Statistical Inference - Peer Graded Assignment

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Part 2: Basic Inferential Data Analysis Instructions

Load the ToothGrowth data and perform some basic exploratory data analyses

```
kable(head(ToothGrowth))
```

len	supp	dose
4.2	VC	0.5
11.5	VC	0.5
7.3	VC	0.5
5.8	VC	0.5
6.4	VC	0.5
10.0	VC	0.5

The Box Plot above seems to indicate additional tooth growth in the OJ supplement over the VC supplement.

The scatter plot show a higher level of tooth growth at lower dosages as compared to the vitamin C. However, at the higher dosage (2mg) the supplments seem equally effective.

Data Summary

```
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: num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 ...
```

```
kable(summary(ToothGrowth))
```

len	supp	dose
Min. : 4.20	OJ:30	Min. :0.500
1st Qu.:13.07	VC:30	1st Qu.:0.500
Median :19.25	NA	Median :1.000
Mean :18.81	NA	Mean :1.167
3rd Qu.:25.27	NA	3rd Qu.:2.000
Max. :33.90	NA	Max. :2.000

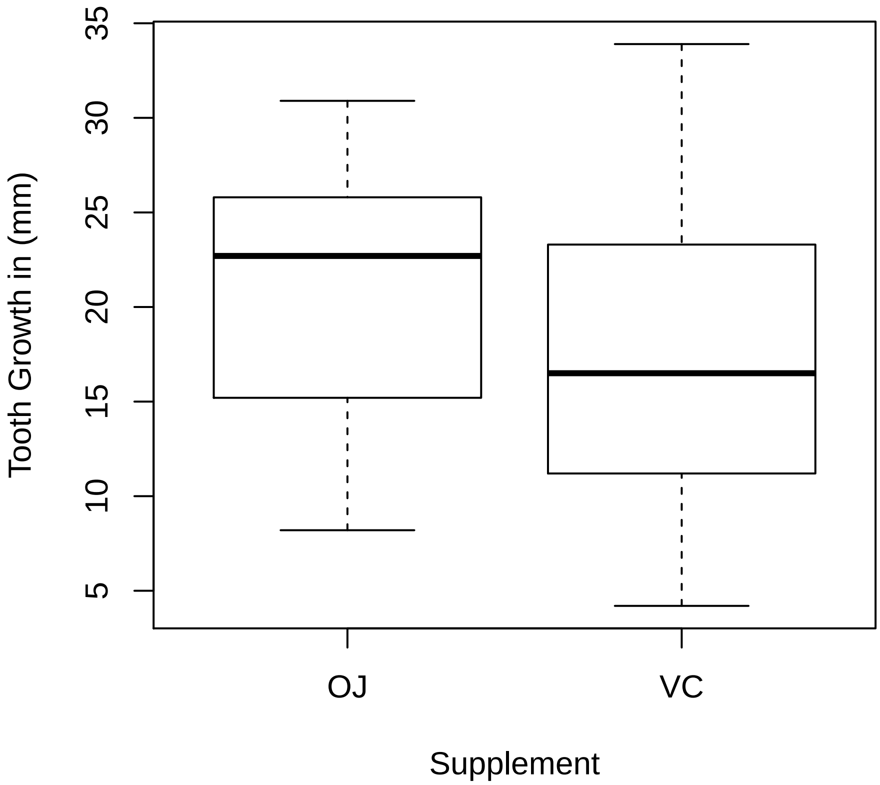

Figure 1: Fig. 4 Tooth Length

Confidence Intervals

```
# Subset the data for confints
ToothGrowth_oj <- subset(ToothGrowth, supp=='OJ')
ToothGrowth_vc <- subset(ToothGrowth, supp=='VC')
ConfIntTable <- rbind(
mean(ToothGrowth$len) + c(-1, 1) * 1.96 * sd(ToothGrowth$len)/sqrt(nrow(ToothGrowth)),
mean(ToothGrowth_oj$len) + c(-1, 1) * 1.96 * sd(ToothGrowth_oj$len)/sqrt(nrow(ToothGrowth_oj)),
mean(ToothGrowth_vc$len) + c(-1, 1) * 1.96 * sd(ToothGrowth_vc$len)/sqrt(nrow(ToothGrowth_vc)))

row.names(ConfIntTable) = c('Overall', 'OJ', 'VC')
df_conf <- as.data.frame.matrix(ConfIntTable)
df_conf %>%
  rename(
    'ConfInt-Low' = 'V1',
    'ConfInt-High' = 'V2')
```

```
##         ConfInt-Low ConfInt-High
## Overall    16.87779     20.74888
## OJ         18.29956     23.02710
## VC         14.00537     19.92129
```

