IS5 in R: Understanding and Comparing Distributions (Chapter 4)

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Introduction and background

This document is intended to help describe how to undertake analyses introduced as examples in the Fifth Edition of *Intro Stats* (2018) by De Veaux, Velleman, and Bock. More information about the book can be found at http://wps.aw.com/aw_deveaux_stats_series. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at http://nhorton.people.amherst.edu/is5.

This work leverages initiatives undertaken by Project MOSAIC (http://www.mosaic-web.org), an NSF-funded effort to improve the teaching of statistics, calculus, science and computing in the undergraduate curriculum. In particular, we utilize the `mosaic` package, which was written to simplify the use of R for introductory statistics courses. A short summary of the R needed to teach introductory statistics can be found in the mosaic package vignettes (http://cran.r-project.org/web/packages/mosaic). A paper describing the mosaic approach was published in the *R Journal*: https://journal.r-project.org/archive/2017/RJ-2017-024.

Chapter 4: Understanding and Comparing Distributions

```r
library(mosaic)
library(readr)
library(janitor)
HopkinsForest <- read_csv("http://nhorton.people.amherst.edu/is5/data/Hopkins_Forest.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Date = col_character(),
##   Year = col_integer(),
##   Month = col_integer(),
##   Day = col_integer(),
##   `Day of Year` = col_integer(),
##   `Max Sol Rad (w/m^2)` = col_integer(),
##   `Min Sol Rad (w/m^2)` = col_integer(),
##   `Total Sol Rad (w/m^2)` = col_integer(),
##   `Min Wind (mph)` = col_integer(),
##   `Max Barom (mb)` = col_integer(),
##   `Min Barom (mb)` = col_integer()
## )
```

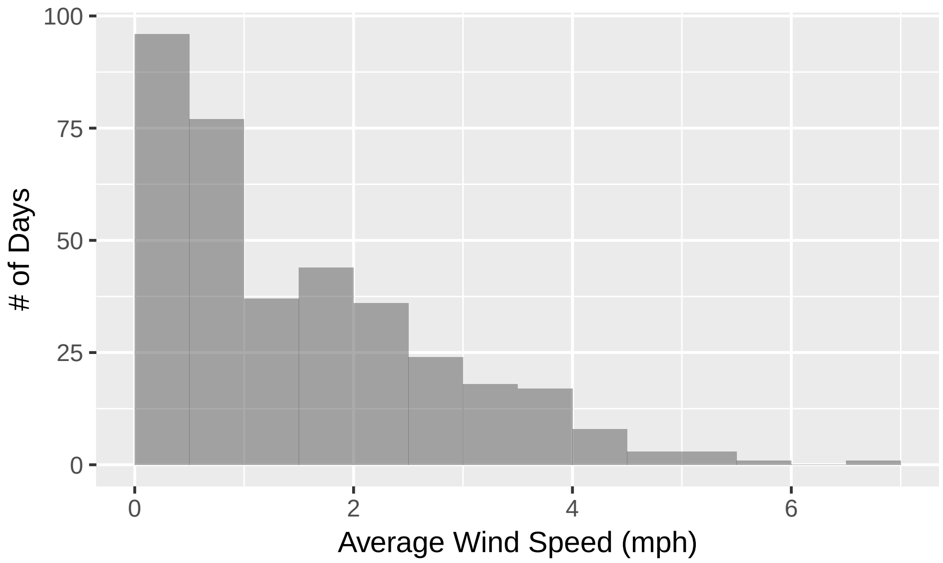
```
## See spec(...) for full column specifications.
```

```r
names(HopkinsForest)
```

```
##  [1] "date"                 "year"                 "month"
##  [4] "day"                  "day_of_year"          "avg_temp_c"
##  [7] "max_temp_c"           "min_temp_c"           "avg_temp_f"
## [10] "max_temp_f"          "min_temp_f"          "avg_rel_hum_percent"
## [13] "max_rel_hum_percent" "min_rel_hum_percent" "avg_sol_rad_w_m_2"
## [16] "max_sol_rad_w_m_2"   "min_sol_rad_w_m_2"   "total_sol_rad_w_m_2"
## [19] "avg_wind_mph"        "max_wind_mph"        "min_wind_mph"
## [22] "avg_barom_mb"        "max_barom_mb"        "min_barom_mb"
## [25] "precip_in"           "deep_well_ft"        "shallow_well_ft"
## [28] "x80_cm_soil_c"       "x10_cm_soil_c"
```

