Analyzing Guinea Pig Tooth Growth Data

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December 27, 2015

Overview

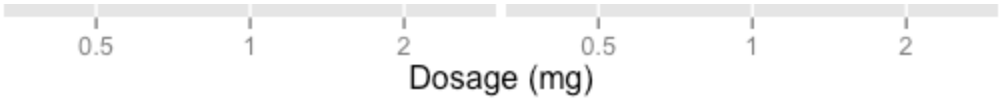
Does delivery method and/or dosage of vitamin C affect tooth growth in guinea pigs? In this paper we will reviews R's 'ToothGrowth' dataset and performs the appropriate analysis to answer this question and identify the method and dosage, if any, that maximizes tooth growth.

Data Summary

```
# load the Guinea Pig Tooth Growth data
data(ToothGrowth)
tg <- mutate(ToothGrowth, doseF = factor(dose), pig = 1:60)
```

The 'ToothGrowth' dataset included in R is the results of giving 60 guinea pigs dosages of vitamin C and measuring the resultant tooth growth. The dosages were 0.5, 1.0, and 2.0 milligrams per day and was delivered either via orange juice or asorbic acid. The guinea pigs were separated into six groups of ten and each group was given the vitamin C in the same dosage and delivery method.

```
gp <- ggplot(tg, aes(x = doseF, y = len, fill = supp))
gp <- gp + geom_boxplot()
gp <- gp + facet_grid(. ~ supp)
gp <- gp + labs(title = "Figure 1: Guinea Pig Tooth Length by Dosage and Delivery Method",
                x = "Dosage (mg)", y = "Tooth Length (mm)")
gp <- gp + guides(fill = guide_legend(title = "Supplement Type"))
gp
```



Looking at the summary data, we can observe a general trend of increasing tooth length with a dosage increase regardless of delivery method as shown in each set of box plots. It is not immediately obvious if the delivery method makes a difference. Below we will examine the differences with dosage and delivery method.

Analysis

These analysis are based on the following assumptions. First, we are assuming that the data are independent and identically distributed (iid) values. We will also assume that the data distributions are not skewed; reviewing the data in the plot above doesn't suggest that the data is order of magnatudes different where we would want to pursue a logirithmic approach. The analysis also assumes that the variances between the different data groups is equal.

```
# Compare the delivery method for 0.5 dosages
test1 <- subset(tg, doseF %in% (0.5))
r1 <- t.test(len ~ supp, data=test1, paired=FALSE, var.equal=TRUE)
```

For our first test, we will see if there is a difference in delivery method at the 0.5 mg daily dosage. The t-test above tests the null hypothesis, that the means for both delivery methods are the same with a 95% confidence level. In order for us to reject the hypothesis in favor of the alternative hypothesis the confidence interval must include the number zero. For this test, the range is 1.77 to 8.73. The p.value for t.test tells how unusual it is to get a different result given the data and the confidence level. For this test, the p.value is 0.0053. Based on these test results, we can say with a high likelihood that the means are different which implies the delivery method of orange juice has a greater impact on guinea pig tooth length than the asorbic acid supplement.

```
# Compare the delivery method for 1 mg dosages
test2 <- subset(tg, doseF %in% (1))
r2 <- t.test(len ~ supp, data=test2, paired=FALSE, var.equal=TRUE)
```

Like the first test, we will see if there is a difference in delivery methods, but at the 1 mg daily dosage. Based on our test above, we find the at the 95% confidence level that the range is 2.841 to 9.019 with a p-value of 7.810^{-4}. These suggest there is high likelihood that the means are different, even more than at the 0.5 mg dosage.

```
# Compare the delivery method for 1 mg dosages
test3 <- subset(tg, doseF %in% (2))
r3 <- t.test(len ~ supp, data=test3, paired=FALSE, var.equal=TRUE)
```

For the third test, we will see if there is a difference in delivery methods at the 2 mg daily dosage. Based on our test above, we find the 95% confidence interval is -3.723 to 3.563 and the test's p-value is 0.96371. Because the confidence interval includes the value zero and the p-value is very close to one, this suggests there is high likelihood that the means are the same, meaning that the differences that we saw at the 0.5 mg and 1.0 mg dosages no longer applies at the 2.0 mg daily dosage.