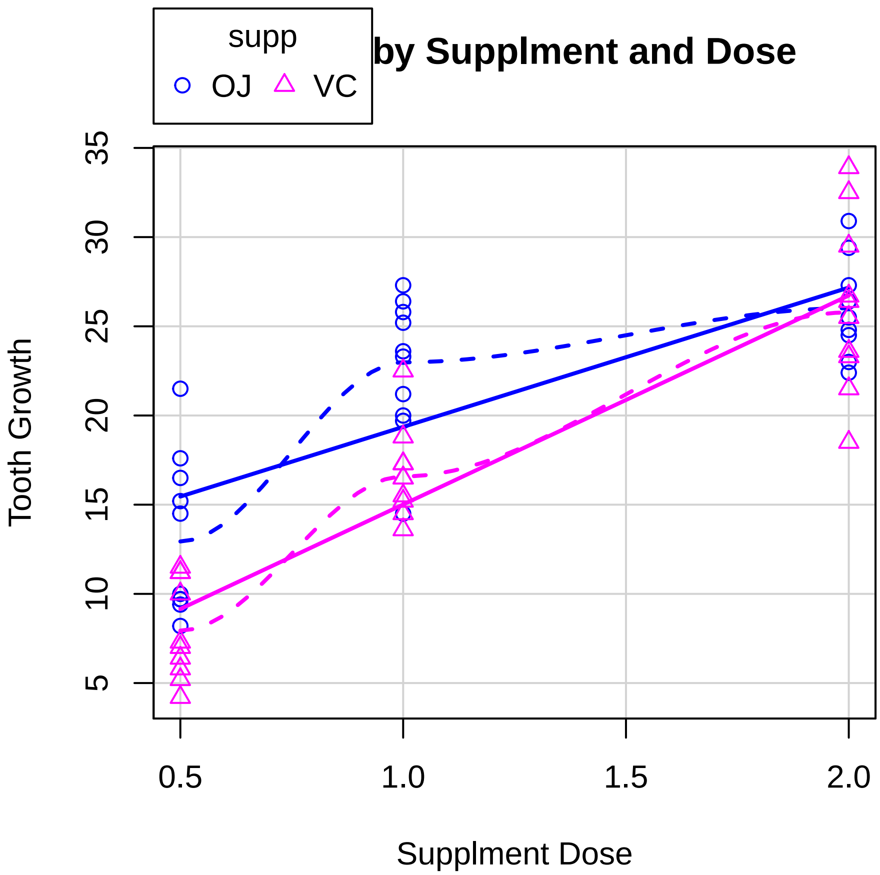

Figure 2: Fig. 5 Growth by Supplement and Dose

Hypothesis Testing and Sample Analysis

All Data

```
#Run Welch Test on entire Sample
    model1 <- t.test(len ~ supp, data = ToothGrowth)
    model1
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 1.9153, df = 55.309, p-value = 0.06063
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.1710156  7.5710156
## sample estimates:
## mean in group OJ mean in group VC
##         20.66333         16.96333
```

```
# Run power tests to determine power properties of our sample
    all_delta <- power.t.test(n = nrow(ToothGrowth), power = .90, sd = sd(ToothGrowth$len))$delta
    all_size <-  power.t.test( power = .90, delta=3, sd = sd(ToothGrowth$len))$n
    all_power <- power.t.test(n = nrow(ToothGrowth), delta = 3, sd = sd(ToothGrowth$len))$power
```

The p value is somewhat high for all dosages. Therefore we accept the null H0 hypthesis that there is no difference in the means of the supplements and also accept that there maybe some significance in general on supplement type accross all dosages.

