor(subject[task == "W"])
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals 19 0.3404 0.01792

Error: factor(subject[task == "W"]):stim[task == "W"]
                    Df Sum Sq Mean Sq F value    Pr(>F)
stim[task == "W"]   1 0.3276  0.3276    78.8 3.46e-08 ***
Residuals          19 0.0790  0.0042
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> eta.2(aov.e1srw, ret.labels=TRUE)
                      eta.2
stim[task == "W"] 0.8057304
```

R output ~ Simple effects

```
Error: factor(subject[task != "W"])
                Df Sum Sq Mean Sq F value Pr(>F)
task[task != "W"]  1 0.1118 0.11176   2.578  0.116
Residuals         39 1.6905 0.04335

Error: factor(subject[task != "W"]):stim[task != "W"]
                                    Df Sum Sq Mean Sq F value Pr(>F)
stim[task != "W"]                    1 0.0601 0.06010   5.898 0.0199 *
task[task != "W"]:stim[task != "W"]  1 0.0000 0.00000   0.000 0.9949
Residuals                           39 0.3974 0.01019
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> eta.2(aov.e1srnw, ret.labels=TRUE)
                                            eta.2
task[task != "W"]                      6.200964e-02
stim[task != "W"]                      1.313716e-01
task[task != "W"]:stim[task != "W"] 1.052142e-06
```

Results