By default, `read_csv()` prints the variable names. These messages can be suppressed using the `message = FALSE` code chunk option to save space and improve readability.
Here we use the `clean_names()` function from the `janitor` package to sanitize the names of the columns (which would otherwise contain special characters or whitespace). You can use the `names()` function to check the cleaned names.

```
# Figure 4.1, page 96
gf_histogram(~ avg_wind_mph, data = HopkinsForest,
             xlab = "Average Wind Speed (mph)", ylab = "# of Days", binwidth = 0.5, center = 0.25)
```



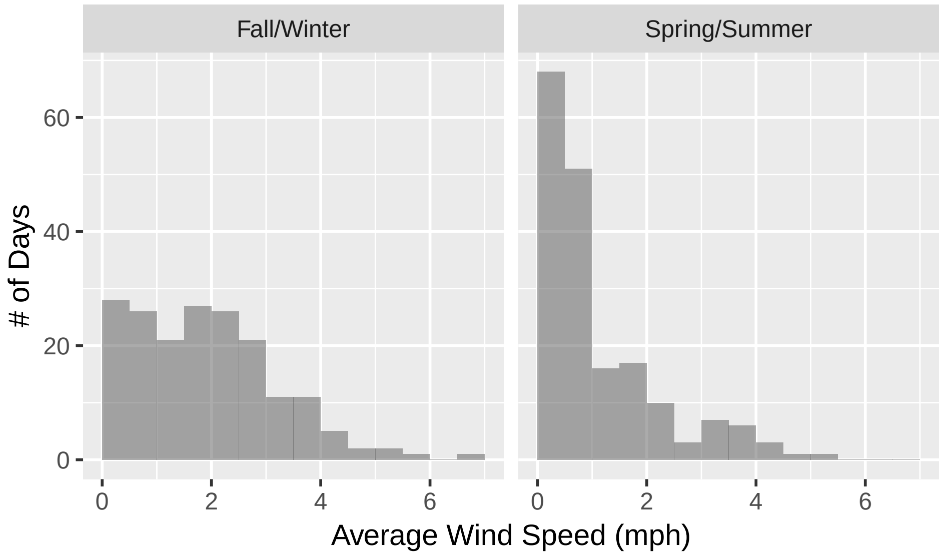
```
favstats(~ avg_wind_mph, data = HopkinsForest)
```

```
##  min   Q1 median   Q3  max     mean       sd   n missing
##    0 0.46   1.12 2.28 6.73 1.507808 1.260161 365       0
```

Section 4.1: Displays for Comparing Groups

Histograms

```
HopkinsForest <- HopkinsForest %>%
  mutate(catmonth = ifelse(month <= 9 & month >= 4, "Spring/Summer", "Fall/Winter"))
# Figure 4.2, page 96
gf_histogram(~ avg_wind_mph, data = HopkinsForest, binwidth = 0.5, center = 0.25,
             xlab = "Average Wind Speed (mph)", y = "# of Days") %>%
  gf_facet_wrap(~ catmonth)
```



```
favstats(avg_wind_mph ~ catmonth, data = HopkinsForest)
```

```
##        catmonth  min   Q1 median     Q3  max     mean       sd   n missing
## 1   Fall/Winter 0.02 0.84   1.72 2.6575 6.73 1.904176 1.287233 182       0
## 2 Spring/Summer 0.00 0.35   0.71 1.6150 5.47 1.113607 1.102176 183       0
```

