Peer Assessment for Coursera Statistical Inference Class

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In this project we analyse the effect of vitamin C on tooth growth in guinea pigs using R.

First, we load the ToothGrowth dataset from the datasets package, rename it to tg, and inspect it.

```
library(datasets)
data("ToothGrowth")
tg = ToothGrowth
tg$dose = as.factor(tg$dose)
dim(tg)
```

```
## [1] 60  3
```

```
head(tg, 3)
```

```
##    len supp dose
## 1  4.2   VC  0.5
## 2 11.5   VC  0.5
## 3  7.3   VC  0.5
```

```
summary(tg)
```

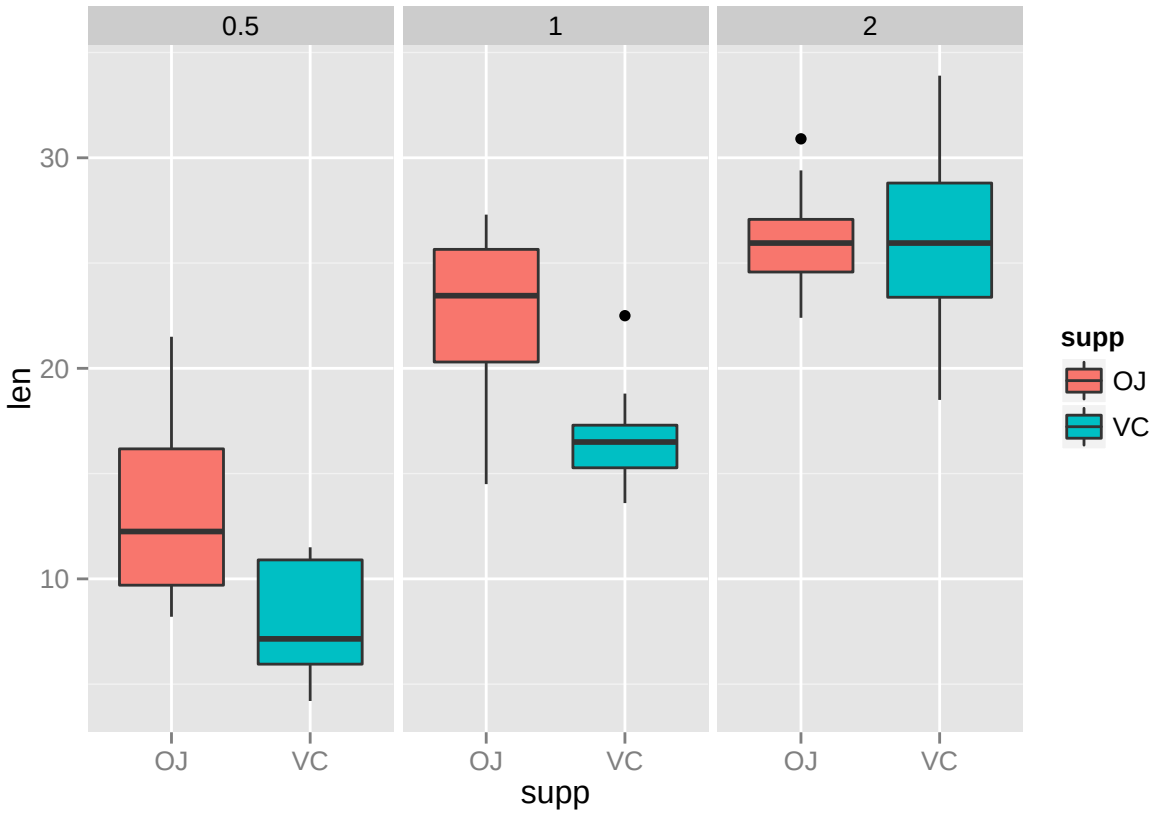
```
##       len        supp     dose
##  Min.   : 4.20   OJ:30   0.5:20
##  1st Qu.:13.07   VC:30   1  :20
##  Median :19.25           2  :20
##  Mean   :18.81
##  3rd Qu.:25.27
##  Max.   :33.90
```

This dataset consists of a dataframe with 60 observations on 3 variables. The response is the tooth length (len, in mm) in each of 10 guinea pigs at each of three dose levels of vitamin C (dose, 0.5, 1, and 2 mg) with each of two delivery methods (supp, OJ = orange juice and VC = ascorbic acid, a form of vitamin C).