Conclusion

Based on the findings above, we can state that the increase in dosage does have an impact on guinea pig tooth growth regardless of delivery method. The analysis also supports the finding that for dosages up to a 2 milligram per day, the orange juice delivery method promotes more tooth growth. At 2 mg/day, however, there is no statistical difference between delivery by orange juice or asorbic acid.

Appendix

A summary of the tooth growth data can be found at https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/ToothGrowth.html (https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/ToothGrowth.html). See also https://bugs.r-project.org/bugzilla3/show_bug.cgi?id=15953 (https://bugs.r-project.org/bugzilla3/show_bug.cgi?id=15953) for additional details on the data set.

This analysis was run with the following configuration.

```
library(devtools)
devtools::session_info() # display environment the script was create and run in.
```

```
## Session info -------------------------------------------------------------
```

```
##  setting  value
##  version  R version 3.1.2 (2014-10-31)
##  system   x86_64, darwin10.8.0
##  ui       X11
##  language (EN)
##  collate  en_US.UTF-8
##  tz       America/Denver
```

```
## Packages -----------------------------------------------------------------
```

```
##  package    * version  date       source
##  assertthat   0.1      2013-12-06 CRAN (R 3.1.0)
##  colorspace   1.2-4    2013-09-30 CRAN (R 3.1.0)
##  DBI          0.3.1    2014-09-24 CRAN (R 3.1.1)
##  devtools   * 1.8.0    2015-05-09 CRAN (R 3.1.3)
##  digest       0.6.4    2013-12-03 CRAN (R 3.1.0)
##  dplyr      * 0.4.1    2015-01-14 CRAN (R 3.1.2)
##  evaluate     0.5.5    2014-04-29 CRAN (R 3.1.0)
##  formatR      1.0      2014-08-25 CRAN (R 3.1.1)
##  ggplot2    * 1.0.0    2014-05-21 CRAN (R 3.1.0)
##  git2r        0.10.1   2015-05-07 CRAN (R 3.1.3)
##  gtable       0.1.2    2012-12-05 CRAN (R 3.1.0)
##  htmltools    0.2.6    2014-09-08 CRAN (R 3.1.1)
##  knitr        1.8      2014-11-11 CRAN (R 3.1.2)
##  labeling     0.3      2014-08-23 CRAN (R 3.1.1)
##  lazyeval     0.1.10   2015-01-02 CRAN (R 3.1.2)
##  magrittr     1.5      2014-11-22 CRAN (R 3.1.2)
##  MASS         7.3-35   2014-09-30 CRAN (R 3.1.2)
##  memoise      0.2.1    2014-04-22 CRAN (R 3.1.0)
##  munsell      0.4.2    2013-07-11 CRAN (R 3.1.0)
##  plyr         1.8.1    2014-02-26 CRAN (R 3.1.0)
##  proto        0.3-10   2012-12-22 CRAN (R 3.1.0)
##  Rcpp         0.11.3   2014-09-29 CRAN (R 3.1.1)
##  RCurl        1.95-4.3 2014-07-29 CRAN (R 3.1.1)
##  reshape2     1.4.1    2014-12-06 CRAN (R 3.1.2)
##  rmarkdown    0.3.10   2015-01-18 Github (rstudio/rmarkdown@b96214b)
##  rversions    1.0.0    2015-04-22 CRAN (R 3.1.3)
##  scales       0.2.4    2014-04-22 CRAN (R 3.1.0)
##  stringr      0.6.2    2012-12-06 CRAN (R 3.1.0)
##  XML          3.98-1.1 2013-06-20 CRAN (R 3.1.0)
##  yaml         2.1.13   2014-06-12 CRAN (R 3.1.0)
```