Power testing indicates that we could only determine a delta of 4.56 mm with our current sample size with .9 power. If we wanted to increase the length sensitivity to a delta of 3mm we would need a sample size of 138. At our current sample size of 60, we can only detect a 3mm growth delta with 0.57 power.

Analysis at .5mg Doses

```
five <- subset(ToothGrowth, dose == "0.5")
model2 <- t.test(len ~ supp, data = five)
model2
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 3.1697, df = 14.969, p-value = 0.006359
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.719057 8.780943
## sample estimates:
## mean in group OJ mean in group VC
##            13.23             7.98
```

```
five_delta <- power.t.test(n = nrow(five), power = .90, sd = sd(five$len))$delta
five_size <-  power.t.test(delta = 3, power = .90, sd = sd(five$len))$n
five_power <- power.t.test(delta = 3,n = nrow(five) , sd = sd(five$len))$power
```

The p value is low at the .5 mg dose level. Therefore we reject the H0 hypthesis that there is no difference in the means of the supplements and we accept that there is some signifcance to the impact on toothgrowth at this dose level.

Power testing indicates that we could only determine a delta of 4.73 mm with our current sample size with .9 power. If we wanted to increase the length sensitivity to a delta of 3mm we would need a sample size of 48. At our current sample size of 20, we can only detect a 3mm growth delta with 0.54 power.

Analysis at 1mg Doses

```
one <- subset(ToothGrowth, dose == "1")
model3 <- t.test(len ~ supp, data = one)
model3
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 4.0328, df = 15.358, p-value = 0.001038
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  2.802148 9.057852
## sample estimates:
## mean in group OJ mean in group VC
##            22.70            16.77
```

```
one_delta <- power.t.test(n = nrow(one), power = .90, sd = sd(one$len))$delta
one_size <-  power.t.test(delta = 3, power = .90, sd = sd(one$len))$n
one_power <- power.t.test(delta = 3, n = nrow(one), sd = sd(one$len))$power
```

The p value is low at the 1 mg dose level. Therefore we reject the H0 hypthesis that there is no difference in the means of the supplements and we accept that there is some signifcance to the impact on toothgrowth at this dose level.

Power testing indicates that we could only determine a delta of 4.65 mm with our current sample size with .9 power. If we wanted to increase the length sensitivity to a delta of 3mm we would need a sample size of 47. At our current sample size of 20, we can only detect a 3mm growth delta with 0.55 power.

Analysis at 2mg Doses

```
two <- subset(ToothGrowth, dose == "2")
model4 <- t.test(len ~ supp, data = two)
model4
```

```
##
##  Welch Two Sample t-test
##
```

```
## data:  len by supp
## t = -0.046136, df = 14.04, p-value = 0.9639
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.79807  3.63807
## sample estimates:
## mean in group OJ mean in group VC
##            26.06            26.14
```

```
two_delta <- power.t.test(n = nrow(two), power = .90, sd = sd(two$len))$delta
two_size <- power.t.test(delta = 3, power = .90, sd = sd(two$len))$n
two_power <- power.t.test(delta = 3,n = nrow(two), sd = sd(two$len))$power
```

Zero is in the confidence interval and the p value is high. Therefore we can not reject the null hypthesis that the means of the two supplememts are equal at the 2mg dose for tooth growth.

Power testing indicates that we could only determine a delta of 3.97 mm with our current sample size with .9 power. If we wanted to increase the length sensitivity to a delta of 3mm we would need a sample size of 34. At our current sample size of 20, we can only detect a 3mm growth delta with 0.69 power.

Conclusion

The exploratory phase of the analysis indicated that there was some possibility of correlation of tooth growth to supplement type and dose. Both Confidence Intervals and Welch Two Sample hypothesis testing confirmed that there is significance at the .5 mg and 1mg dose levels and no attributable significance to the dose level by supplement type at the 2 mg level. However, we must careful when we interpret the dosages as the power t.test indicates that diffences in the means is just within the required sample size. We reccomend that the analysis be conducted with higher sample sizes in the future in order to confirm these findings.