Guinea Pig Tooth Growth as Result of Vitamin C Supplements

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2016-06-10

Overview:

This report analyzes the ToothGrowth data in the R data sets package. The data is the result of measuring the affect of different dosage amounts of Vitamin C on the length of odontoblasts (teeth) of ten guinea pigs. There are two supplement types of Vitamin C tested, Orange Juice and Ascorbic Acid, and they are given in three three different milligram dosage amount, 0.5, 1.0, and 2.0. The report goes through the process of cleansing the dataset, conducting exploratory analysis, and a completing statistical inference around different categorizations to the length of the teeth.

This report is for a Coursera Class project - Statistical Inference (Part 2). Per the project requirements, the below solution maintains the following:

- Did you perform an exploratory data analysis of at least a single plot or table highlighting basic features of the data?
- Did the student perform some relevant confidence intervals and/or tests?
- Were the results of the tests and/or intervals interpreted in the context of the problem correctly?
- Did the student describe the assumptions needed for their conclusions?

Source code for this entire report can be found here: http://github.com/mjfii/Statistical-Inference

More information regarding the source dataset can be found here: https://stat.ethz.ch/R-manual/R-devel/library/datasets/html/ToothGrowth.html

Data Cleansing:

From the source, we will load the ToothGrowth data into a data.table object, change the column names to something more meaningful, and declare a join key. In order to make categorizing a little more simple, we will add an additional column for Dosage by converting the 0.5 dose to 'SM', the 1.0 to 'MD', and the 2.0 to 'LG'. A single observation is shown below.

```
#  load data and make column names meaningful dt<-data.table(ToothGrowth)
setnames(dt,c('len','supp','dose'),c('Length','Supplement','Dose'))


#  add 'Dosage'and set the join key
dt<-dt[,Dosage:=sapply(as.character(dt$Dose),function(x) as.factor(switch(x,'0.5'='SM','1'='MD','2'='LG
setkey(dt,Supplement,Dosage)
head(dt,1)
```

```
#       Length Supplement Dose Dosage
## 1:      15.2         OJ  0.5     SM
```

Exploratory Analysis:

The following result sets are two a simple exploratory methods to understand the content and the structure of the data.table that we will continue to analyze in later sections of the report.

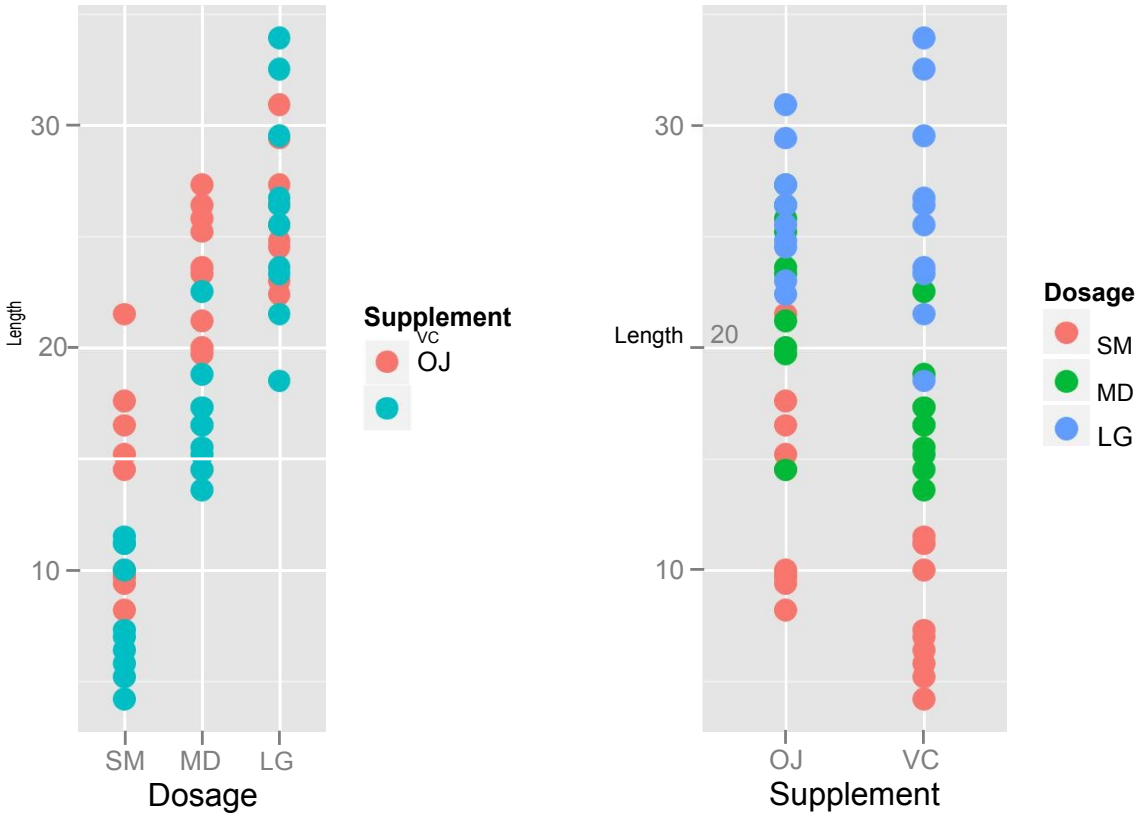
```
summary(dt)
```

```
##          Length          Supplement          Dose          Dosage
##   Min.         : 4.20   OJ:30          Min.         :0.500   SM:20
##      1st Qu.:13.07   VC:30             1st Qu.:0.500   MD:20
##   Median :19.25                      Median :1.000      LG:20
##   Mean         :18.81                Mean         :1.167
##      3rd Qu.:25.27                     3rd Qu.:2.000
##   Max.         :33.90                Max.         :2.000
```

```
str(dt)
```

```
## Classes 'data.table' and 'data.frame':   60                obs. of  4 variables:
##   $ Length        : num  15.2 21.5 17.6          9.7 14.5 10 8.2 9.4 16.5 9.7 ...
#    $ Supplement: Factor w/ 2 levels "OJ","VC": 1 1 1 1 1 1 1 1 1 1 ...
  ##  $ Dose            : num  0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5              0.5      0.5 ...
  ##  $ Dosage        : Factor w/ 3 levels "SM","MD","LG": 1            1 1    1 1 1 1      1 1 1 ...
#    - attr(*, ".internal.selfref")=<externalptr>
#    - attr(*, "sorted")= chr  "Supplement" "Dosage"
```

