STAT 8010 R Lab 11

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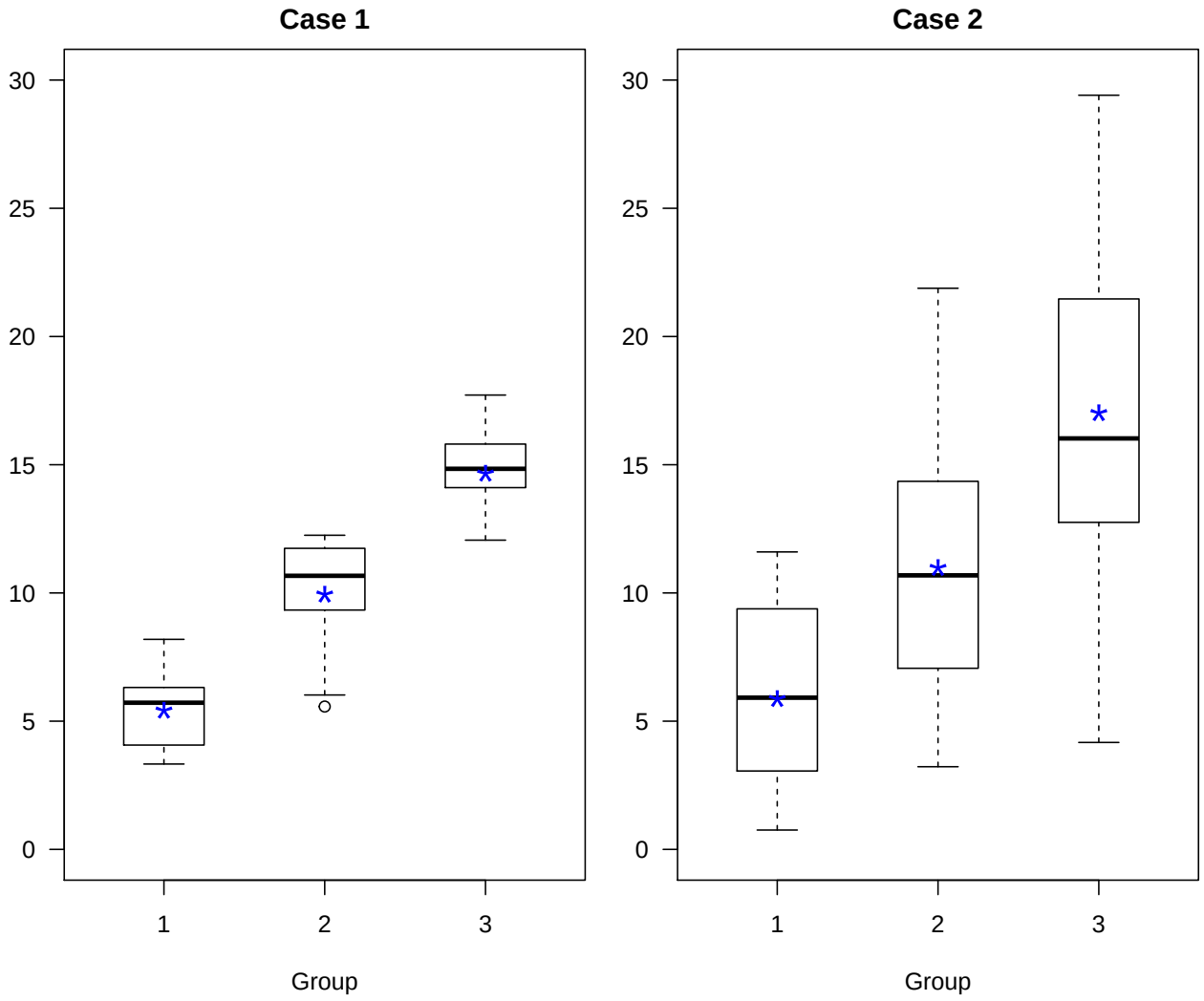
Contents

