# Statistical Inference Course Project Part Two: Data Analysis

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## Overview

We will explore the effects of vitamin supplementation on guinea pig tooth growth. Supplementation is provided either by ascorbic acid (VC) or by orange juice (OJ). Three dosage levels were applied: 0.5 mg/day, 1 mg/day, 2 mg/day. Subseqeunt tooth length is given in unspecified units.

## Examining The Data

We load in the data and acquaint ourselves with its basic details.

```
library(datasets)
data("ToothGrowth")
```

Let us look at aggregate summary data to determine how supplement and dose might affect tooth length.

```
aggregate(len ~ supp + dose, data = ToothGrowth, mean)
```

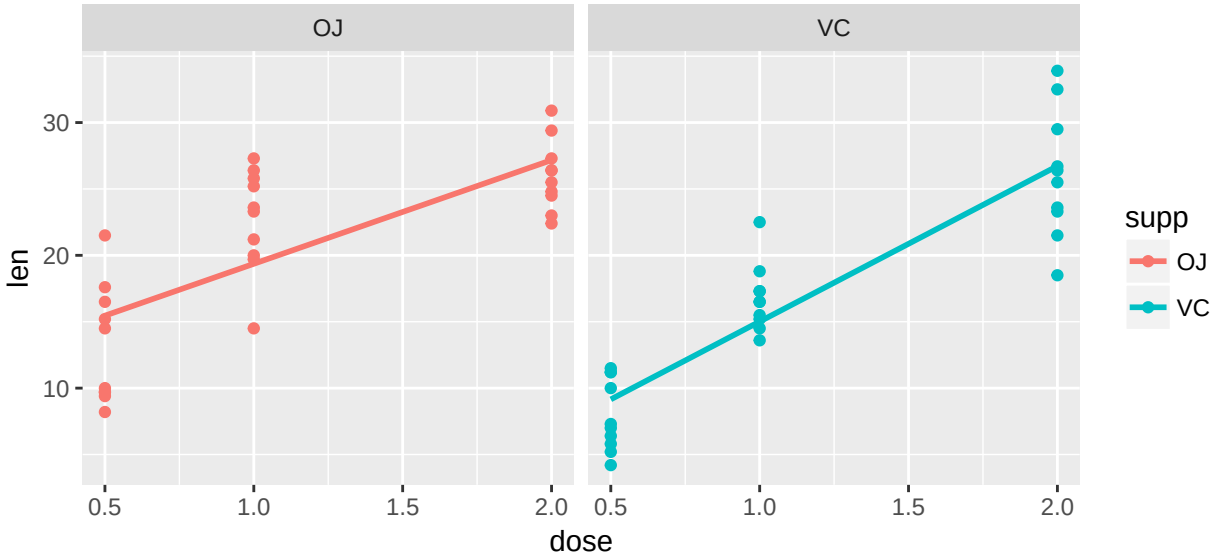
```
##   supp dose   len
## 1   OJ  0.5 13.23
## 2   VC  0.5  7.98
## 3   OJ  1.0 22.70
## 4   VC  1.0 16.77
## 5   OJ  2.0 26.06
## 6   VC  2.0 26.14
```

The data suggest that tooth growth is dose-dependent, and for lower doses, orange juice is superior to ascorbic acid. This effect decreases as dose increases. Let us visualize the data to see if it strengthens this hypothesis.

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.4.1
```

```
ggplot(ToothGrowth,
       aes(x = dose, y = len)) +
  geom_point(aes(col = supp)) +
  geom_smooth(aes(col = supp),
              method = "lm",
              se = FALSE) +
  facet_wrap(~supp, nrow = 1)
```




Indeed, we see that both regression lines terminate at a similar value for dose 2 mg/day, but the line for ascorbic acid is steeper. Let us test these hypotheses.

## Hypothesis Testing

Null hypotheses: tooth growth does not vary with changes in dose or between supplements.

### Dose Dependency

#### OJ

Alternative hypothesis: greater dose elicits greater tooth growth.

```
oj.halfmg <- with(ToothGrowth, len[supp == "OJ" & dose == 0.5])
oj.onemg <- with(ToothGrowth, len[supp == "OJ" & dose == 1.0])
t.test(oj.onemg, oj.halfmg, alternative = "greater")$p.value
```

```
## [1] 4.39246e-05
```

```
oj.twomg <- with(ToothGrowth, len[supp == "OJ" & dose == 2.0])
t.test(oj.twomg, oj.onemg, alternative = "greater")$p.value
```

```
## [1] 0.01959757
```

For p = .05, the null hypothesis is rejected. 1 mg/day elicits greater growth than 0.5 mg/day; 2 mg/day elicits greater growth than 1 mg/day.

#### VC

Alternative hypothesis: greater dose elicits greater tooth growth.

```
vc.halfmg <- with(ToothGrowth, len[supp == "VC" & dose == 0.5])
vc.onemg <- with(ToothGrowth, len[supp == "VC" & dose == 1.0])
t.test(vc.onemg, vc.halfmg, alternative = "greater")$p.value
```

```
## [1] 3.405509e-07
```

```r
vc.twomg <- with(ToothGrowth, len[supp == "VC" & dose == 2.0])
t.test(vc.twomg, vc.onemg, alternative = "greater")$p.value
```

```
## [1] 4.577802e-05
```

For p = .05, the null hypothesis is rejected. 1 mg/day elicits greater growth than 0.5 mg/day; 2 mg/day elicits greater growth than 1 mg/day.

#### Conclusion

Supplement dose correlates strongly with tooth growth. An increase in supplementation level, regardless of the supplement, corresponds to greater tooth growth, $p < .05$.

### Supplement Choice

#### OJ vs. VC, 0.5 mg/day

Alternative hypothesis: OJ elicits greater tooth growth than VC.

```r
t.test(oj.halfmg, vc.halfmg, alternative = "greater")$p.value
```

```
## [1] 0.003179303
```

```r
t.test(oj.onemg, vc.onemg, alternative = "greater")$p.value
```

```
## [1] 0.0005191879
```

```r
t.test(oj.twomg, vc.twomg, alternative = "greater")$p.value
```

```
## [1] 0.5180742
```

For p = .05 and dose 0.5 mg/day or 1 mg/day, we reject the null hypothesis. For dose 2 mg/day, we fail to reject the null hypothesis.

Let us see if there is any detectable difference in mean between the two supplements at 2 mg/day, with a two-sided T-test.

```r
t.test(oj.twomg, vc.twomg, alternative = "two.sided")$p.value
```

```
## [1] 0.9638516
```

Again, for p = .05 or for any reasonable p-value, we fail to reject the null hypothesis.

#### Conclusion

For the two smaller dosages, OJ elicits greater tooth growth than VC ($p < .05$). For a dose of 2 mg/day, there is no difference between supplements.

## Summary

Tooth growth increases as supplement growth increases. For a dose of 0.5 mg/day or 1 mg/day, orange juice results in greater tooth growth than ascorbic acid, however at a dose of 2 mg/day the tooth growth between supplements is identical.

We assume that the data are independent and identically distributed.