Example 4.1: Comparing Groups with Stem-And-Leaf

```
# Figure 4.1, page 97
NestEgg <- read_csv("http://nhorton.people.amherst.edu/is5/data/Nest_Egg_Index.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   State = col_character(),
##   Nest.Egg.Index = col_double(),
##   Region = col_character()
## )
```

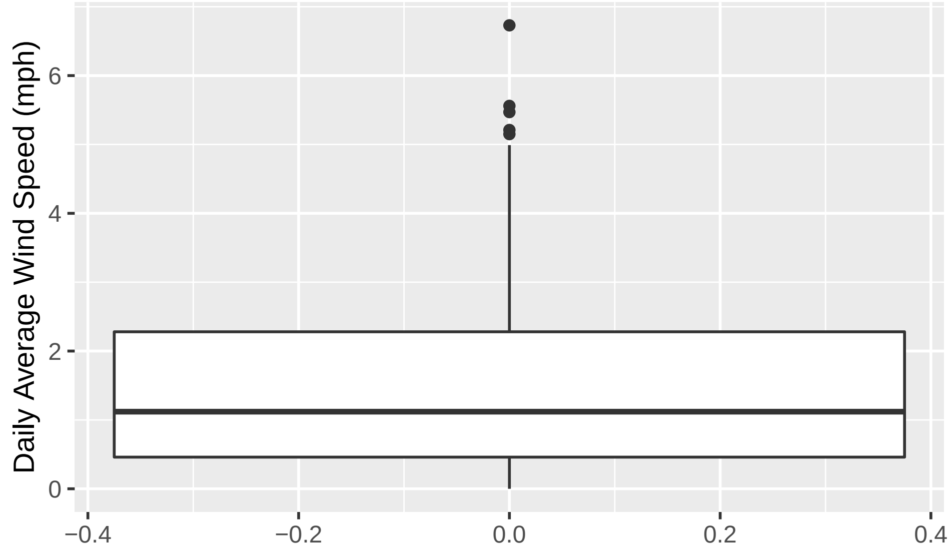
```
with(NestEgg, stem(nest_egg_index))
```

```
##
##   The decimal point is 1 digit(s) to the right of the |
##
##    8 | 57789
##    9 | 0123344
##    9 | 667777888899
##   10 | 0012233333344
##   10 | 5566779
##   11 | 122444
```

Boxplots

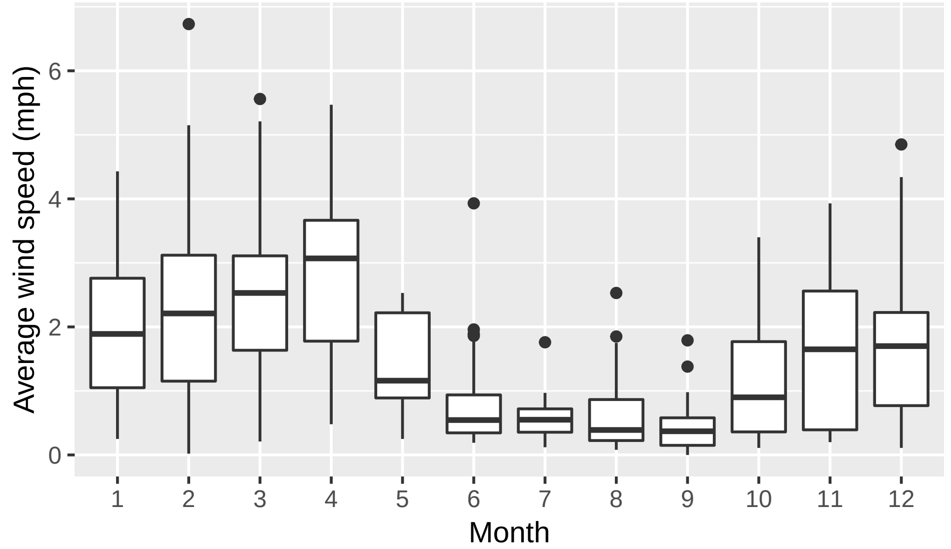
As noted in the book, boxplots are most useful to compare distributions. Below, we have replicated the single boxplot from page 98, but we don't recommend the use of single boxplots.

```
# Step 4 on page 98
gf_boxplot(~ avg_wind_mph, data = HopkinsForest, y = "Daily Average Wind Speed (mph)")  # or gf_boxplot
```



