Statistical Inference Course Project 2

Overview

Load the ToothGrowth data and perform some basic exploratory data analyses

- Provide a basic summary of the data.
- Use confidence intervals and/or hypothesis tests to compare tooth growth by supp and dose. (***Only use the techniques from class, even if there's other approaches worth considering***)
- State your conclusions and the assumptions needed for your conclusions.

Load Libraries and Data

```
library(tidyverse)
library(ggplot2)
library(datasets)
library(gridExtra)
library(GGally)
library(knitr)
```

```
# The Effect of Vitamin C on Tooth Growth in Guinea Pigs
data(ToothGrowth)
toothGrowth <- ToothGrowth # derive a dataset and edit accordingly
toothGrowth <- toothGrowth %>% mutate(dose = as.factor(dose)) # convert dose 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
```

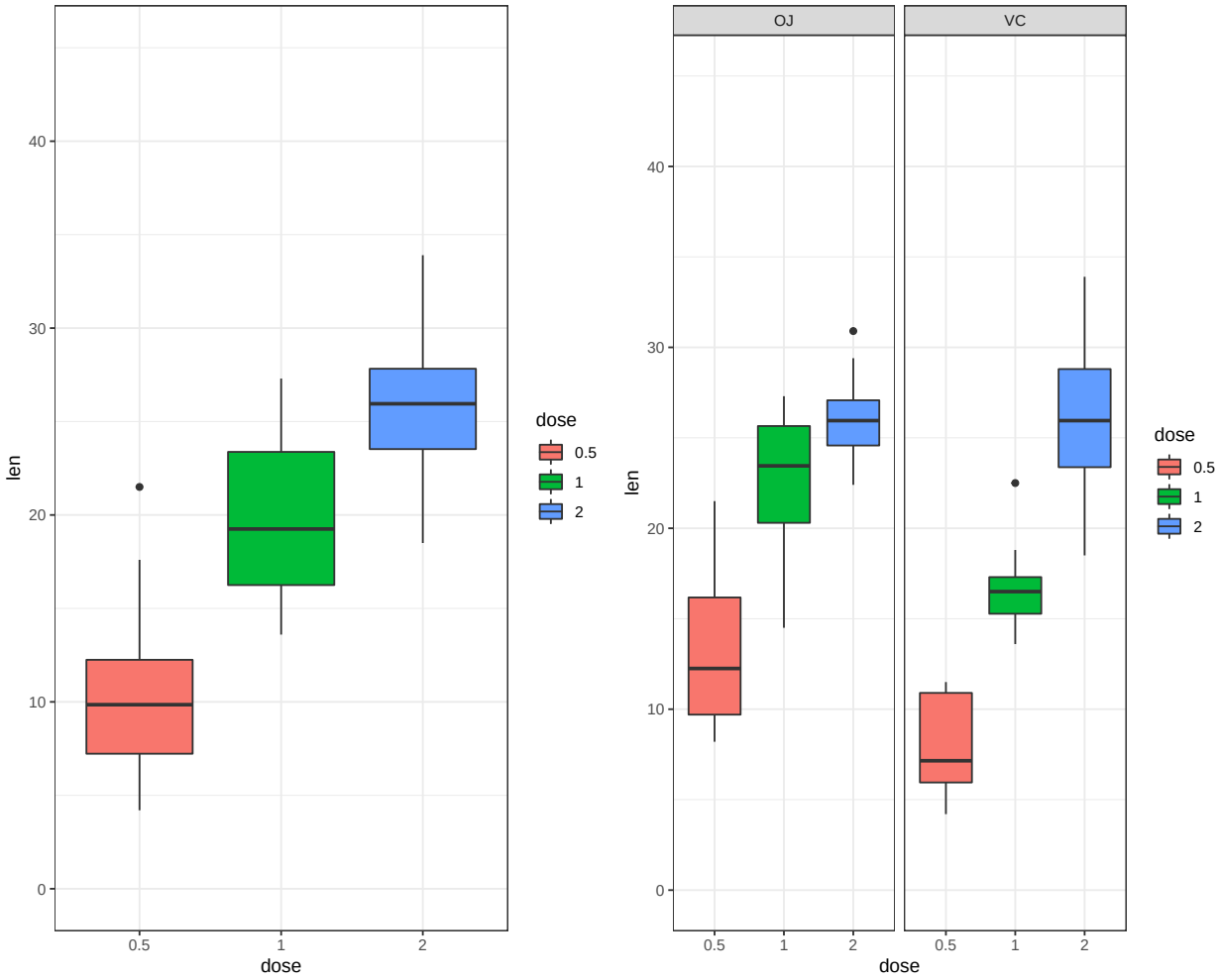
```
head(toothGrowth)
```

```
##    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
```

