Tooth Growth Analysis

James Sheldon

May 24, 2016

```
sessionInfo()
```

```
## R version 3.2.5 (2016-04-14)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 7 x64 (build 7601) Service Pack 1
##
## locale:
## [1] LC_COLLATE=English_United States.1252
## [2] LC_CTYPE=English_United States.1252
## [3] LC_MONETARY=English_United States.1252
## [4] LC_NUMERIC=C
## [5] LC_TIME=English_United States.1252
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] ggplot2_2.1.0
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_0.12.5      digest_0.6.9     plyr_1.8.3       grid_3.2.5
##  [5] gtable_0.2.0     formatR_1.4      magrittr_1.5     evaluate_0.9
##  [9] scales_0.4.0     stringi_1.0-1    rmarkdown_0.9.6  tools_3.2.5
## [13] stringr_1.0.0    munsell_0.4.3    yaml_2.1.13      colorspace_1.2-6
## [17] htmltools_0.3.5  knitr_1.13
```

Overview

This analysis pertains to the ToothGrowth dataset made available in the R platform. We will load and summarize the data, perform some exploratory analysis and use confidence intervals and hypothesis tests to determine any relationships between tooth growth and the other variables.

```
data("ToothGrowth")
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           Median :1.000
##  Mean   :18.81           Mean   :1.167
##  3rd Qu.:25.27           3rd Qu.:2.000
##  Max.   :33.90           Max.   :2.000
```

```r
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 ...
```

```r
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
tail(ToothGrowth)
```

```
##     len supp dose
## 55 24.8   OJ    2
## 56 30.9   OJ    2
## 57 26.4   OJ    2
## 58 27.3   OJ    2
## 59 29.4   OJ    2
## 60 23.0   OJ    2
```

```r
unique(ToothGrowth$dose)
```

```
## [1] 0.5 1.0 2.0
```

```r
unique(ToothGrowth$supp)
```

```
## [1] VC OJ
## Levels: OJ VC
```

```r
by(ToothGrowth$len, INDICES = list(ToothGrowth$supp, ToothGrowth$dose), summary)
```

```
## : OJ
## : 0.5
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    8.20    9.70   12.25   13.23   16.18   21.50
## ------------------------------------------------------------
## : VC
## : 0.5
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    4.20    5.95    7.15    7.98   10.90   11.50
## ------------------------------------------------------------
## : OJ
```

```
## : 1
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   14.50   20.30   23.45   22.70   25.65   27.30
## ------------------------------------------------------------
## : VC
## : 1
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   13.60   15.27   16.50   16.77   17.30   22.50
## ------------------------------------------------------------
## : OJ
## : 2
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   22.40   24.58   25.95   26.06   27.08   30.90
## ------------------------------------------------------------
## : VC
## : 2
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   18.50   23.38   25.95   26.14   28.80   33.90
```

