Statistical Inference - Assignment Part 2

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Library

```
library(dplyr)
library(ggplot2)
```

Overview

This report will explore ToothGrowth Data and whether different delivery methods and doses are statistically related to differences in tooth growth rate. Confidence Intervals and Hypothesis tests will be used to see if there is significance difference.

Data

“The response is the length of odontoblasts (cells responsible for tooth growth) in 60 guinea pigs. Each animal received one of three dose levels of vitamin C (0.5, 1, and 2 mg/day) by one of two delivery methods, orange juice or ascorbic acid (a form of vitamin C and coded as VC).”

Hypothesis

Null hypothesis: The average tooth growth is no different regardless of dose or delivery method used.
$H_o : \mu_o = \mu_a$, $H_a : \mu_o \neq \mu_a$

Data Exploration

```
##    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
```

```
num.NA.obs <- length(df[complete.cases(df) == FALSE,]$len)
```

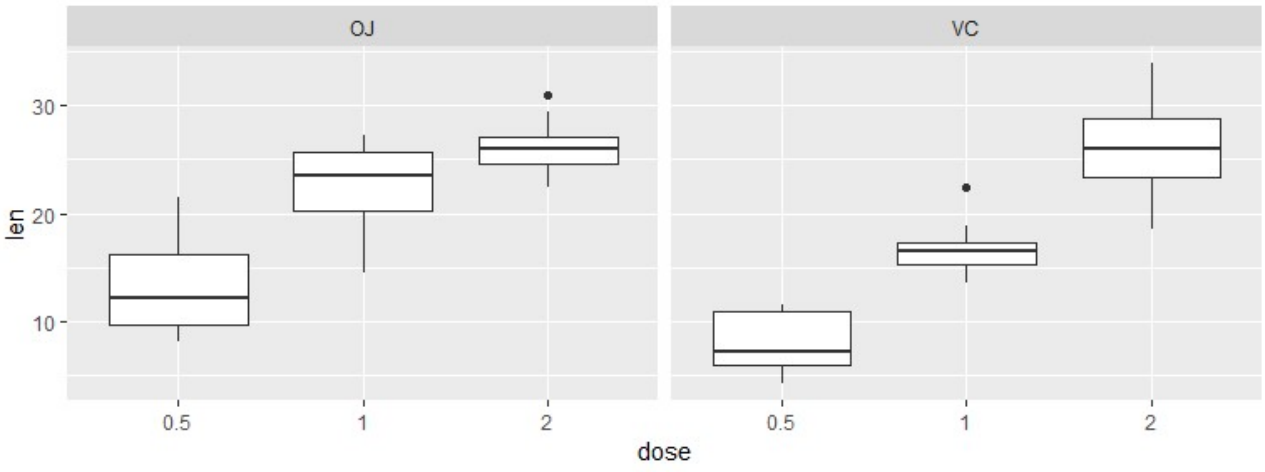
No data quality issues were detected. There are 0 missing or non-number values.

```
##   supp dose mean.length  mean sd.length   sd
## 1   OJ  0.5       13.23 13.23  4.459709 4.46
## 3   OJ  1.0       22.70 22.70  3.910953 3.91
## 5   OJ  2.0       26.06 26.06  2.655058 2.66
## 2   VC  0.5        7.98  7.98  2.746634 2.75
## 4   VC  1.0       16.77 16.77  2.515309 2.52
## 6   VC  2.0       26.14 26.14  4.797731 4.80
```

The variance of the different doses and delivery methods are not consistent as the table shows below. This will affect our confidence interval and p-value calculation method - the Two Sample Welch t-test will be used.

This is further confirmed by graphing the distribution of values.

```
df$dose <- as.factor(df$dose)
a <- ggplot(df, aes(x=dose, y=len)) + geom_boxplot() +
        facet_grid(.~supp)
plot(a)
```



Data Manipulation

Data is subsetted into groups.

Hypothesis Tests

A two-tailed 95% confidence interval will be used since the hypothesis are as follows
$H_o : \mu_o = \mu_a$, $H_a : \mu_o \neq \mu_a$
Therefore, $\alpha = 0.025$

Delivery Method Test

The delivery methods were compared against each other at different doses.

```
#OJ 0.5 vs VC 0.5
t.test(len ~ supp, data = rbind(OJ.small.len, VC.small.len))
```

```
##
##  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
```

```
#OJ 1 vs VC 1
t.test(len ~ supp, data = rbind(OJ.med.len, VC.med.len))
```

```
##
##  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
```

```
#OJ 2 vs VC 2
t.test(len ~ supp, data = rbind(OJ.high.len, VC.high.len))
```

```
##
##  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
```

- The null hypothesis that delivery method is statistically irrelevant can be rejected at 1 mg/day and lower, but cannot be rejected at 2 mg/day.

Dose Level Test

The dose were compared against each other using the same delivery methods.

```
#OJ 0.5 vs OJ 0.1
t.test(len ~ dose, data = rbind(OJ.small.len, OJ.med.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -5.0486, df = 17.698, p-value = 8.785e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -13.415634  -5.524366
## sample estimates:
## mean in group 0.5   mean in group 1
##             13.23             22.70
```

```
#OJ 1 vs OJ 2
t.test(len ~ dose, data = rbind(OJ.med.len, OJ.high.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -2.2478, df = 15.842, p-value = 0.0392
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -6.5314425 -0.1885575
## sample estimates:
## mean in group 1 mean in group 2
##           22.70           26.06
```

```
#OJ 0.5 vs OJ 2
t.test(len ~ dose, data = rbind(OJ.small.len, OJ.high.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -7.817, df = 14.668, p-value = 1.324e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -16.335241  -9.324759
## sample estimates:
## mean in group 0.5   mean in group 2
##             13.23             26.06
```

```
#VC 0.5 vs VC 0.1
t.test(len ~ dose, data = rbind(VC.small.len, VC.med.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -7.4634, df = 17.862, p-value = 6.811e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.265712  -6.314288
## sample estimates:
## mean in group 0.5   mean in group 1
##              7.98             16.77
```

```
#VC 1 vs VC 2
t.test(len ~ dose, data = rbind(VC.med.len, VC.high.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -5.4698, df = 13.6, p-value = 9.156e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -13.054267  -5.685733
## sample estimates:
## mean in group 1 mean in group 2
##           16.77           26.14
```

```
#VC 0.5 vs VC 2
t.test(len ~ dose, data = rbind(VC.small.len, VC.high.len))
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -10.388, df = 14.327, p-value = 4.682e-08
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -21.90151 -14.41849
## sample estimates:
## mean in group 0.5   mean in group 2
##              7.98             26.14
```

- In all tests, the results were considered all significant as p-values were less than α , except for 1 mg/day vs 2 mg/day doses of Orange Juice.

Conclusion

Assmptions:

- Observations are iid variables - independent and identical distributions
- Data is not paired
- Data groups variance are not the same

Conclusions:

- Choice of delivery method is statistically significant up to 1 mg/day. There is a statistical association between teeth growth difference and delivery method of vitamin C at these doses.
- Choice of delivery method is statistically insignificant for teeth growth difference at 2 mg/day. There is no statistical association between teeth growth difference and delivery method of vitamin C at 2 mg/day.
- Amount of dose is statistically significant for teeth growth regardless of delivery method in most cases. There is a statistical association between teeth growth difference and doses.
- There is no statistical association in teeth growth differnece between 1 mg/day vs 2 mg/day doses of Orange Juice.