Statistical Inference Course Project - Part 2

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Overview

The second part of this class project is to perform an analysis of the ToothGrowth data set. The analysis will proceed in four parts:

1. Load the ToothGrowth data and perform some basic exploratory data analyses
2. A basic summary of the data.
3. An analysis of variance to compare tooth growth by both supplement and dosage.
4. A statement of conclusions and the necessary assumptions needed for those conclusions.

Load Data

```
# load neccesary libraries
library(ggplot2)
library(datasets)
library(gridExtra)
library(GGally)

# The Effect of Vitamin C on Tooth Growth in Guinea Pigs
data(ToothGrowth)
toothGrowth <- ToothGrowth
toothGrowth$dose <- as.factor(toothGrowth$dose) # convert to factor
```

Basic Summary of the data

```
str(toothGrowth)
```

```
## 'data.frame':    60 obs. of  3 variables:
##  $ len : num  4.2 11.5 7.3 5.8 6.4 10 11.2 11.2 5.2 7 ...
##  $ supp: Factor w/ 2 levels "OJ","VC": 2 2 2 2 2 2 2 2 2 2 ...
##  $ dose: Factor w/ 3 levels "0.5","1","2": 1 1 1 1 1 1 1 1 1 1 ...
```

```
summary(toothGrowth)
```

```
##       len        supp     dose
##  Min.   : 4.20   OJ:30   0.5:20
##  1st Qu.:13.07   VC:30   1  :20
##  Median :19.25           2  :20
##  Mean   :18.81
##  3rd Qu.:25.27
##  Max.   :33.90
```

```
head(toothGrowth)
```

```
##    len supp dose
## 1  4.2   VC  0.5
```

```
## 2 11.5   VC  0.5
## 3  7.3   VC  0.5
## 4  5.8   VC  0.5
## 5  6.4   VC  0.5
## 6 10.0   VC  0.5
```

```r
table(toothGrowth$supp, toothGrowth$dose)
```

```
##
##      0.5  1  2
##   OJ  10 10 10
##   VC  10 10 10
```

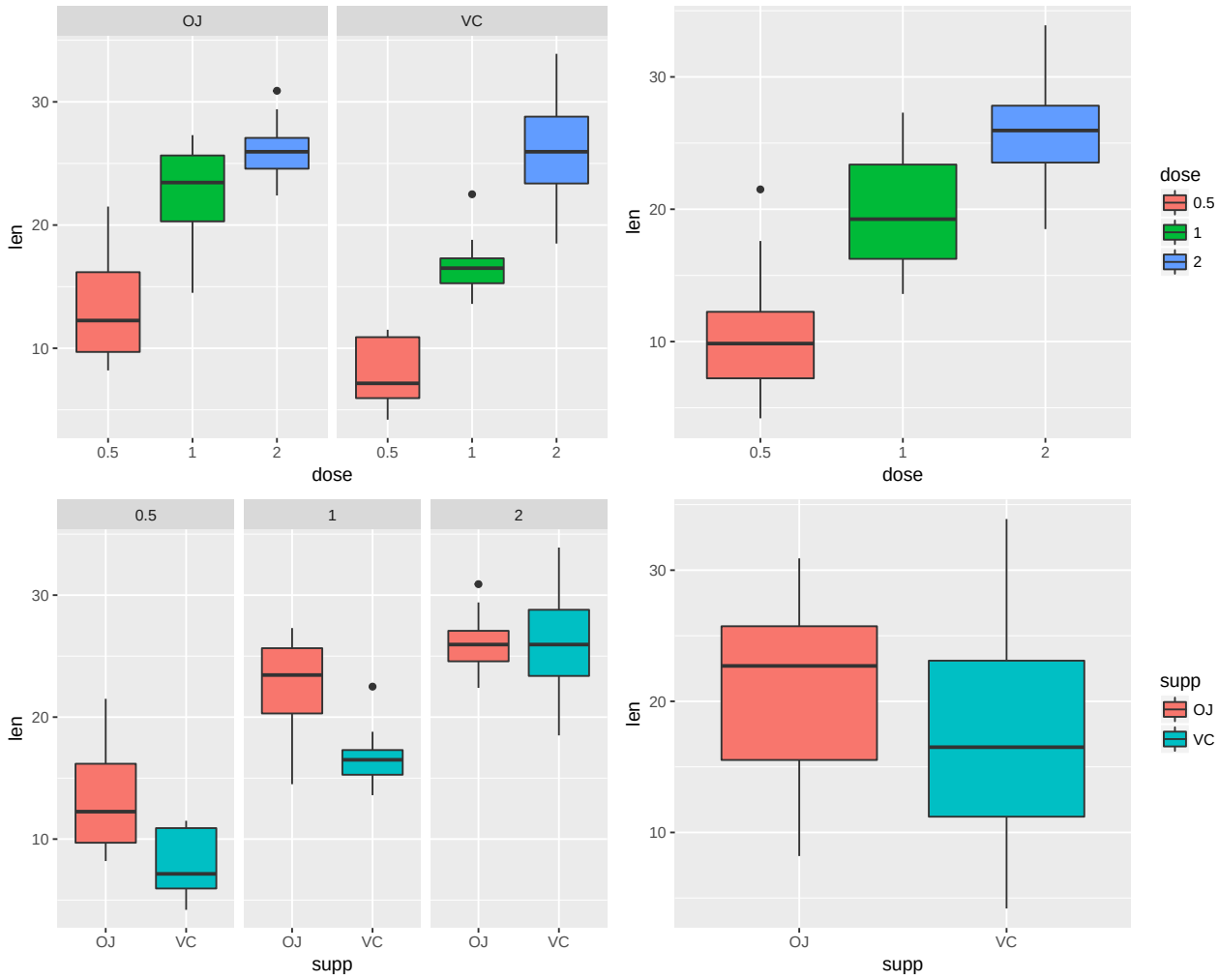
```r
p1 <- ggplot(data=toothGrowth, aes(x=dose,y=len,fill=dose)) +
  geom_boxplot() +
  theme(legend.position="none") +
  facet_grid(.~supp)

p2 <- ggplot(data=toothGrowth, aes(x=supp,y=len,fill=supp)) +
  geom_boxplot() +
  theme(legend.position="none") +
  facet_grid(.~dose)

p3 <- ggplot(data=toothGrowth, aes(x=supp,y=len,fill=supp)) +
  geom_boxplot()

p4 <- ggplot(data=toothGrowth, aes(x=dose,y=len,fill=dose)) +
  geom_boxplot()

grid.arrange(p1, p4, p2, p3, ncol = 2, nrow=2)
```