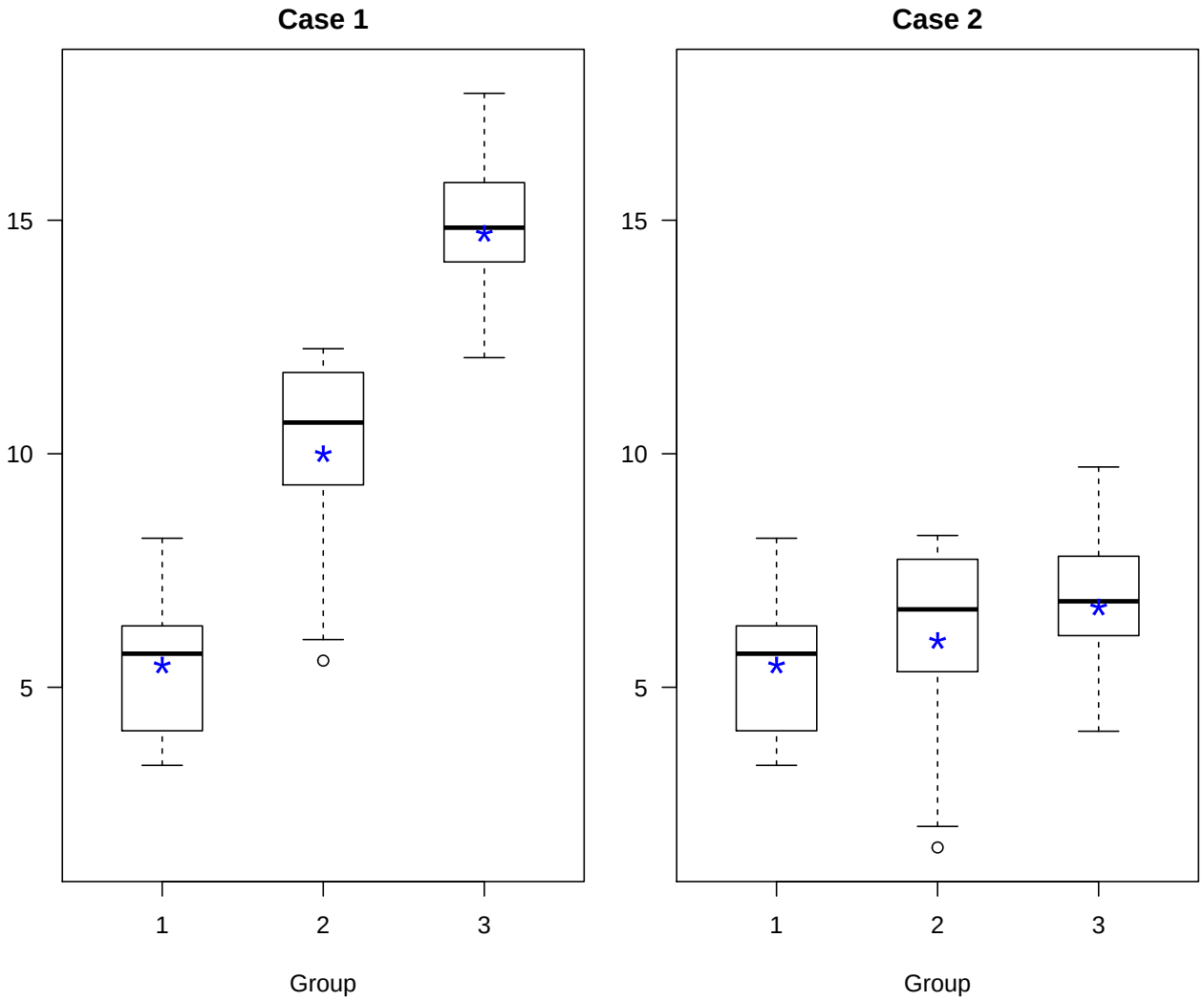
AONVA Toy Examples

```
set.seed(1)
base1 <- rnorm(n = 36, sd = 2)
base2 <- rnorm(n = 36, sd = 6)
dat1 <- base1 + c(rep(5, 12), rep(10, 12), rep(15, 12))
dat2 <- base2 + c(rep(5, 12), rep(10, 12), rep(15, 12))
dat3 <- base1 + rep(5:7, each = 12)
level <- as.factor(rep(1:3, each = 12))
dat1 <- data.frame(x = dat1, Group = level)
dat2 <- data.frame(x = dat2, Group = level)
dat3 <- data.frame(x = dat3, Group = level)
library(dplyr)
g1summary <- dat1 %>%
select(x, Group) %>%
group_by(Group) %>%
summarise(mean = mean(x), sd1 = sd(x))

g2summary <- dat2 %>%
select(x, Group) %>%
group_by(Group) %>%
summarise(mean = mean(x), sd1 = sd(x))

g3summary <- dat3 %>%
select(x, Group) %>%
group_by(Group) %>%
summarise(mean = mean(x), sd1 = sd(x))


par(mfrow = c(1, 2), mar = c(4.1, 2.1, 2.1, 1.1))
boxplot(x ~ Group, data = dat1, las = 1, boxwex = 0.5,
        ylab = "", ylim = c(0, 30), main = "Case 1")
for (i in 1:3) points(i, g1summary$mean[i], pch = "*",
                      col = "blue", cex = 2)
boxplot(x ~ Group, data = dat2, las = 1, boxwex = 0.5,
```

```
        ylab = "", ylim = c(0, 30), main = "Case 2")
for (i in 1:3) points(i, g2summary$mean[i], pch = "*",
                      col = "blue", cex = 2)
```




```
par(mfrow = c(1, 2), mar = c(4.1, 2.1, 2.1, 1.1))
boxplot(x ~ Group, data = dat1, las = 1, boxwex = 0.5,
        ylab = "", ylim = c(1.5, 18), main = "Case 1")
for (i in 1:3) points(i, g1summary$mean[i], pch = "*",
                      col = "blue", cex = 2)
boxplot(x ~ Group, data = dat3, las = 1, boxwex = 0.5,
        ylab = "", ylim = c(1.5, 18), main = "Case 2")
for (i in 1:3) points(i, g3summary$mean[i], pch = "*",
                      col = "blue", cex = 2)
```




```
model1 <- lm(x ~ Group, data = dat1)
model2 <- lm(x ~ Group, data = dat2)
anova(model1)
```

```
## Analysis of Variance Table
##
## Response: x
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Group      2 512.54 256.271  75.443 4.902e-13 ***
## Residuals 33 112.10   3.397
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

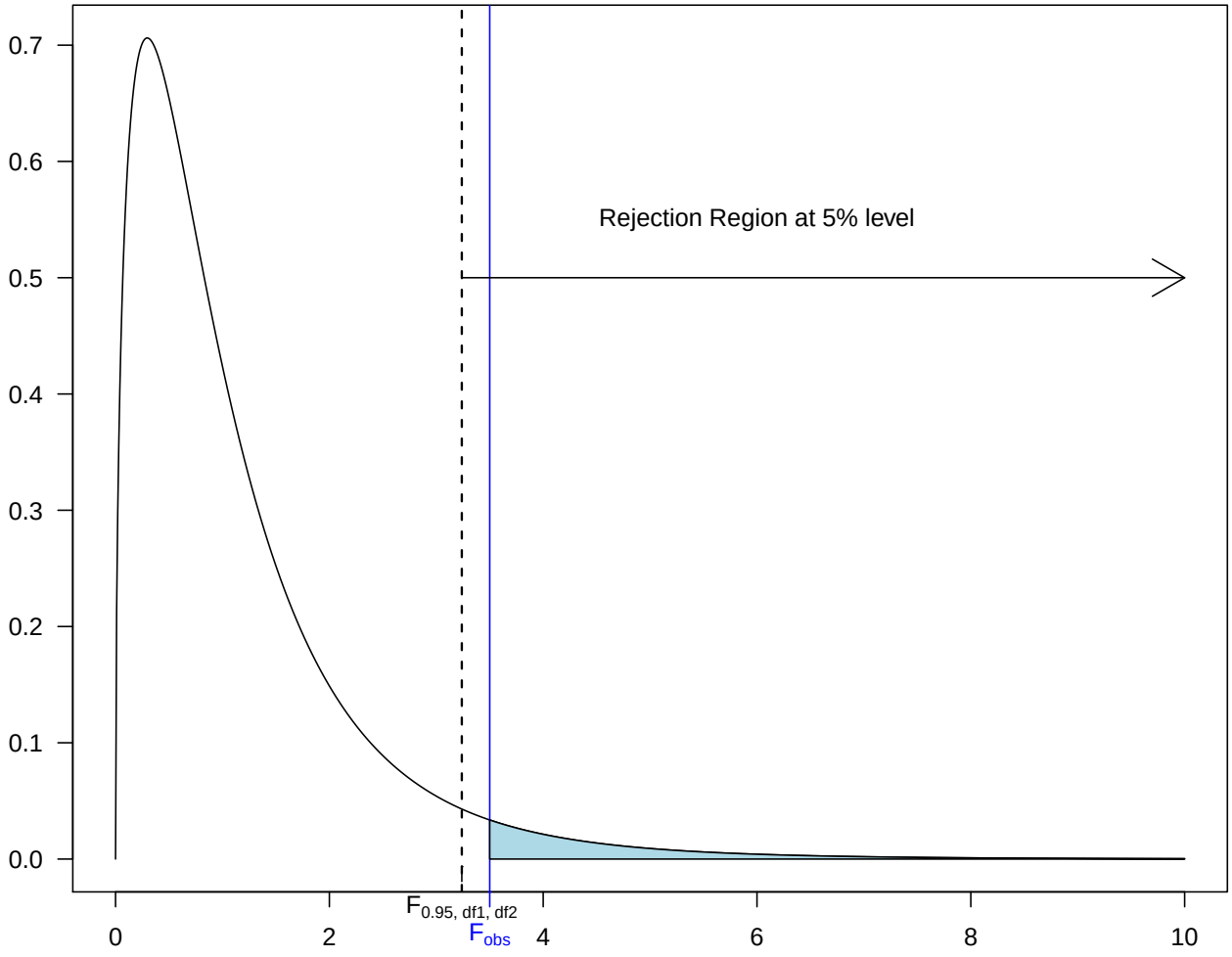
```
anova(model2)
```