Instead, we can make comparisons more easily by placing boxplots side by side with the following code:

```
# Figure 4.3, page 99
gf_boxplot(avg_wind_mph ~ as.factor(month), data = HopkinsForest) %>%
  gf_labs(x = "Month", y = "Average wind speed (mph)")
```



We use the `as.factor()` function to convert a variable into a factor.

We also use `gf_labs()` to clean up the code for the first line and improve readability.

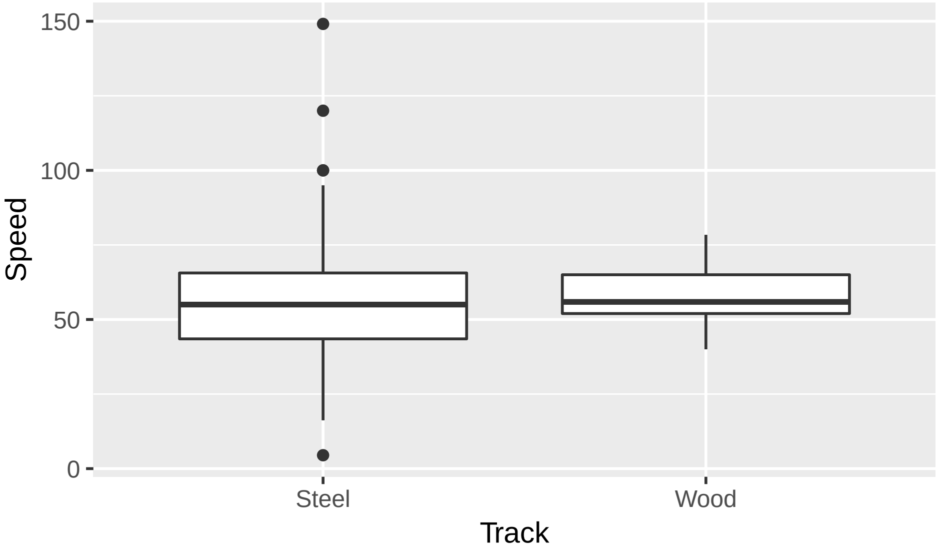
Here we use the mosaic modeling language to specify the variables. As a general form, `GOAL(Y ~ X)` carries out a specific goal for Y as a function of X.

Example 4.2: Comparing Groups with Boxplots

```
# Example 4.2, page 99
Coasters <- read_csv("http://nhorton.people.amherst.edu/is5/data/Coasters_2015.csv")
```

```
## Parsed with column specification:
## cols(
##   Name = col_character(),
##   Park = col_character(),
##   Track = col_character(),
##   Speed = col_double(),
##   Height = col_double(),
##   Drop = col_double(),
##   Length = col_double(),
##   Duration = col_integer(),
##   Inversions = col_integer()
## )
```

```
gf_boxplot(Speed ~ Track, data = Coasters)
```