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

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

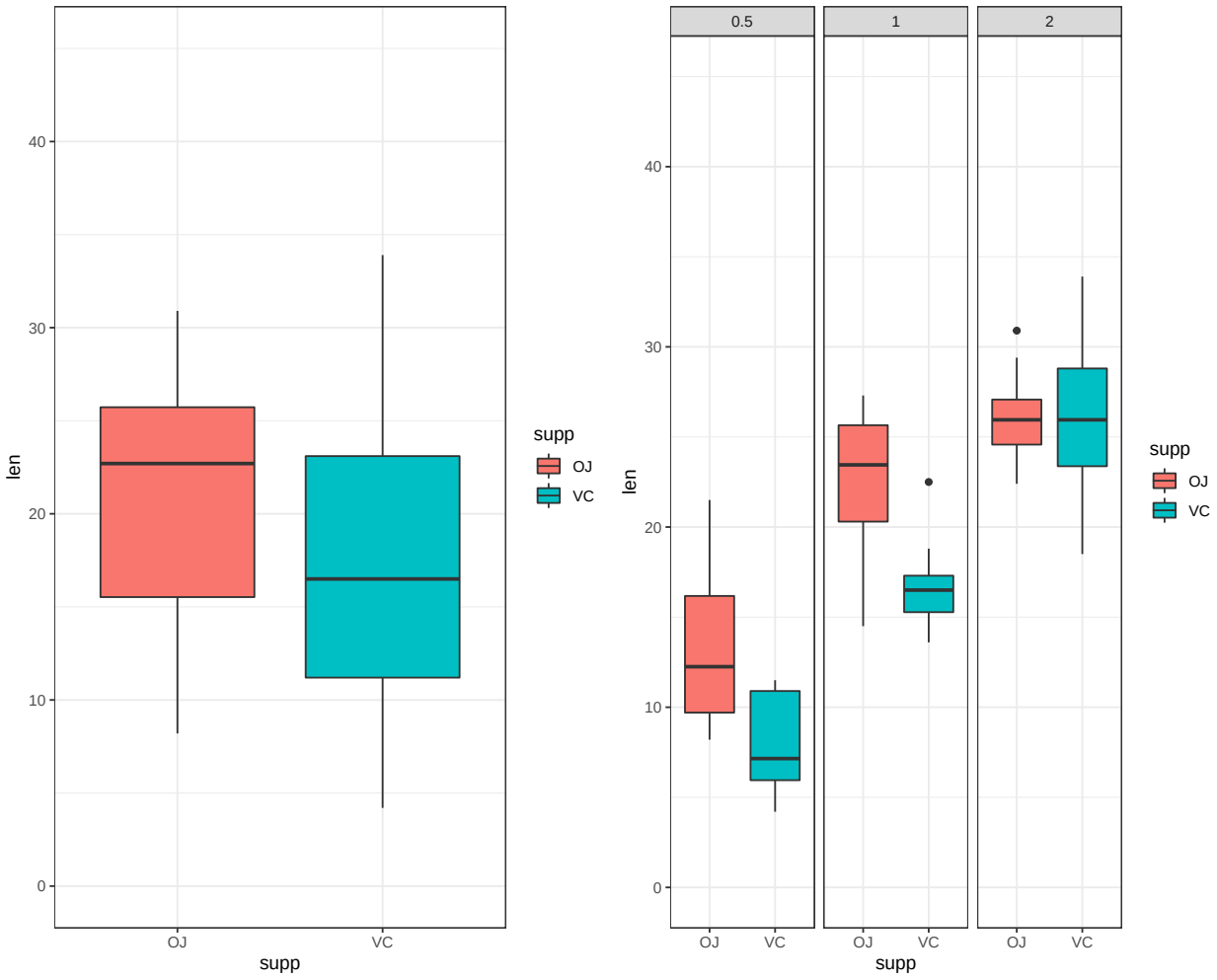
Plots Distribution of the dose variable, with an additiona breakdown by supplement type