```
## Analysis of Variance Table
##
## Response: x
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## Group      2  747.35  373.67  11.323 0.0001802 ***
## Residuals 33 1089.03   33.00
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

F Distribution

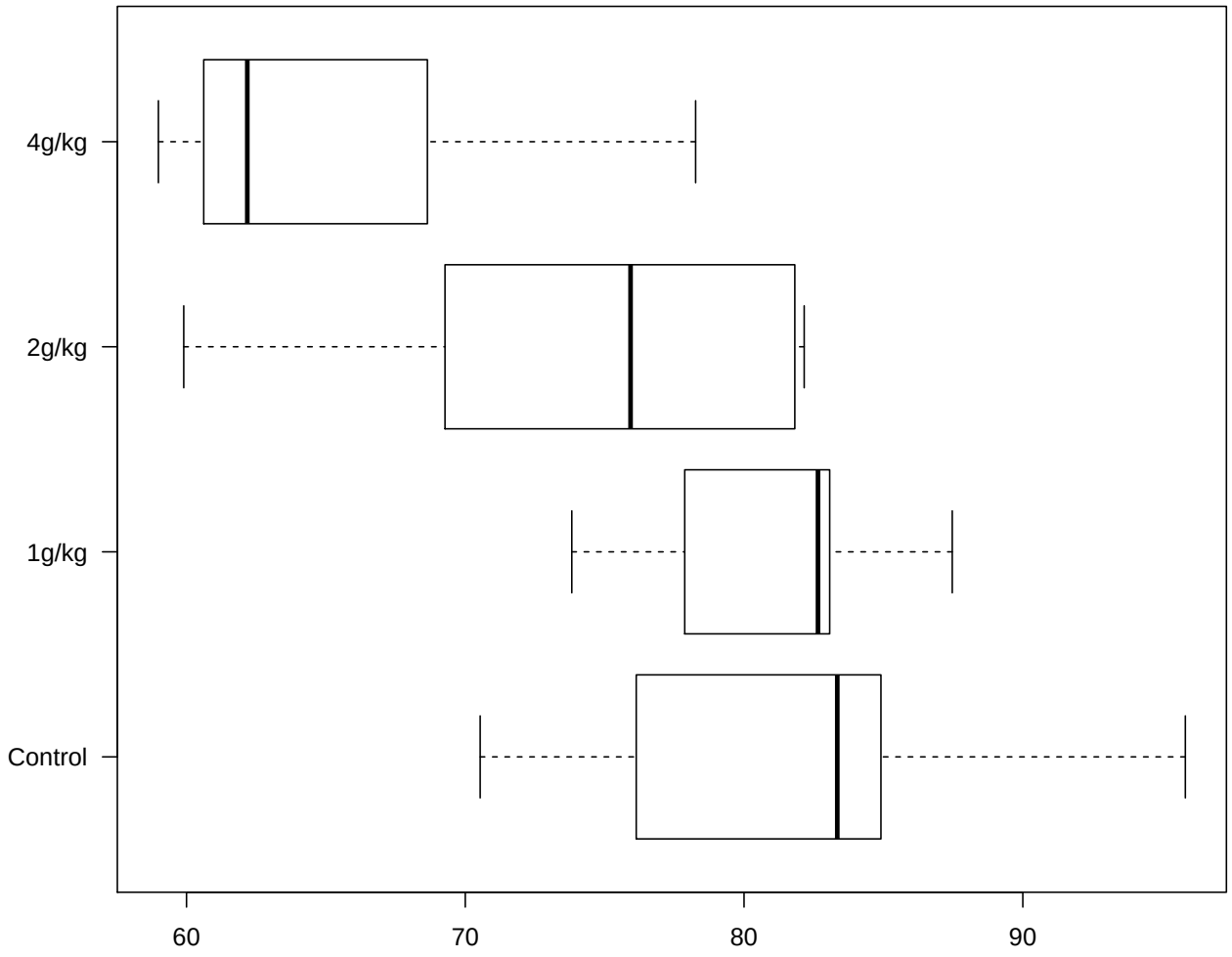
```
par(mar = c(4.1, 2.6, 1.1, 1.1))
curve(df(x, 3, 16), from = 0, to = 10, n = 1001, las = 1,
      xlab = "", ylab = "")
abline(v = 3.5, col = "blue")
abline(v = qf(0.95, 3, 16), lty = 2, lwd = 1.5)
xg <- seq(3.5, 10, 0.01)
yg <- df(xg, 3, 16)
polygon(c(xg[xg >= 3.5], rev(c(xg[xg >= 3.5]))), c(yg[xg >= 3.5], rep(0, length(yg[xg >= 3.5]))),
        col = "lightblue")
axis(1, at = 3.5, labels = expression(F["obs"]), col = "blue", col.axis = "blue")
axis(1, at = qf(0.95, 3, 16), line = -0.85, labels = expression(F[paste(0.95, ", df1", ", df2")]))
arrows(qf(0.95, 3, 16), 0.5, 10)
text(6, 0.55, "Rejection Region at 5% level")
```



Effects of Ethanol on Sleep Time Example

Data setup

```
set.seed(124)
g1 <- rnorm(5, 83, 9); g2 <- rnorm(5, 76, 9.5); g3 <- rnorm(5, 73, 9.2); g4 <- rnorm(5, 70, 9)
dat <- cbind(Response = c(g1, g2, g3, g4), Treatment = as.factor(rep(1:4, each = 5)))
dat <- data.frame(dat)
dat$Treatment <- as.factor(dat$Treatment)
par(mar = c(4.1, 4.1, 1.1, 1.1))
boxplot(Response ~ Treatment, data = dat, horizontal = T, yaxt = "n", ylab = "", xlab = "")
axis(2, at = 1:4, labels = c("Control", "1g/kg", "2g/kg", "4g/kg"), las = 1)
```



Data Summary

```
summary <- dat %>%
select(Response, Treatment) %>%
group_by(Treatment) %>%
summarise(mean = mean(Response),
          sd1 = sd(Response))
lm <- lm(Response ~ Treatment, dat)
anova(lm)
```

```
## Analysis of Variance Table
##
## Response: Response
##           Df  Sum Sq Mean Sq F value  Pr(>F)
## Treatment  3  861.13 287.044  4.2542 0.02173 *
## Residuals 16 1079.56  67.472
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Pairwise t-test

```
t.test(dat$Response[1:5], dat$Response[6:10], var.equal = T)
```

```
##
##  Two Sample t-test
##
## data:  dat$Response[1:5] and dat$Response[6:10]
## t = 0.24012, df = 8, p-value = 0.8163
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -10.09426  12.44081
## sample estimates:
## mean of x mean of y
##  82.15052  80.97724
```

```
t.test(dat$Response[1:5], dat$Response[6:10], var.equal = F)
```

```
##
##  Welch Two Sample t-test
##
## data:  dat$Response[1:5] and dat$Response[6:10]
## t = 0.24012, df = 6.2015, p-value = 0.818
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -10.68922  13.03577
## sample estimates:
## mean of x mean of y
##  82.15052  80.97724
```

Facebook Example

