Tooth Growth Analysis

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This is my Class Project for the Coursera Class of Statistical Inference, August 2014

Question B: Explore Tooth Growth Data

```
library(datasets);data(ToothGrowth);library(ggplot2)
data <- ToothGrowth

#load function to show 2 ggplots sode by side, from http://gettinggeneticsdone.blogspot.com/201
0/03/arrange-multiple-ggplot2-plots-in-same.html. I modified the function to allow for adding a
 common title at the top
require(grid)
vp.layout <- function(x, y) viewport(layout.pos.row=x, layout.pos.col=y)
arrange_ggplot2 <- function(..., nrow=NULL, ncol=NULL, as.table=FALSE) {
  dots <- list(...)
    n <- length(dots)
    if(is.null(nrow) & is.null(ncol)) { nrow = floor(n/2) ; ncol = ceiling(n/nrow)}
    if(is.null(nrow)) { nrow = ceiling(n/ncol)}
    if(is.null(ncol)) { ncol = ceiling(n/nrow)}
        ## NOTE see n2mfrow in grDevices for possible alternative
grid.newpage()
pushViewport(viewport(layout=grid.layout(nrow+1,ncol,heights = unit(c(0.5,5),"null")  ) ))
    ii.p <- 1
    for(ii.row in seq(1, nrow)){
    ii.table.row <- ii.row
    if(as.table) {ii.table.row <- nrow - ii.table.row + 1}
        for(ii.col in seq(1, ncol)){
            ii.table <- ii.p
            if(ii.p > n) break
            print(dots[[ii.table]], vp=vp.layout(ii.table.row+1, ii.col))
            ii.p <- ii.p + 1
        }
    }
}
```

```
ch1<-ggplot(data,aes(x=factor(dose),y=len,fill=factor(dose)))+geom_boxplot(notch=T,notchwidth =
 0.2)+theme_bw()
ch1 <- ch1+facet_wrap(~supp)+ theme(legend.position="none")+scale_x_discrete("Dosage in mg")+sc
ale_y_continuous("Length of Teeth")
ch2<-ggplot(data,aes(x=dose,y=len,color=supp,group=supp))+geom_point()+stat_smooth(method="lm",
alpha=0.1)
ch2 <-ch2+theme_bw()+theme(legend.justification=c(1,0),legend.position=c(1, 0))+scale_color_dis
crete("Supplement")
ch2<-ch2+scale_x_continuous("Dosage in mg")+scale_y_continuous("Length of Teeth")
```

```
library(dplyr);library(reshape2)

#Load function to ceate a markdown table, from http://www.r-bloggers.com/writing-papers-using-r
-markdown/
tableCat <- function(inFrame) {
     outText <- paste(names(inFrame), collapse = " | ")
     outText <- c(outText, paste(rep("---", ncol(inFrame)), collapse = " | "))
     invisible(apply(inFrame, 1, function(inRow) {
         outText <<- c(outText, paste(inRow, collapse = " | "))
     }))
     return(outText)
 }
```

