Research of confidence intervals in effect of Vitamin C supplement on guinea pig tooth growth

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Overview

Confidence intervals in ToothGrowth dataset show that Vitamin C supplement does indeed increase length of guinea pigs' tooth.

Basic exploratory data analyses

```
data(ToothGrowth)
# ?ToothGrowth
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
```

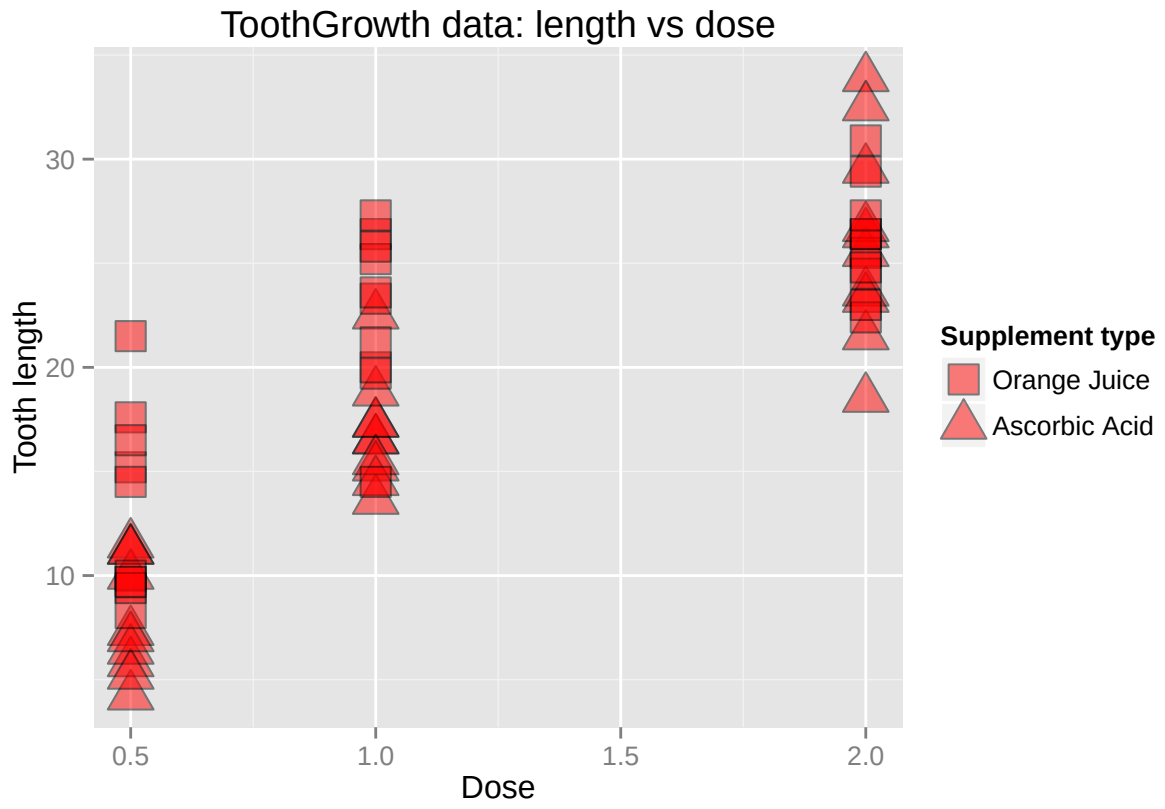
```
summary(ToothGrowth)
```

```
##       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
```

```
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 ...
```

```
print(ggplot(data=ToothGrowth, aes(x=dose, y=len, shape=supp)) +
              xlab("Dose") +
              ylab("Tooth length") +
       ggtitle("ToothGrowth data: length vs dose") +
       geom_point(size=6, alpha=0.5, fill="red") + #guides(shape=FALSE) +
         scale_shape_manual(values=c(22, 24),
                            name="Supplement type",
                         breaks=c("OJ", "VC"),
                         labels=c("Orange Juice", "Ascorbic Acid"))
               )
```



ToothGrowth dataset describes response in the length of teeth of 10 guinea pigs treated with Vitamin C. There are six groups produced for three dose levels (0.5, 1 and 2 mg) and two supplement delivery methods (orange juice and ascorbic acid).

There were six groups of the animals: 10 guinea pigs at each of three dose levels of Vitamin C (0.5, 1, and 2 mg) with each of two delivery methods (orange juice or ascorbic acid).

Confidence intervals

Intuitive interpretation of the data on the chart is that supplement does affects tooth length, but delivery type efficiency depends on dose. Let's check this intuitive interpretations by calculating confidence intervals.

Length per dose

Visually we see that teeth length significantly higher for each level of supplement dose. This is our assumption. Let's calculate confidence intervals to see if it is indeed so, and intuitive comprehension of the chart doesn't trick us.

It's not completely clear if 10 guinea pigs described in the help page for ToothGrowth dataset are the same animals in each of groups, or different ones. Even if they are the same, there's no clear indication in the dataset of particular rodents, so we are going to treat them as if they were different, and data points aren't paired. If we will still see that changes are signigicant, then it will be true even if pigs were the same and data points paired, because paired data is less variable, and less confidence intervals are narrower.

We calculate confidence intervals for tooth length change for four pair of groups: dose change from 0.5 to 1 and dose change from 1 to 2 - for each type of supplement. Notice that t.test()'s default value for paired is FALSE, and this is what we want. We also presume that variability in groups isn't equal and this is also the default setting for the t test.

```
CheckIntervalByDose <- function(before,after,supp) {
      if(missing(supp)) suppC <- TRUE else suppC <- ToothGrowth$supp == supp
      t.test(ToothGrowth$len[ToothGrowth$dose == after & suppC],
       ToothGrowth$len[ToothGrowth$dose == before & suppC]
       )$conf.int
}

CheckIntervalByDose(0.5, 1, "OJ")
```

```
## [1]  5.524366 13.415634
## attr(,"conf.level")
## [1] 0.95
```

```
CheckIntervalByDose(1,   2, "OJ")
```

```
## [1] 0.1885575 6.5314425
## attr(,"conf.level")
## [1] 0.95
```

```r
CheckIntervalByDose(0.5, 1, "VC")
```

```
## [1]  6.314288 11.265712
## attr(,"conf.level")
## [1] 0.95
```

```r
CheckIntervalByDose(1,   2, "VC")
```

```
## [1]  5.685733 13.054267
## attr(,"conf.level")
## [1] 0.95
```

We see that the confidence intervals lie entirely above zero in every case, so it's clear that increasing the dosage of the supplement does indeed increase tooth length in guinea pigs with 95% confidence level.

Now, it probably wouldn't make much sense for a real research to lose information we have about the experiment and ignore supplement delivery type, but just for the training purposes, let's see if the result changes when we do that.

```r
CheckIntervalByDose(0.5, 1)
```

```
## [1]  6.276219 11.983781
## attr(,"conf.level")
## [1] 0.95
```

```r
CheckIntervalByDose(1,   2)
```

```
## [1] 3.733519 8.996481
## attr(,"conf.level")
## [1] 0.95
```

Intervals are still entirely above zero, and the distances aren't dramatically different than before - it's probably because increased variability was compensated by having twice as much data points, and having more points increases confidence.

Result

Assuming data is normally distributed, and using t distribution for safer approximation for small given number of observations, the confidence interval show that that change in teeth length is statistically significant for each level of dose increase, both with separate analysis of two different delivery ways, and mixed as well. Given this, we can say that vitamin C supplements do indeed increase tooth length in guinea pigs.