```
dat <- read.csv("FacebookFriends.csv")
head(dat); str(dat)
```

```
##   Friends Participant Score
## 1     102           1   3.8
## 2     102           2   3.6
## 3     102           3   3.2
## 4     102           4   2.4
## 5     102           5   4.8
## 6     102           6   3.0
```

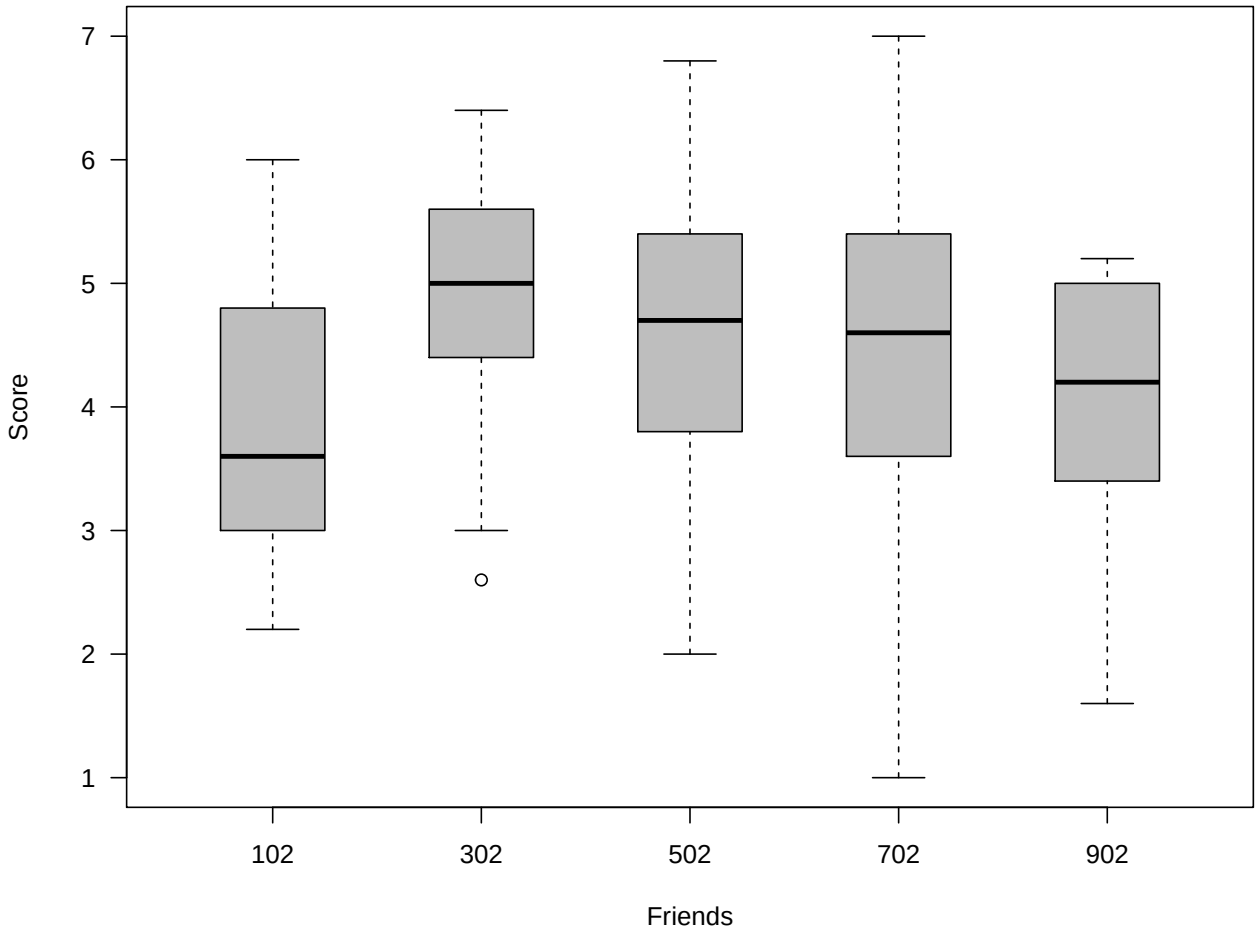
```
## 'data.frame':    134 obs. of  3 variables:
##  $ Friends    : int  102 102 102 102 102 102 102 102 102 102 ...
##  $ Participant: int  1 2 3 4 5 6 7 8 9 10 ...
```

```
##  $ Score      : num  3.8 3.6 3.2 2.4 4.8 3 4.2 3.6 3.2 3 ...
```

```
dat$Friends <- as.factor(dat$Friends)
str(dat)
```

```
## 'data.frame':    134 obs. of  3 variables:
##  $ Friends    : Factor w/ 5 levels "102","302","502",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Participant: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Score      : num  3.8 3.6 3.2 2.4 4.8 3 4.2 3.6 3.2 3 ...
```

```
boxplot(Score ~ Friends, data = dat, las = 1, col = "gray", boxwex = 0.5)
```