Step-By-Step Example: Comparing Groups

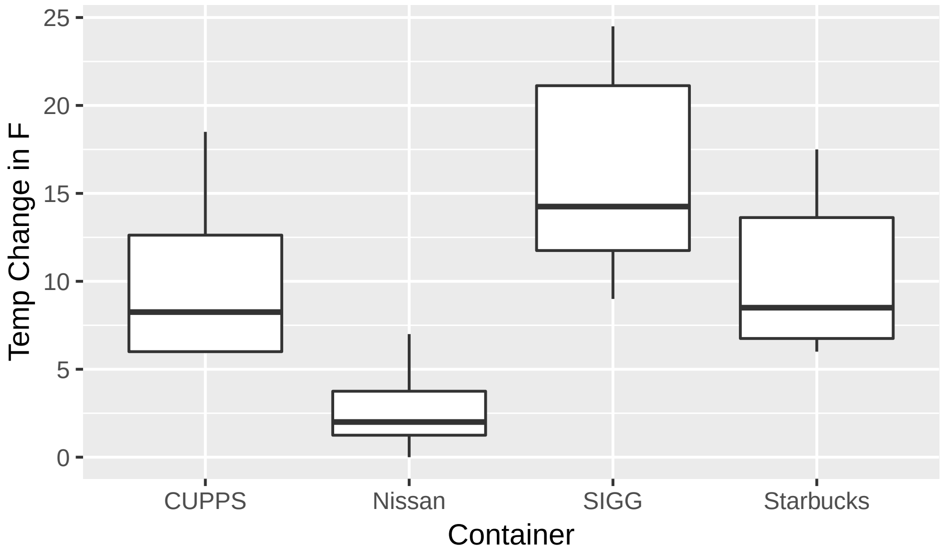
```
Cups <- read_csv("http://nhorton.people.amherst.edu/is5/data/Cups.csv")
```

```
## Parsed with column specification:
## cols(
##   Difference = col_double(),
##   Container = col_character()
## )
```

```
favstats(Difference ~ Container, data = Cups)
```

```
##   Container min    Q1 median     Q3  max    mean       sd n missing
## 1     CUPPS   6  6.00   8.25 12.625 18.5 10.1875 5.202592 8       0
## 2    Nissan   0  1.25   2.00  3.750  7.0  2.7500 2.507133 8       0
## 3      SIGG   9 11.75  14.25 21.125 24.5 16.0625 5.900590 8       0
## 4 Starbucks   6  6.75   8.50 13.625 17.5 10.2500 4.551295 8       0
```

```
# Mechanics, page 101
gf_boxplot(Difference ~ Container, data = Cups, ylab = "Temp Change in F")
```