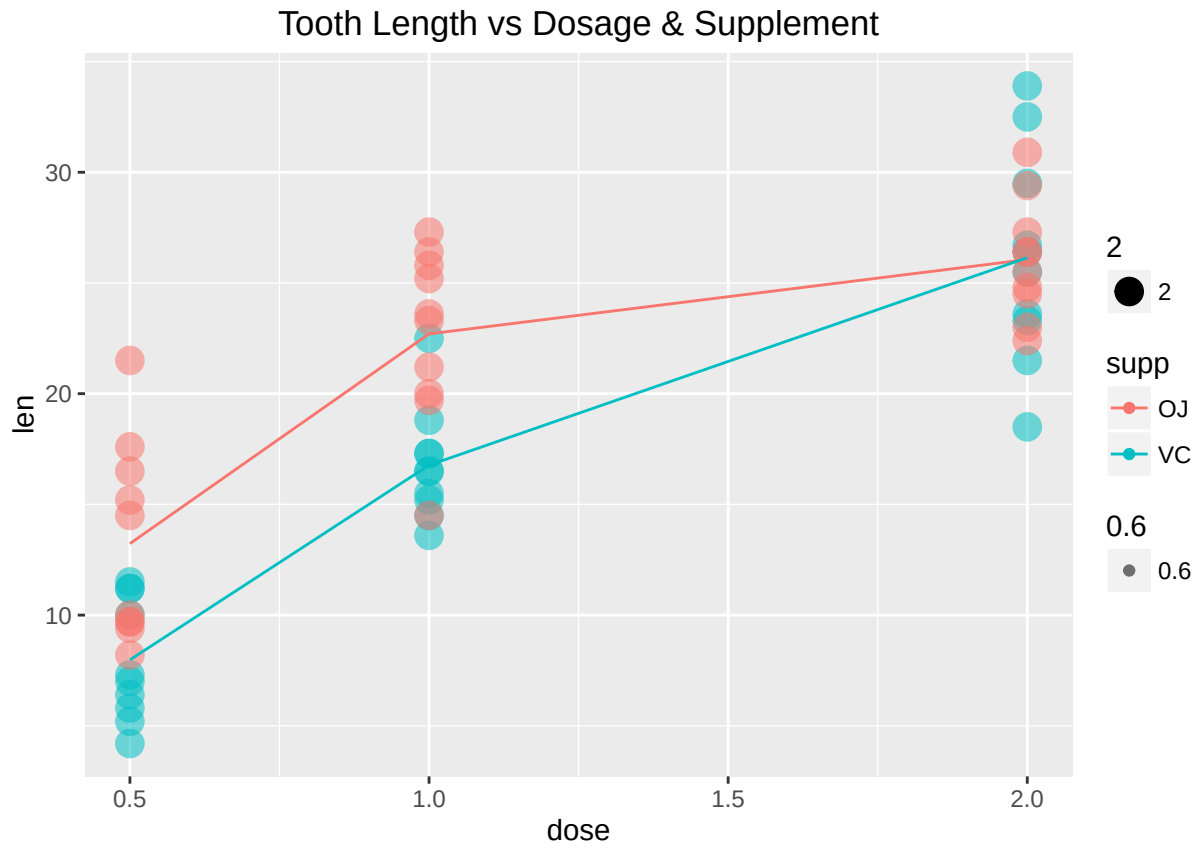
What we're seeing is this data represents the delivery of three different levels of Vitamin C (0.5, 1, and 2 mg) via two different vectors: orange juice or ascorbic acid. There are 60 total observations with three variables:

1. `len` which is a numeric value that represents the tooth length.
2. `supp` is the delivery vector.
3. `dose` is the numeric measure of the dose size in milligrams.