```
library(dplyr)
summary <- dat %>%
select(Score, Friends) %>%
group_by(Friends) %>%
summarise(mean = mean(Score),
          sd1 = sd(Score))
summary
```

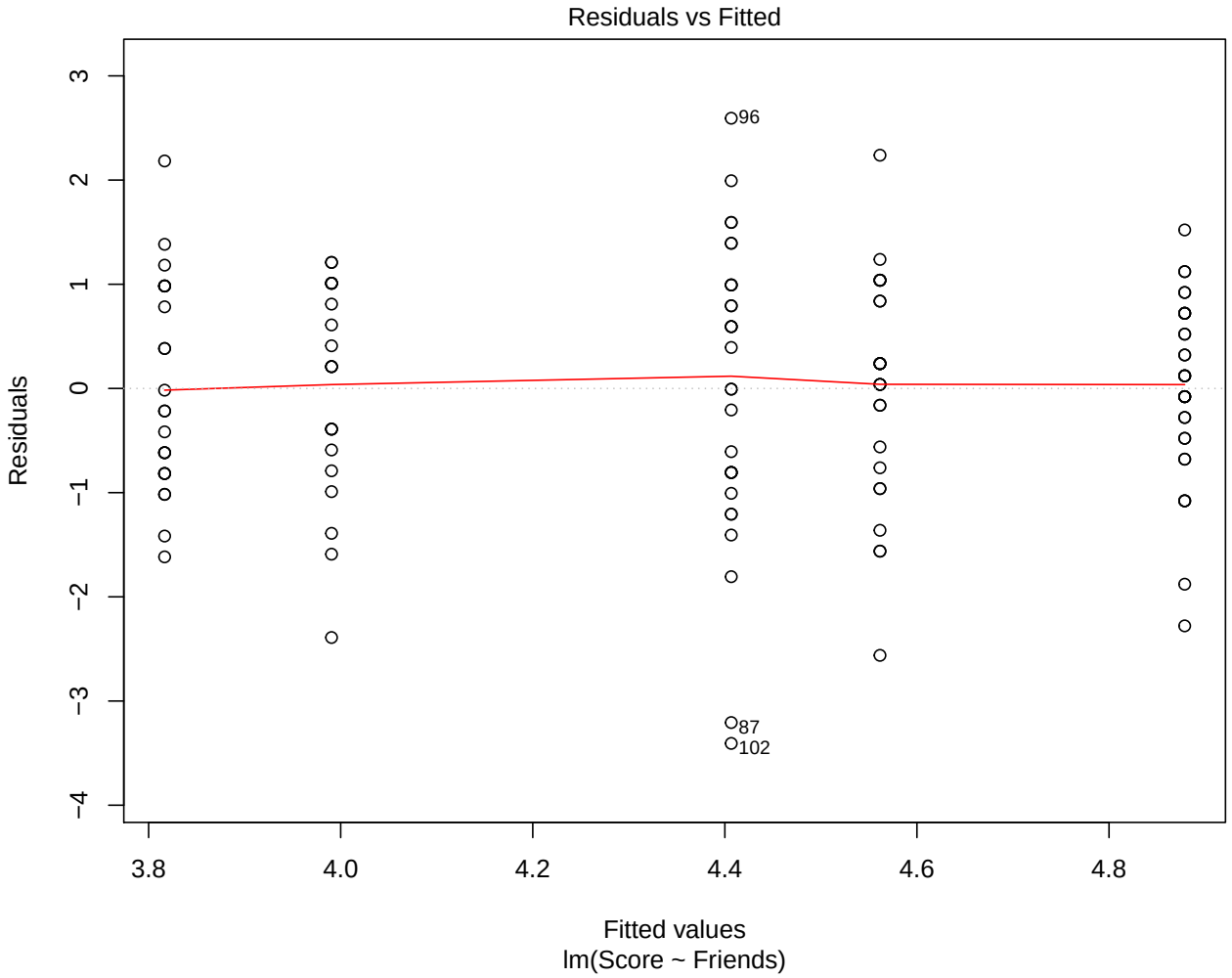
```
## # A tibble: 5 x 3
##   Friends  mean   sd1
##   <fct>   <dbl> <dbl>
## 1 102      3.82 0.999
## 2 302      4.88 0.851
## 3 502      4.56 1.07
```