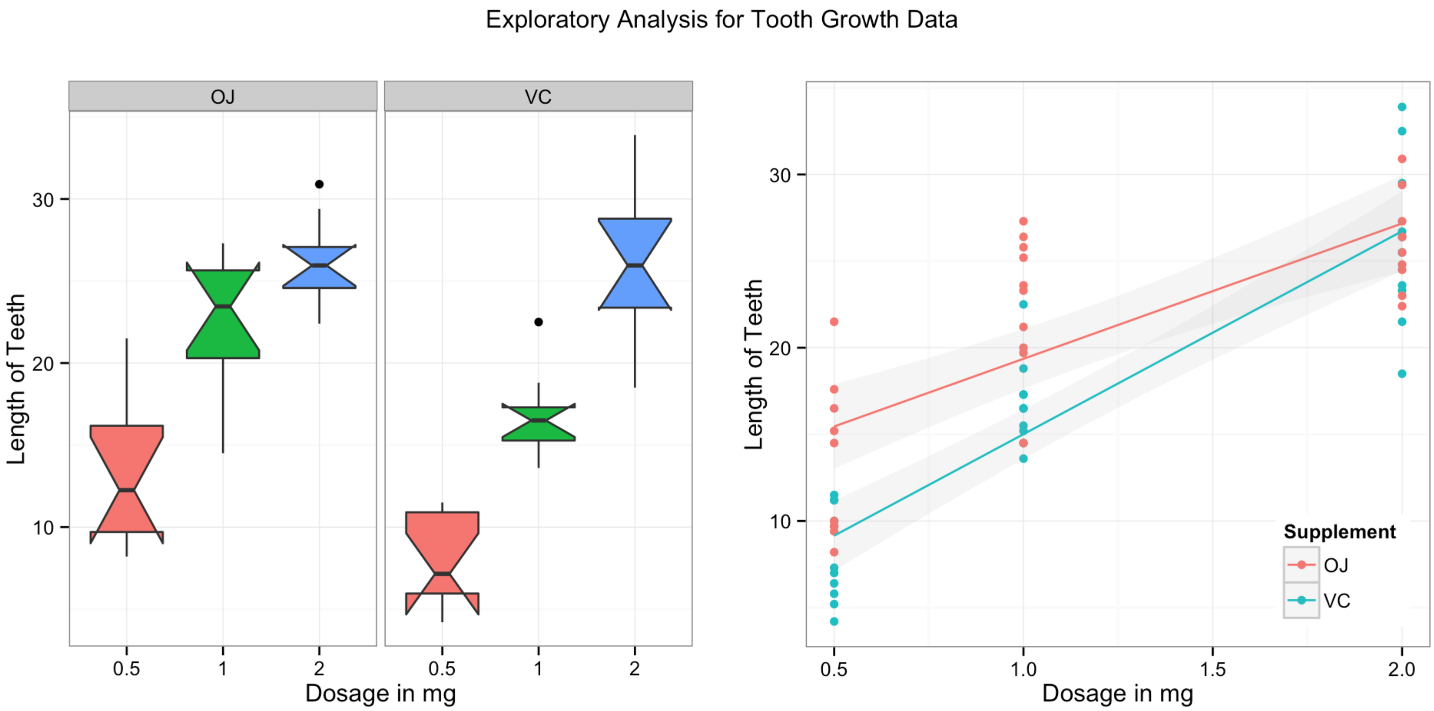
Summary of Tooth Growth Data and Exploratory Data Analysis

```
aux <- data %.% group_by(supp,dose) %.% summarise(Mean=mean(len),Min=min(len),Max=max(len),"Std
. Dev"=sd(len))
aux2<-dcast(melt(aux,id.vars=c("supp","dose")),dose~supp+variable,fun.aggregate=sum)
aux2<- round(aux2,2)
names(aux2)[1] <- "Dosage"
aux3<- tableCat(aux2)
#cat(aux3, sep = "\n") #this line generates the table, it is on a separate chunk with echo=F
```

Dosage	OJ_Mean	OJ_Min	OJ_Max	OJ_Std. Dev	VC_Mean	VC_Min	VC_Max	VC_Std. Dev
0.5	13.23	8.2	21.5	4.46	7.98	4.2	11.5	2.75
1	22.7	14.5	27.3	3.91	16.77	13.6	22.5	2.52
2	26.06	22.4	30.9	2.66	26.14	18.5	33.9	4.8

The table above shows some sumamry statistics for the Tooth Growth data. It suggest that orange juice is more effective at lower dosages but that bth supplements are similalry effective at the 2mg dose. It also suugests that Vitamon C has less variability in results for lower doses and more for the higher dose

```
arrange_ggplot2(ch1,ch2)
grid.text("Exploratory Analysis for Tooth Growth Data", vp = viewport(layout.pos.row = 1, layou
t.pos.col = 1:2))
```



The figure above shows the impact of the supplement and the dosage on the length of teeth of Guinea Pigs. The left panel shows the distributions (in boxplots) for the different combinations of supplement and dosage, the fact that the boxplot notched do not overlap is strong evidence that their medians are different and if we assume normality which is logical for bilogical patterns like growth that the means are different (as the median is the same as the mean for a noral distribution) The right panel shows a scatter plot of the data with linear regression fits of teeth length as a function of dosage for each supplement. Both Panels show that higher dosages appears to be related to longer teeth (however there appears there may be some diminishig returns for larger doeses of orange juice). It is also possible to see that fr dosage of 0.5 and 1 mg, orange Juice appears to be far superior, whereas Vitamin C could potentially lead to longer teeth at the 2mg dose.