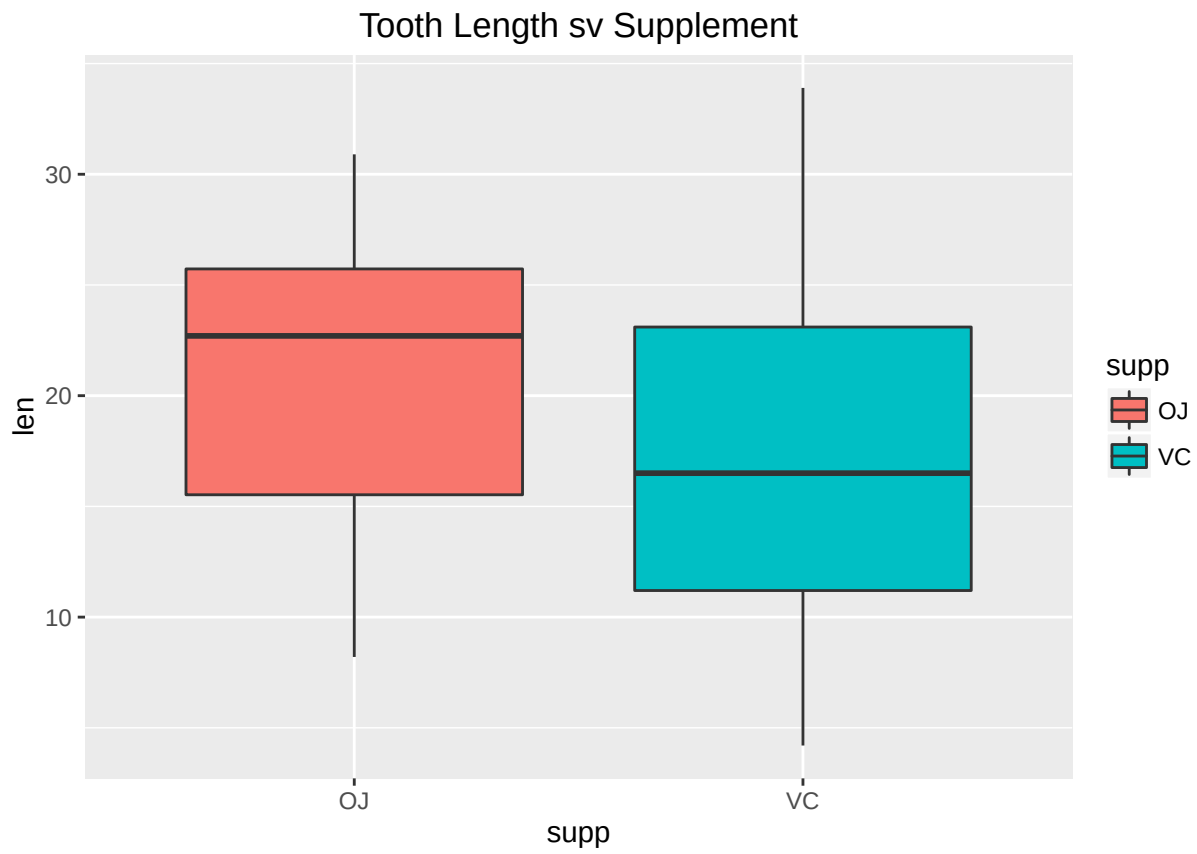
Exploratory Analysis

Let's now explore the data a bit. We'll take a look at a number of boxplots. This should hopefully help us at least get an idea on whether or not there are correlations between different data elements. Of course, it's important to remember that *correlation does not imply causation.* We are merely looking for some correlations and will explore those correlations further once they're noted.