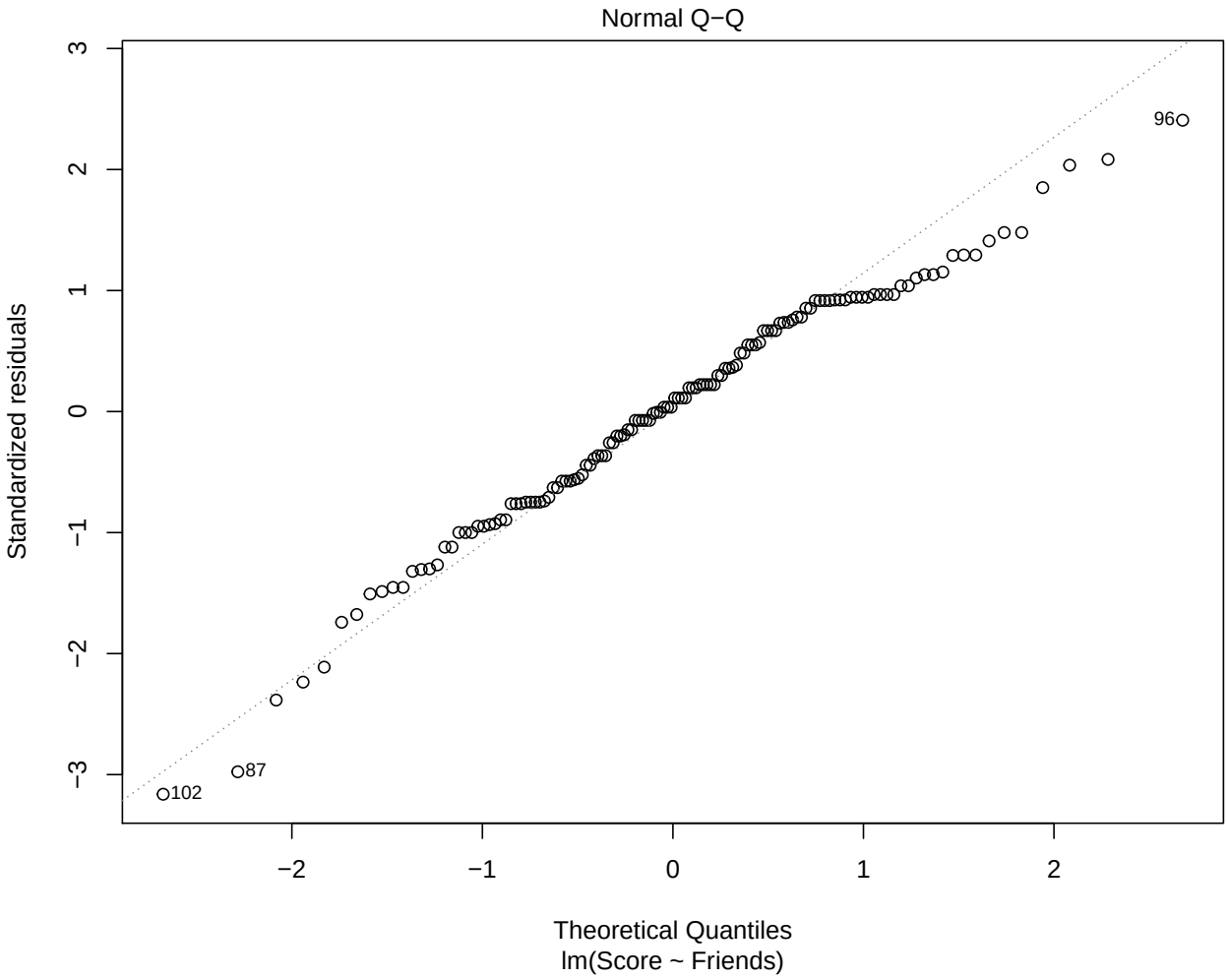
```
## 4 702      4.41 1.43
## 5 902      3.99 1.02
```

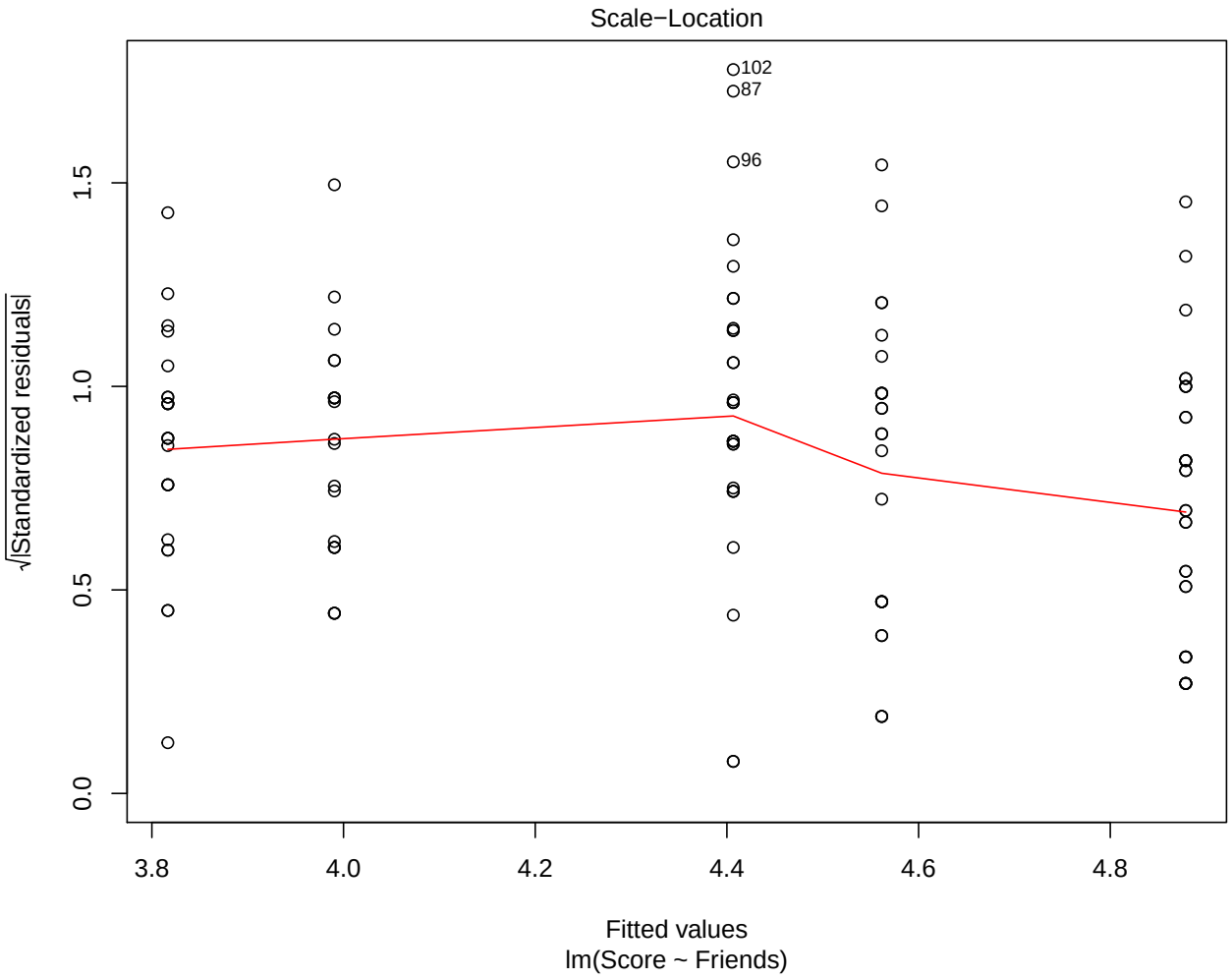
```
lm <- lm(Score ~ Friends, dat)
anova(lm)
```

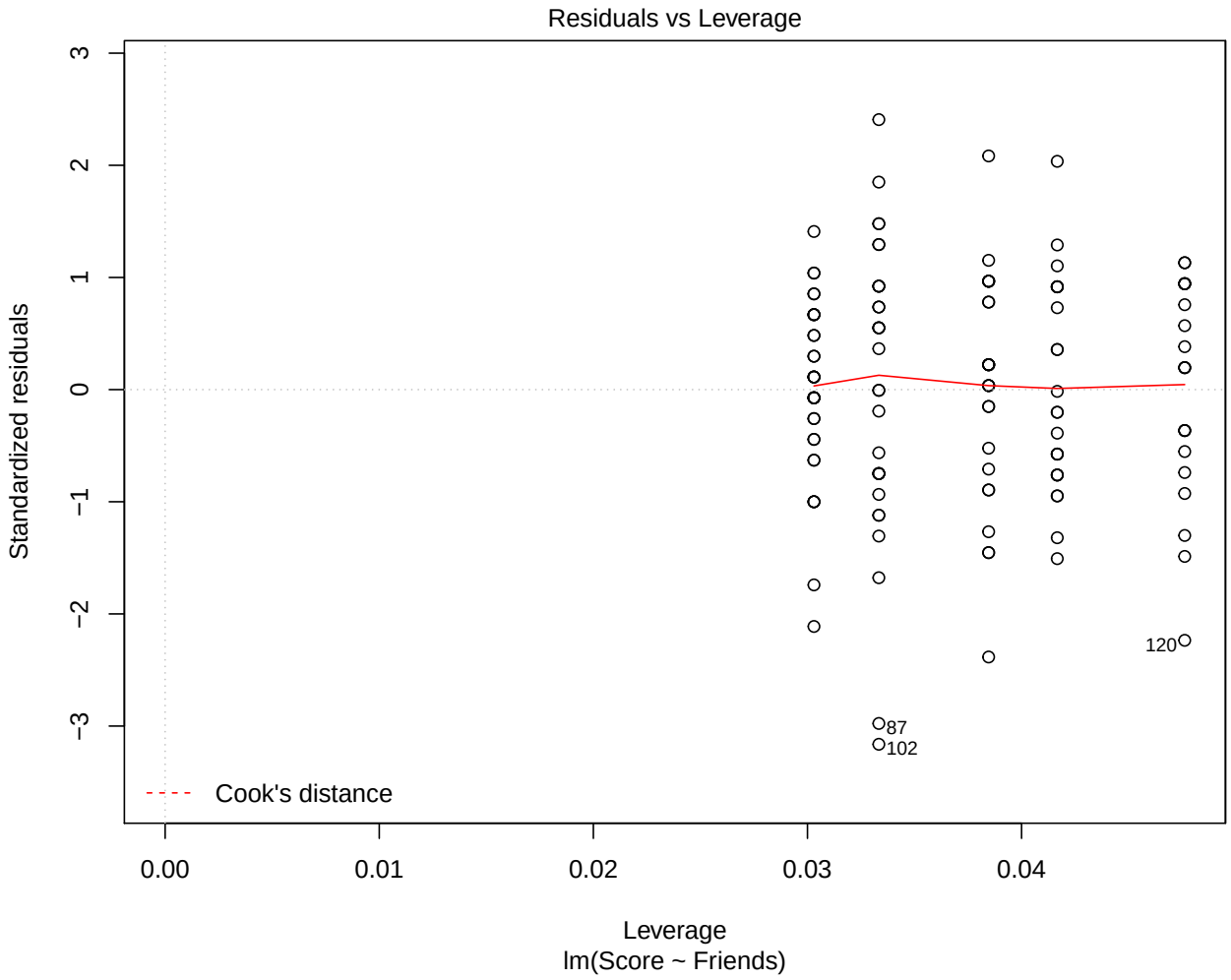
```
## Analysis of Variance Table
##
## Response: Score
##            Df Sum Sq Mean Sq F value  Pr(>F)
## Friends     4  19.89  4.9726   4.142 0.00344 **
## Residuals 129 154.87  1.2005
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(lm)
```




Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(Score ~ Friends)
96
87
102
3
2
1
0
−1
−2
−3
−2
−1
0
1
2


Scale−Location
102
87
96
√|Standardized residuals|
0.0
0.5
1.0
1.5
3.8
4.0
4.2
4.4
4.6
4.8
Fitted values
lm(Score ~ Friends)