First, we perform some exploratory data analysis by plotting the tooth length according to delivery method and dose of vitamin C.

```
library(ggplot2)

ggplot(aes(x = supp, y = len), data = tg) +
    geom_boxplot(aes(fill = supp)) + facet_wrap(~ dose)
```



It seems that, at the two lower doses of vitamin C, tooth length is shorter when delivered as ascorbic acid. At the highest dose of vitamin C, both delivery methods (ascorbic acid or orange juice) appear to be equivalent. It also seems that there is a dose-dependent effect (the highest the dose the longest the tooth) irrespective of delivery method; however this effect seems to plateau at the highest dose of vitamin C when delivered as orange juice.

Let's verify these preliminary conclusions by comparing these groups using t-tests.

First, we check whether the groups that we are going to compare meet the assumption of equal variance because it does not look like so in the previous plot.

```
library(dplyr)
library(magrittr)

tg %>% group_by(dose, supp) %>%
  summarise(n = n(), len.mean = mean(len), len.var = var(len))
```

```
## Source: local data frame [6 x 5]
## Groups: dose
##
##   dose supp  n len.mean   len.var
## 1  0.5   OJ 10    13.23 19.889000
## 2  0.5   VC 10     7.98  7.544000
## 3    1   OJ 10    22.70 15.295556
## 4    1   VC 10    16.77  6.326778
## 5    2   OJ 10    26.06  7.049333
## 6    2   VC 10    26.14 23.018222
```

It is clear, from the summary table above, that for most group comparisons the assumption of equal variance

is not a valid one. Therefore, we will proceed accordingly by NOT assuming equal variance in all of the t-tests that follow.

First, we group the observations according to delivery method and dose of vitamin C.

```
oj.low = filter(tg, supp == 'OJ' & dose == 0.5)
vc.low = filter(tg, supp == 'VC' & dose == 0.5)
oj.mid = filter(tg, supp == 'OJ' & dose == 1)
vc.mid = filter(tg, supp == 'VC' & dose == 1)
oj.high = filter(tg, supp == 'OJ' & dose == 2)
vc.high = filter(tg, supp == 'VC' & dose == 2)
```

Last, we perform group comparisons using t-tests.

First, we compare delivery methods at each dose of vitamin C.

```
t.test(oj.low$len, vc.low$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  oj.low$len and vc.low$len
## 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 of x mean of y
##     13.23      7.98
```

```
t.test(oj.mid$len, vc.mid$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  oj.mid$len and vc.mid$len
## 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 of x mean of y
##     22.70     16.77
```

```
t.test(oj.high$len, vc.high$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  oj.high$len and vc.high$len
## t = -0.0461, 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 of x mean of y
##     26.06     26.14
```

Indeed, as concluded previously, tooth length is significantly shorter (p-val < 0.05) when delivered as ascorbic acid at the two lower doses of vitamin C. On the contrary, at the highest dose of vitamin C, both delivery methods (ascorbic acid or orange juice) are equivalent (i.e., we can't reject the null hypothesis with alpha $= 0.05$).

Second, we compare doses of vitamin C at each delivery method.

```
t.test(oj.low$len, oj.mid$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  oj.low$len and oj.mid$len
## 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 of x mean of y
##     13.23     22.70
```

```
t.test(oj.mid$len, oj.high$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  oj.mid$len and oj.high$len
## 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 of x mean of y
##     22.70     26.06
```

```
t.test(vc.low$len, vc.mid$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  vc.low$len and vc.mid$len
## 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 of x mean of y
##      7.98     16.77
```

```r
t.test(vc.mid$len, vc.high$len, paired = FALSE, var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  vc.mid$len and vc.high$len
## 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 of x mean of y
##     16.77     26.14
```

Indeed, as concluded previously, there is a dose-dependent effect (the highest the dose the longest the tooth) irrespective of delivery method; however this effect seems to plateau (i.e., is no longer significant) at the highest dose of vitamin C when delivered as orange juice.