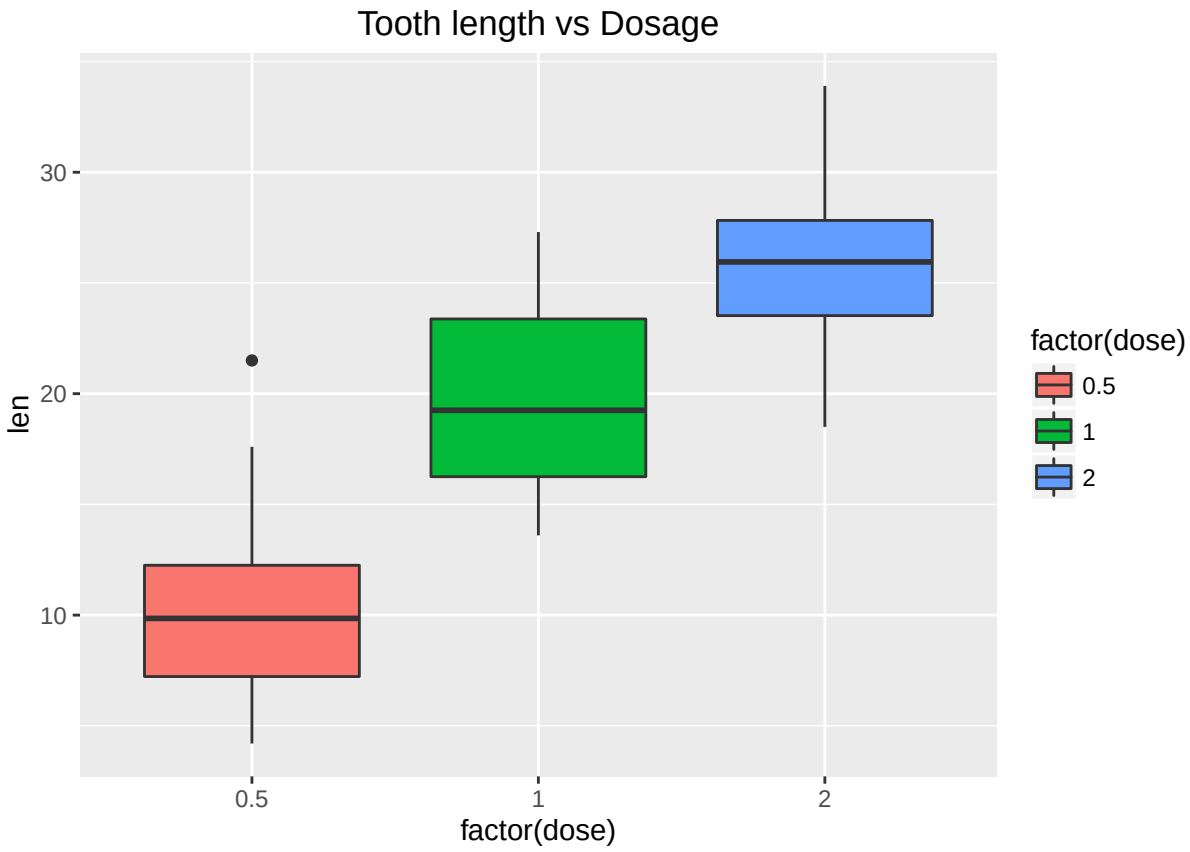
```
avg <- aggregate(len~.,data=ToothGrowth,mean)
#Plot the Tooth Length relative to Dosage & Supplement
ggplot(data = ToothGrowth,aes(x=dose,y=len)) + geom_point(aes(group=supp,colour=supp,size=2,alpha=0.6))
```



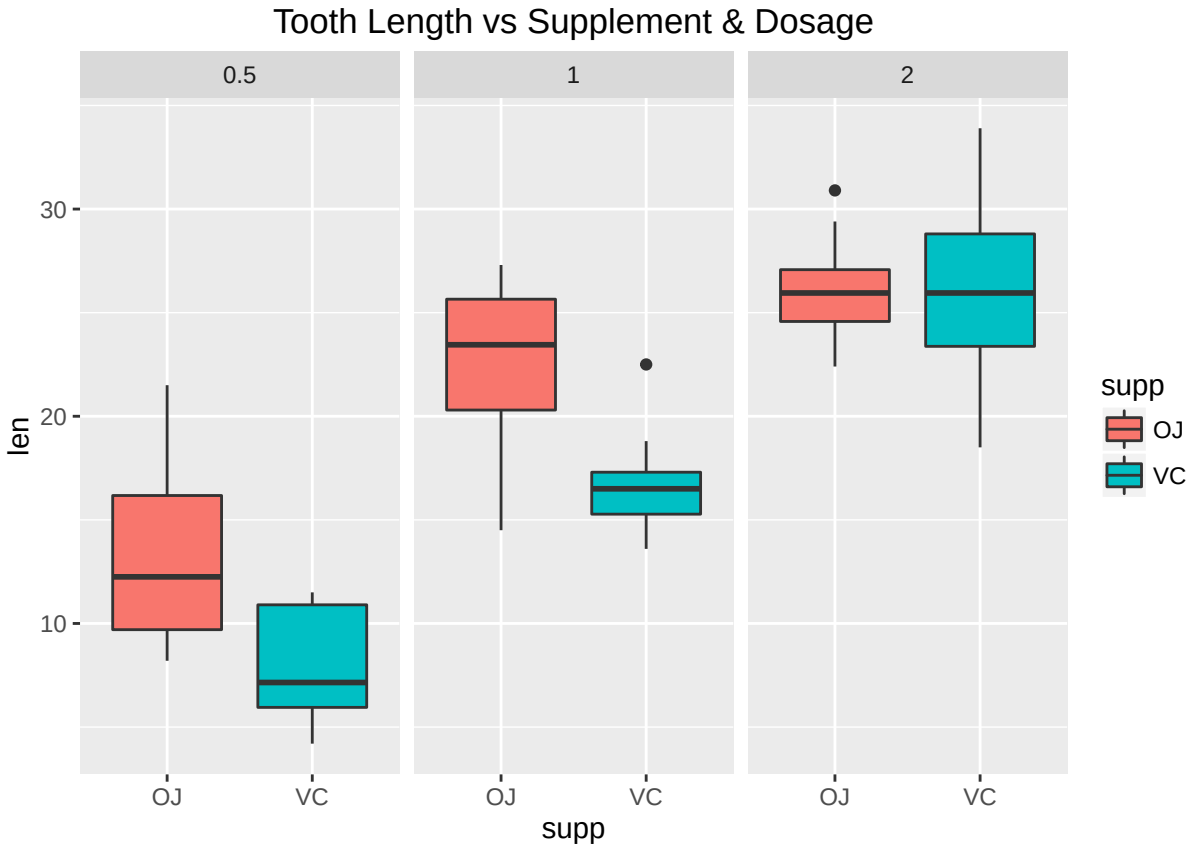

```
ggplot(aes(x = supp, y = len), data = ToothGrowth) + geom_boxplot(aes(fill = supp)) + labs(title="Tooth
```




```
ggplot(aes(x = factor(dose), y = len), data = ToothGrowth) + geom_boxplot(aes(fill = factor(dose))) + la
```