```
aov <- aov(Score ~ Friends, dat)
aov
```

```
## Call:
##    aov(formula = Score ~ Friends, data = dat)
##
## Terms:
##                    Friends Residuals
## Sum of Squares   19.89023 154.86679
## Deg. of Freedom         4       129
##
## Residual standard error: 1.095681
## Estimated effects may be unbalanced
```

Fisher's LSD

```
library(agricolae)
LSD_none <- LSD.test(aov ,"Friends", p.adj = "none")
LSD_none$groups
```

```
##        Score groups
## 302 4.878788      a
## 502 4.561538     ab
```

```
## 702 4.406667    abc
## 902 3.990476     bc
## 102 3.816667      c
```

```
LSD_bon <- LSD.test(aov ,"Friends", p.adj = "bonferroni")
LSD_bon$groups
```

```
##        Score groups
## 302 4.878788      a
## 502 4.561538     ab
## 702 4.406667     ab
## 902 3.990476      b
## 102 3.816667      b
```

Tukey's HSD

```
HSD <- TukeyHSD(aov, conf.level = 0.95)
HSD$Friends
```

```
##               diff        lwr         upr       p adj
## 302-102  1.0621212  0.2488644  1.87537798 0.003889635
## 502-102  0.7448718 -0.1132433  1.60298691 0.121456224
## 702-102  0.5900000 -0.2402014  1.42020143 0.288431585
## 902-102  0.1738095 -0.7320145  1.07963355 0.984016816
## 502-302 -0.3172494 -1.1121910  0.47769215 0.804080046
## 702-302 -0.4721212 -1.2368466  0.29260420 0.432633745
## 902-302 -0.8883117 -1.7345313 -0.04209203 0.034535577
## 702-502 -0.1548718 -0.9671402  0.65739661 0.984391504
## 902-502 -0.5710623 -1.4604793  0.31835479 0.391768065
## 902-702 -0.4161905 -1.2787075  0.44632652 0.669927748
```