Compare Peformance and Dosage

- Is Orange Juice more effective than Vitamin C?

```
t.test(len~supp,paired=F,var.equal=T,data=data,alternative="g")
t.test(len~supp,paired=F,var.equal=F,data=data,alternative="g")
```

```
##
##  Two Sample t-test
##
## data:  len by supp
## t = 1.915, df = 58, p-value = 0.0302
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.4708    Inf
## sample estimates:
## mean in group OJ mean in group VC
##            20.66            16.96
```

```
##
##  Welch Two Sample t-test
##
## data:  len by supp
## t = 1.915, df = 55.31, p-value = 0.03032
## alternative hypothesis: true difference in means is greater than 0
## 95 percent confidence interval:
##  0.4683    Inf
## sample estimates:
## mean in group OJ mean in group VC
##            20.66            16.96
```

It appears from performing t-test (either with equal or unequal variance) that overall orange juice had a greater impact on tooth growth than Vitamin C as the confidence intervals do not contain zero

- Does Dosage Matter?

```
results = data.frame(supplement=character(),dose_1=numeric(),dose_2=numeric(),ll=numeric(),
                     ul=numeric(),pval=numeric(),variance_equal=logical(),test=character(),stri
ngsAsFactors=F)
k=1
for (i in levels(data$supp)) {
  for (j in unique(data$dose)) {
    for (test in c("greater","less")) {
      for (variance in c(T,F)) {
        data1 <- subset(data,supp==i & dose!=j)
        temp <- t.test(len~dose,paired=F,var.equal=variance,data=data1,alternative=test)
        results[k,"supplement"] <- i; results[k,"dose_1"] <- unique(data1$dose)[1];
        results[k,"dose_2"] <- unique(data1$dose)[2]; results[k,"ll"] <- temp$conf.int[1]
        results[k,"ul"] <- temp$conf.int[2]; results[k,"pval"] <- temp$p.value
        results[k,"variance_equal"] <- variance; results[k,"test"] <- test
        k <- k+1
      }
    }
  }
}

results$outcome <- ifelse(results$pval<=0.05,"Difference","No Difference")
results[4:6] <- round(results[4:6],3)
results2 <- subset(results,outcome=="Difference")
results3 <- tableCat(results2)
#cat(results3, sep = "\n") #this line generates the table, it is on a separate chunk with echo=
F
```

supplement	dose_1	dose_2	ll	ul	pval	variance_equal	test	outcome
OJ	1.0	2	-Inf	-0.768	0.019	TRUE	less	Difference
OJ	1.0	2	-Inf	-0.749	0.020	FALSE	less	Difference
OJ	0.5	2	-Inf	-9.984	0.000	TRUE	less	Difference
OJ	0.5	2	-Inf	-9.948	0.000	FALSE	less	Difference
OJ	0.5	1	-Inf	-6.217	0.000	TRUE	less	Difference
OJ	0.5	1	-Inf	-6.214	0.000	FALSE	less	Difference
VC	1.0	2	-Inf	-6.399	0.000	TRUE	less	Difference
VC	1.0	2	-Inf	-6.347	0.000	FALSE	less	Difference
VC	0.5	2	-Inf	-15.129	0.000	TRUE	less	Difference
VC	0.5	2	-Inf	-15.086	0.000	FALSE	less	Difference
VC	0.5	1	-Inf	-6.748	0.000	TRUE	less	Difference
VC	0.5	1	-Inf	-6.747	0.000	FALSE	less	Difference

The table above shows the dosage comparisons for each supplement for which a statistical difference at 95% was observed. It shows that higher dosages are more effective that lower dosages for either supplement.