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



The above plots illustrate there is a strong positive correlation between dosage and tooth length. on the surface, the vector being employed doesn't show as strong of a correlation; however, it is too early to rule that out.

Confidence Testing

Now let's apply some t-tests to determine confidence intervals for any correlations we may be seeing in the data.

```
t.test(len ~ supp, paired = FALSE, var.equal = FALSE, data = ToothGrowth)
```

```
##
##  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
```

```r
dose1 <- subset(ToothGrowth, dose %in% c(0.5, 1.0))
dose2 <- subset(ToothGrowth, dose %in% c(0.5, 2.0))
dose3 <- subset(ToothGrowth, dose %in% c(1.0, 2.0))
t.test(len ~ dose, paired = FALSE, var.equal = FALSE, data = dose1)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -6.4766, df = 37.986, p-value = 1.268e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -11.983781  -6.276219
## sample estimates:
## mean in group 0.5   mean in group 1
##            10.605            19.735
```

```r
t.test(len ~ dose, paired = FALSE, var.equal = FALSE, data = dose2)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -11.799, df = 36.883, p-value = 4.398e-14
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -18.15617 -12.83383
## sample estimates:
## mean in group 0.5   mean in group 2
##            10.605            26.100
```

```r
t.test(len ~ dose, paired = FALSE, var.equal = FALSE, data = dose3)
```

```
##
##  Welch Two Sample t-test
##
## data:  len by dose
## t = -4.9005, df = 37.101, p-value = 1.906e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -8.996481 -3.733519
## sample estimates:
## mean in group 1 mean in group 2
##          19.735          26.100
```

```r
Tooth.dose4 <- subset(ToothGrowth, dose == 0.5)
Tooth.dose5 <- subset(ToothGrowth, dose == 1.0)
Tooth.dose6 <- subset(ToothGrowth, dose == 2.0)
t.test(len ~ supp, paired = FALSE, var.equal = FALSE, data = Tooth.dose4)
```

```
##
```

```
##  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
```

```
t.test(len ~ supp, paired = FALSE, var.equal = FALSE, data = Tooth.dose5)
```

```
##
##  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
```

```
t.test(len ~ supp, paired = FALSE, var.equal = FALSE, data = Tooth.dose6)
```

```
##
##  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
```

Conclusions

From the above confidence interval results we can conclude that there is a significant correlation between tooth length and dose levels.