

## 6.7.3: Using R

### R - Mixed Effects Models

- Load the schools data.
- Obtain the ANOVA for the mixed effects model.
- Obtain estimators and CIs for means for each combination of region and school type.
- Obtain a means plot for each combination of region and school type.
- Obtain Tukey's multiple comparisons CIs.

1. Load the schools data by using the following commands:

```
setwd("~/path-to-folder/")
schools_data <- read.table("schools_data.txt", header=T)
attach(schools_data)
```

2. Obtain the ANOVA for the mixed effects model by using the following commands:

```
library(lmerTest)
library(lme4)
mixed_schools<-lmer(SR_score ~ region + school_type + region:school_type + (1 | teacher)
summary(mixed_schools) # Partial output
#Random effects:
# Groups              Name                Variance Std.Dev.
# (region:school_type):teacher (Intercept) 9.375     3.062
# Residual                        4.687     2.165
# Number of obs: 16, groups: (region:school_type):teacher, 8
anova(mixed_schools)
#Type III Analysis of Variance Table with Satterthwaites method
#              Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
#region          112.812  112.812     1     4 24.0667 0.008011 **
#school_type       15.312   15.312     1     4  3.2667 0.144986
#region:school_type 52.812   52.812     1     4 11.2667 0.028395 *
#---
# Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Note that the command `lmer()` gives the ANOVA table only for the fixed effects. Therefore, in this example, since there are fixed effects, we get the ANOVA table with their  $F$  values and  $p$ -values.

In the "Random effects" section of the output, under the column variance, we get the estimates for  $\sigma_{\gamma}^2$  and  $\sigma^2$  which are equal to 9.375 and 4.687 respectively.

Alternatively, we can use the command `aov()` which gives a partial ANOVA table.

```
mixed_schools1<-aov(SR_score ~ region + school_type + region*school_type + Error((region:school_type)
summary(mixed_schools1)
#Error: region
#              Df Sum Sq Mean Sq
#region      1  564.1    564.1
#Error: school_type
#              Df Sum Sq Mean Sq
```

```
#school_type 1 76.56 76.56
#Error: region:school_type
#
# Df Sum Sq Mean Sq
#region:school_type 1 264.1 264.1
#Error: region:school_type:teacher
#
# Df Sum Sq Mean Sq F value Pr(>F)
#Residuals 4 93.75 23.44
#Error: Within
#
# Df Sum Sq Mean Sq F value Pr(>F)
#Residuals 8 37.5 4.688
```

3. Obtain estimators, CIs, and multiple comparisons CIs for means for each combination of region and school type by using the following commands:

```
library(emmeans)
pairwise_conf_intervals<-emmeans(mixed_schools,list(pairwise~region:school_type),adju
CI<-confint(pairwise_conf_intervals)
$`emmeans of region, school_type`
# region school_type emmean SE df lower.CL upper.CL
# EastUS Private 85.8 2.42 4 79.0 92.5
# WestUS Private 89.5 2.42 4 82.8 96.2
# EastUS Public 73.2 2.42 4 66.5 80.0
# WestUS Public 93.2 2.42 4 86.5 100.0
#Degrees-of-freedom method: kenward-roger
#Confidence level used: 0.95
$`pairwise differences of region, school_type`
# 1 estimate SE df lower.CL upper.CL
# EastUS Private - WestUS Private -3.75 3.42 4 -17.69 10.19
# EastUS Private - EastUS Public 12.50 3.42 4 -1.44 26.44
# EastUS Private - WestUS Public -7.50 3.42 4 -21.44 6.44
# WestUS Private - EastUS Public 16.25 3.42 4 2.31 30.19
# WestUS Private - WestUS Public -3.75 3.42 4 -17.69 10.19
# EastUS Public - WestUS Public -20.00 3.42 4 -33.94 -6.06
#Degrees-of-freedom method: kenward-roger
#Confidence level used: 0.95
#Conf-level adjustment: tukey method for comparing a family of 4 estimates
```

4. Obtain means plot for each combination of region and school type by using the following commands:

```
library(plotrix)
region_means<-as.data.frame(CI$`emmeans of region, school_type`)
region<-region_means$region
school_type<-region_means$school_type
region_school_type<-paste(region,school_type)
plotCI(x=region_means$emmean,y=NULL,li=region_means$lower.CL,ui=region_means$upper.CL
axis(1,at=1:4,labels=region_school_type)
```


 Means plot of SR score for each combination of region and school type.

Figure 6.7.3.1: SR scores mean plot for Region\*SchoolType.

5. Obtain Tukey's multiple comparisons plot by using the following commands:

```
diff_comp<-as.data.frame(CI$`pairwise differences of region, school_type`)  
diff_reg_sch<-diff_comp[,1]  
plotCI(x=diff_comp$estimate,y=NULL,li=diff_comp$lower.CL,ui=diff_comp$upper.CL,xaxt="i",  
abline(h=0)  
axis(1,at=1:6,labels=diff_reg_sch,las=1,cex.axis=0.6)  
detach(schools_data)
```


 Tukey's multiple comparisons plot

Figure 6.7.3.2: Tukey comparisons differences of means plot.

This page titled [6.7.3: Using R](#) is shared under a [CC BY-NC 4.0](#) license and was authored, remixed, and/or curated by [Penn State's Department of Statistics](#).