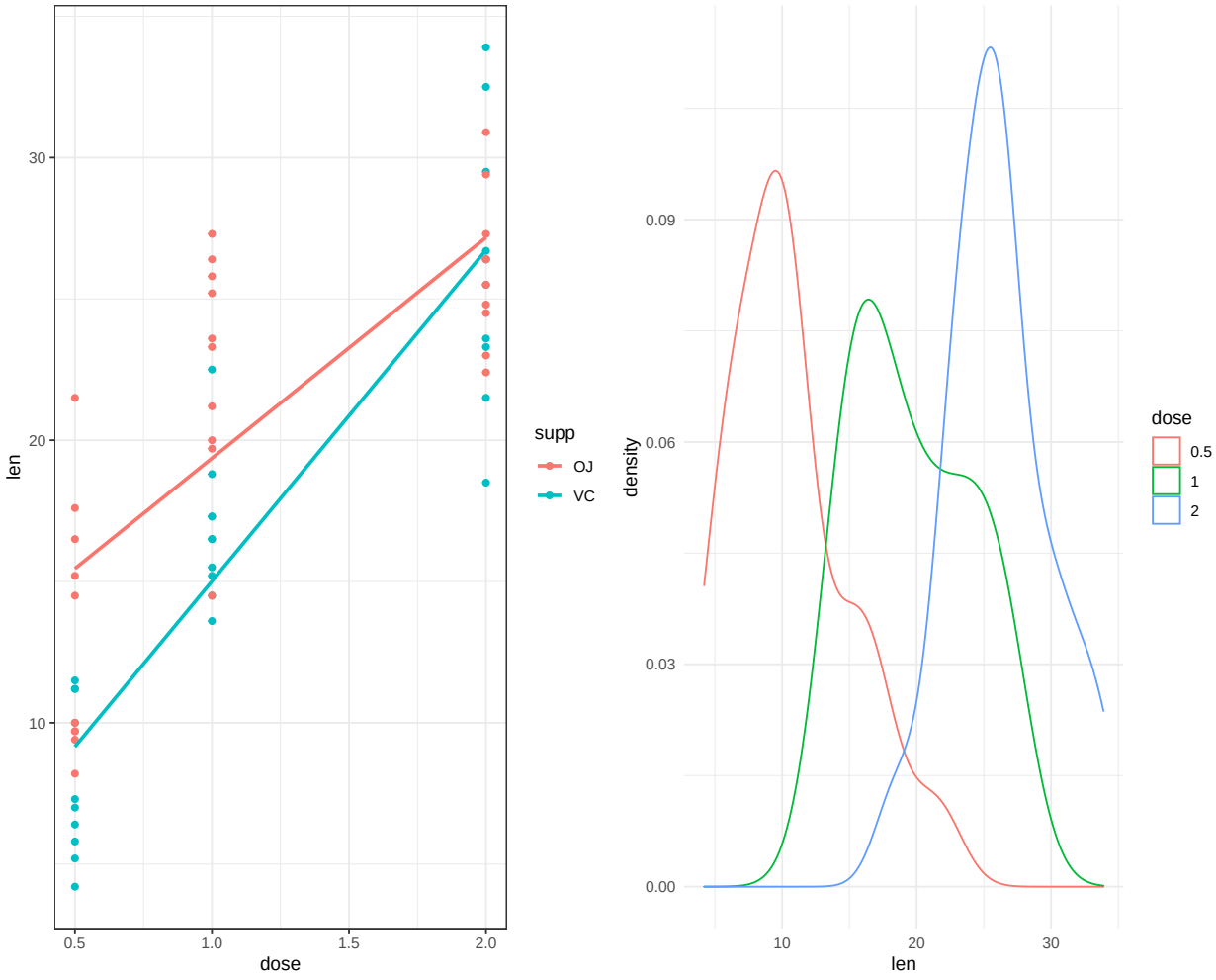
Distribution of the Supplement variable, with an additional breakdown by dose level

```
p3 <- ggplot(data=toothGrowth, aes(x=supp,y=len,fill=supp)) +
  geom_boxplot()+ ylim(c(0,45)) +
```

```
  theme_bw()
p4 <- ggplot(data=toothGrowth, aes(x=supp,y=len,fill=supp)) +
  geom_boxplot() +  ylim(c(0,45)) +
  theme(legend.position="none") +
  facet_grid(.~dose) +theme_bw()
grid.arrange(p3, p4, ncol = 2, nrow=1)
```




```
p5 <- toothGrowth %>% mutate(dose=as.numeric(as.character(dose))) %>%
  ggplot(aes(x=dose,y=len,col=supp)) +
  geom_point()+
  geom_smooth(method=lm,se=FALSE) +
  theme_bw()
p6 <-  toothGrowth %>% ggplot(aes(len,col=dose)) + geom_density() +
  theme_minimal()
grid.arrange(p5, p6, ncol = 2, nrow=1)
```



ANOVA

Carry out some analysis based on Analysis of Variance (ANOVA)

```
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***).
- Finally 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 HSD Test

```
##   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=3)
```

```
## Tables of means
## Grand mean
##
## 18.81333
##
##  supp
## supp
##    OJ    VC
## 20.66 16.96
##
##  dose
## dose
##   0.5     1     2
## 10.60 19.73 26.10
##
##  supp:dose
##     dose
## supp 0.5   1     2
##   OJ 13.23 22.70 26.06
##   VC  7.98 16.77 26.14
```

Conclusions

There are clear indications that both the supplement as the dosage have clear independent effects on the length of teeth guinea pigs. Higher dosage means on average longer teeth. Supplement type has a clear influence too, but OJ has a greater avarage teethgrowth in combination with dosages 0.5 and 1 then for 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)

These conclusions are predicated on the validity of 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.