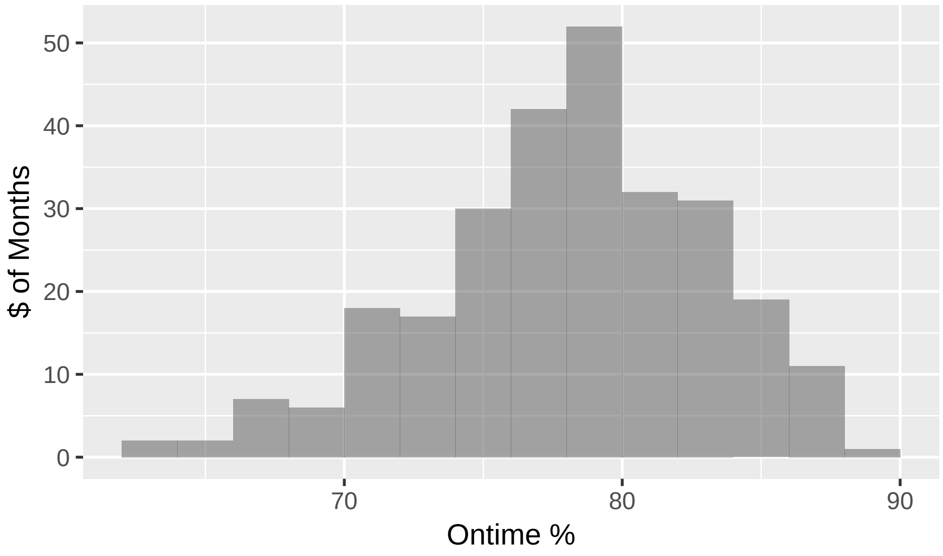


Just Checking

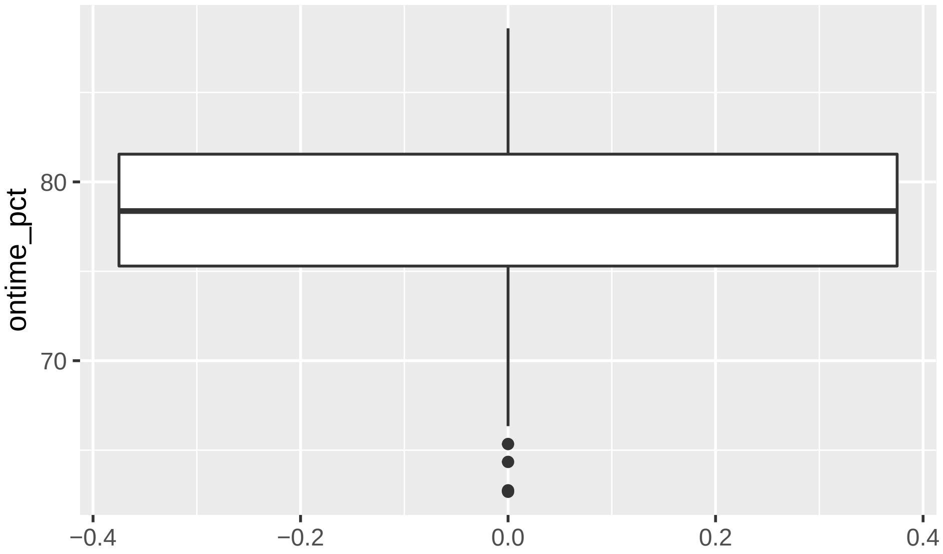
```
Flights <- read_csv("http://nhorton.people.amherst.edu/is5/data/Flights_on_time_2016.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   Year = col_double(),
##   Month = col_character(),
##   Onetime.Arrivals = col_integer(),
##   Ontime.pct = col_double(),
##   Arrival.Delays = col_integer(),
##   Delayed.pct = col_double(),
##   Flights.Cancelled = col_integer(),
##   Cancelled.Pct = col_double(),
##   Diverted = col_integer(),
##   Flight.Operations = col_integer()
## )
```

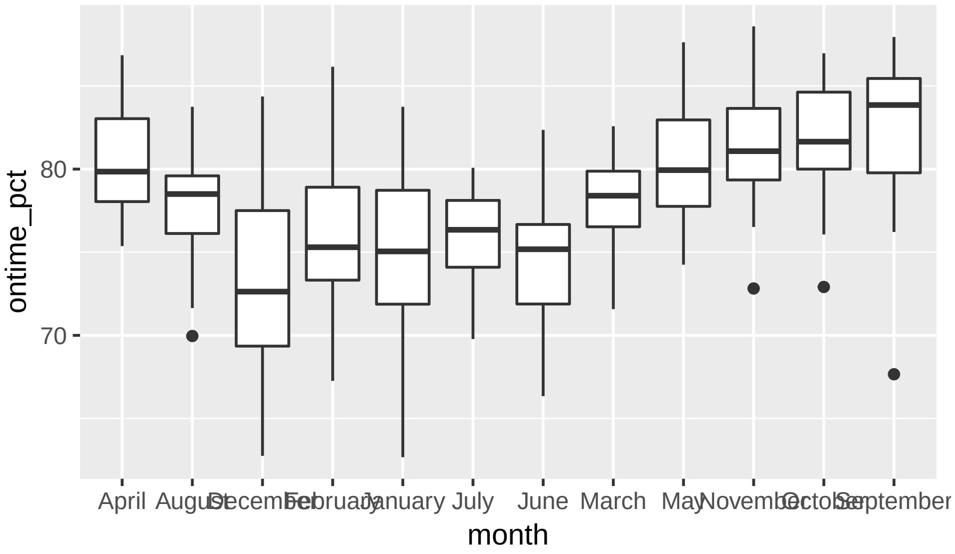
```
# Bureau of Transportation Statistics, page 101
gf_histogram(~ ontime_pct, data = Flights, binwidth = 2, center = 1) %>%
  gf_labs(x = "Ontime %", y = "$ of Months")
```



```
gf_boxplot(~ ontime_pct, data = Flights)
```



```
gf_boxplot(ontime_pct ~ month, data = Flights)
```