An Analysis of Variance (ANOVA) between supplement and dosage:

```
anova.out <- aov(len ~ supp * dose, data=toothGrowth)
summary(anova.out)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## supp         1  205.4   205.4  15.572 0.000231 ***
## dose         2 2426.4  1213.2  92.000  < 2e-16 ***
## supp:dose    2  108.3    54.2   4.107 0.021860 *
## Residuals   54  712.1    13.2
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The results show there is a notable interaction between the length (len) and dosage (dose) ($F(1,54)=15.572; p<0.01$) Also a very clear effect on length(len) by supplement type (supp) ($F(2,54)=92; p<0.01$). Last but not least there is a minor interaction between the combination of supplement type (supp) and dosage (dose) compared to the length (len) ($F(2,54)=4.107; p<0.05$).

```
TukeyHSD(anova.out)
```

```
##   Tukey multiple comparisons of means
```

```
##     95% family-wise confidence level
##
## Fit: aov(formula = len ~ supp * dose, data = toothGrowth)
##
## $supp
##       diff       lwr       upr     p adj
## VC-OJ -3.7 -5.579828 -1.820172 0.0002312
##
## $dose
##         diff       lwr       upr   p adj
## 1-0.5  9.130  6.362488 11.897512 0.0e+00
## 2-0.5 15.495 12.727488 18.262512 0.0e+00
## 2-1    6.365  3.597488  9.132512 2.7e-06
##
## $`supp:dose`
##                 diff        lwr        upr     p adj
## VC:0.5-OJ:0.5 -5.25 -10.048124 -0.4518762 0.0242521
## OJ:1-OJ:0.5    9.47   4.671876 14.2681238 0.0000046
## VC:1-OJ:0.5    3.54  -1.258124  8.3381238 0.2640208
## OJ:2-OJ:0.5   12.83   8.031876 17.6281238 0.0000000
## VC:2-OJ:0.5   12.91   8.111876 17.7081238 0.0000000
## OJ:1-VC:0.5   14.72   9.921876 19.5181238 0.0000000
## VC:1-VC:0.5    8.79   3.991876 13.5881238 0.0000210
## OJ:2-VC:0.5   18.08  13.281876 22.8781238 0.0000000
## VC:2-VC:0.5   18.16  13.361876 22.9581238 0.0000000
## VC:1-OJ:1     -5.93 -10.728124 -1.1318762 0.0073930
## OJ:2-OJ:1      3.36  -1.438124  8.1581238 0.3187361
## VC:2-OJ:1      3.44  -1.358124  8.2381238 0.2936430
## OJ:2-VC:1      9.29   4.491876 14.0881238 0.0000069
## VC:2-VC:1      9.37   4.571876 14.1681238 0.0000058
## VC:2-OJ:2      0.08  -4.718124  4.8781238 1.0000000
```

The Tukey HSD analysis shows that there are significant differences between each of the groups in supp and dose Only the interactions between VC:0.5-OJ:0.5; VC:1-OJ:0.5; OJ:2-OJ:1; VC:2-OJ:1 and VC:2-OJ:2 are not significant.

```
confint(anova.out)
```

```
##                    2.5 %    97.5 %
## (Intercept)  10.9276907 15.532309
## suppVC       -8.5059571 -1.994043
## dose1         6.2140429 12.725957
## dose2         9.5740429 16.085957
## suppVC:dose1 -5.2846186  3.924619
## suppVC:dose2  0.7253814  9.934619
```

```
print(model.tables(anova.out,"means"),digits=2)
```

```
## Tables of means
## Grand mean
##
## 18.81333
##
##  supp
## supp
##   OJ   VC
```

```
## 20.7 17.0
##
##  dose
## dose
##  0.5    1    2
## 10.6 19.7 26.1
##
##  supp:dose
##     dose
## supp 0.5  1    2
##   OJ 13.2 22.7 26.1
##   VC  8.0 16.8 26.1
```

Conclusions

There are clear indications that both the supplement and the dosage have independent effects on the length of guinea pigs' teeth. More, these means indicate longer teeth on avarage. OJ increases avarage growth in combination with dosages 0.5 and 1 more than the VC supplement, while teeth length for the VC supplement vs the OJ in combiantion with dosage 2 has no significant effect (almost same mean & same confidence interval).

The conclusions are based are based on the following assumptions:

- that the guinea pigs are repesentative for the population of guinea pigs,
- that dosage and supplement were randomly assigned, and
- that the distribution of the means is normal.