- Which Supplement is Better at a Given Dosage?

```
results_a = data.frame(dose=numeric(),supplement1=character(),supplement2=character(),ll=numeri
c(),
                     ul=numeric(),pval=numeric(),variance_equal=logical(),test=character(),stri
ngsAsFactors=F)
k=1
for (j in unique(data$dose)) {
    for (test in c("greater","less")) {
      for (variance in c(T,F)) {
        data1 <- subset(data, dose==j)
        temp <- t.test(len~supp,paired=F,var.equal=variance,data=data1,alternative=test)
        results_a[k,"supplement1"] <- levels(data1$supp)[1]; results_a[k,"supplement2"] <- leve
ls(data1$supp)[2]
        results_a[k,"dose"] <- j; results_a[k,"ll"] <- temp$conf.int[1]
        results_a[k,"ul"] <- temp$conf.int[2]; results_a[k,"pval"] <- temp$p.value
        results_a[k,"variance_equal"] <- variance; results_a[k,"test"] <- test
        k <- k+1
      }
    }
}

results_a$outcome <- ifelse(results_a$pval<=0.05,"Difference","No Difference")
results_a[4:6] <- round(results_a[4:6],3)
results_a2 <- subset(results_a,outcome=="Difference")
results_a3 <- tableCat(results_a2)
#cat(results_a3, sep = "\n") #this line generates the table, it is on a separate chunk with ech
o=F
```

dose	supplement1	supplement2	ll	ul	pval	variance_equal	test	outcome
0.5	OJ	VC	2.378	Inf	0.003	TRUE	greater	Difference
0.5	OJ	VC	2.346	Inf	0.003	FALSE	greater	Difference
1.0	OJ	VC	3.380	Inf	0.000	TRUE	greater	Difference
1.0	OJ	VC	3.356	Inf	0.001	FALSE	greater	Difference

The table above shows the supplement comparisons for each dosage for which a statistical difference at 95% was observed. It shows that orange juice is more effective at 0.5 and 1 mg but that both supplements are equally effecive at 2mg.

- Which Dosage is Better?

```
results_b = data.frame(dose1=numeric(),dose2=numeric(),ll=numeric(),ul=numeric(),pval=numeric()
,
                       variance_equal=logical(),test=character(),stringsAsFactors=F)
k=1
for (j in unique(data$dose)) {
    for (test in c("greater","less")) {
      for (variance in c(T,F)) {
        data1 <- subset(data, dose!=j)
        temp <- t.test(len~dose,paired=F,var.equal=variance,data=data1,alternative=test)
        results_b[k,"dose1"] <- unique(data1$dose)[1]; results_b[k,"dose2"] <- unique(data1$dos
e)[2]
        results_b[k,"ll"] <- temp$conf.int[1]; results_b[k,"ul"] <- temp$conf.int[2];
        results_b[k,"pval"] <- temp$p.value
        results_b[k,"variance_equal"] <- variance; results_b[k,"test"] <- test
        k <- k+1
      }
    }
}

results_b$outcome <- ifelse(results_b$pval<=0.05,"Difference","No Difference")
results_b[3:5] <- round(results_b[3:5],3)
results_b$difference <- ifelse(results_b$outcome=="Difference",T,F)
results_b2 <- subset(results_b,outcome=="Difference")
results_b3 <- tableCat(results_b2)
#cat(results_b3, sep = "\n") #this line generates the table, it is on a separate chunk with ech
o=F
```

dose1	dose2	ll	ul	pval	variance_equal	test	outcome	difference
1.0	2	-Inf	-4.175	0	TRUE	less	Difference	TRUE
1.0	2	-Inf	-4.174	0	FALSE	less	Difference	TRUE
0.5	2	-Inf	-13.281	0	TRUE	less	Difference	TRUE
0.5	2	-Inf	-13.279	0	FALSE	less	Difference	TRUE
0.5	1	-Inf	-6.753	0	TRUE	less	Difference	TRUE
0.5	1	-Inf	-6.753	0	FALSE	less	Difference	TRUE

The table above shows the comparisons across supplements for each dosage for which a statistical difference at 95% was observed. It shows that 2mg is superior.