To further conduct the exploratory analysis, we can plot Length against both Dosage and Supplement. When we do this we see that the larger the Dosage, the longer the tooth Length. However, it is slightly unclear as to which supplement is more effective, Orange Juice OJ or Ascorbic Acid VC.



Confidence Interval Testing:

In order to understand Vitamin C's affect on tooth growth, we will conduct the following confidence interval testing scenarios:

- Dosage Alone
- Supplement Alone
- Supplement by Each Dosage

For each of the comparisons, we will subset dt appropriately and utilize the t.test R function to determine each scenarios confidence interval, subset means, and p-value.

```
t1<-subset(dt,Dosage=='SM')$Length t2<-
subset(dt,Dosage=='MD')$Length t<-
t.test(t1,t2,paired=FALSE,var.equal=FALSE)
t$conf.int[1:2]
```

Compare Dosage Alone

```
## [1] -11.983781  -6.276219
```

If we increase the Vitamin C dose from 0.5 to 1.0 milligrams, the confidence interval does not contain zero, so we can reject the null hypothesis that this dose increase does not increase tooth length.

```
t1<-subset(dt,Dosage=='MD')$Length t2<-
subset(dt,Dosage=='LG')$Length t<-
t.test(t1,t2,paired=FALSE,var.equal=FALSE)
t$conf.int[1:2]
```

[1] -8.996481 -3.733519

Next, if we increase the Vitamin C dose from 1.0 to 2.0 milligrams, the confidence interval againg does not contain zero, so we can reject the null hypothesis that this dose increase does not increase tooth length.
In both of these scenarios, an increased dose amount leads to an increased tooth length.

```
t1<-subset(dt,Supplement=='VC')$Length t2<-
subset(dt,Supplement=='OJ')$Length t<-
t.test(t1,t2,paired=FALSE,var.equal=FALSE)
t$p.value
```

Compare Supplement Alone

[1] 0.06063451

```
t$conf.int[1:2]
```

[1] -7.5710156 0.1710156

In this single comparison, the p-value is 0.061 and the confidence interval contains zero; so, here we do not reject the null hypothesis and conclude that the type of Vitamin C supplement alone does not affect tooth growth.

```
t1<-subset(dt,Supplement=='VC' & Dosage=='SM')$Length
t2<-subset(dt,Supplement=='OJ' & Dosage=='SM')$Length
t<-t.test(t1,t2,paired=FALSE,var.equal=FALSE) t$conf.int[1:2]
```

Compare Supplement by Each Dosage

[1] -8.780943 -1.719057

When we continue the analysis, and compare a ‘SM’ dosage of Ascorbic Acid to a’SM’ dosage of Orange Juice, we see the confidence interval does not contain zero, so we can reject the null hypothesis that supplement type with a ‘SM’ dosage does not affect tooth growth.

```
t1<-subset(dt,Supplement=='VC' & Dosage=='MD')$Length
t2<-subset(dt,Supplement=='OJ' & Dosage=='MD')$Length
t<-t.test(t1,t2,paired=FALSE,var.equal=FALSE) t$conf.int[1:2]
```

```
## [1] -9.057852 -2.802148
```

Next, we compare a 'MD' dosage of Ascorbic Acid to a 'MD' dosage of Orange Juice, and, again, we see the confidence interval does not contain zero; so, we can reject the null hypothesis that supplement type with a 'MD' dosage does not affect tooth growth.

```
t1<-subset(dt,Supplement=='VC' & Dosage=='LG')$Length
t2<-subset(dt,Supplement=='OJ' & Dosage=='LG')$Length t<-
t.test(t1,t2,paired=FALSE,var.equal=FALSE) t$p.value
```

```
#   [1]   0.9638516
```

```
t$conf.int[1:2]
```

```
#   [1] -3.63807  3.79807
```

Lastly, we compare a 'LG' dosage of Ascorbic Acid to a 'LG' dosage of Orange Juice; this time, however, we observer the confidence interval contains zero and there is a p-value of almost 1.0. In turn, we do not reject the null hypothesis that supplement type with a 'LG' dosage does not affect tooth growth. Meaning, with a 'LG' Dosage, we cannot conclude which supplement type has a greater affect on tooth growth.

Conclusions:

1. As Vitamin C dose size alone increases, the tooth length increases as well, and
2. Irrespective of dose size, supplement type alone does not affect tooth growth; however,
3. The supplement type of Orange Juice, or 'OJ', affects tooth length greater then Ascorbic Acid, or 'VC', with a 0.5 and 1.0 dose size, in turn,
4. When the dose size reached 2.0 milligrams, there is no difference between Orange Juice and Ascorbic Acid.

Assumptions:

1. The confidence intervals are assumed to not be paired, i.e. we are not comparing two different supplement types from individual guinea pig.
2. The samples are independent.
3. The distribution approximately is normal.