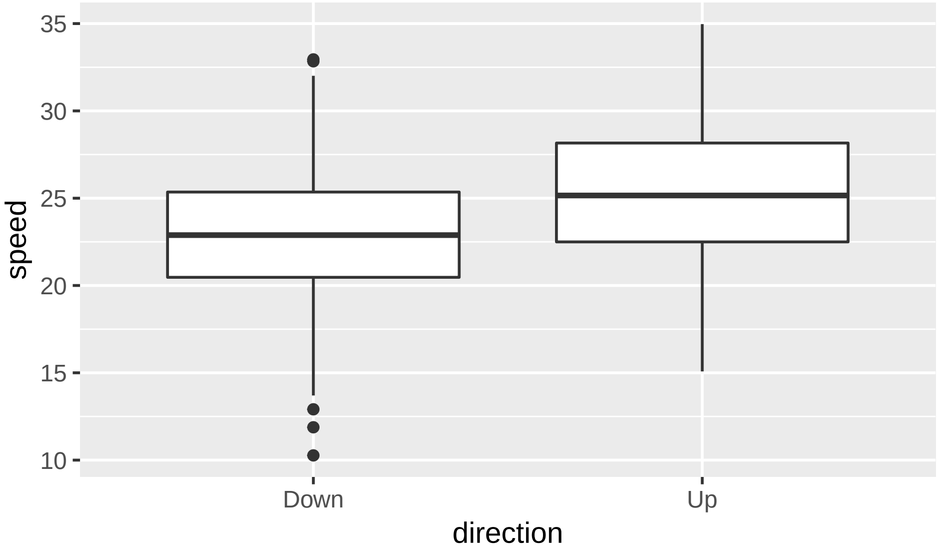


Random Matters

```
# Figure 4.4, page 102
CarSpeeds <- read_csv("http://nhorton.people.amherst.edu/is5/data/Car_speeds.csv")
```

```
## Parsed with column specification:
## cols(
##   direction = col_character(),
##   speed = col_double()
## )
```

```
gf_boxplot(speed ~ direction, data = CarSpeeds)
```



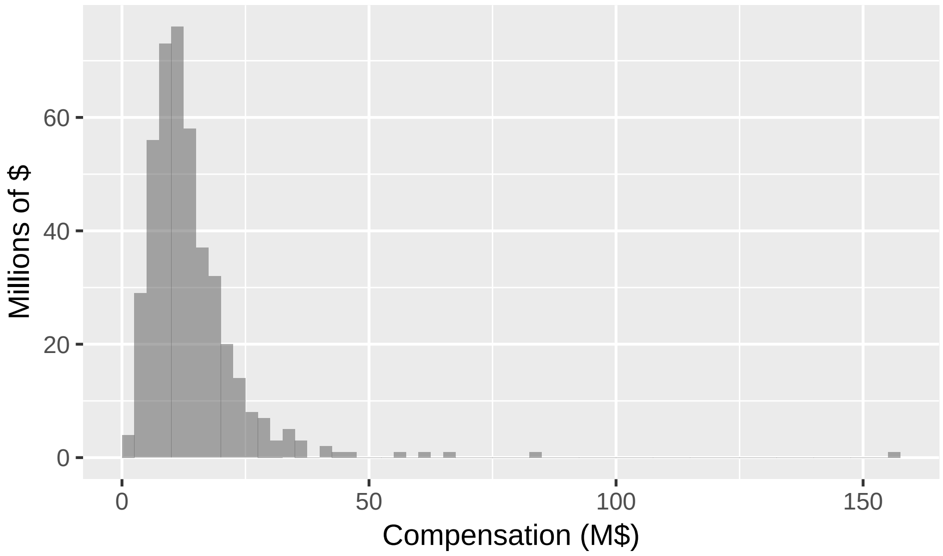
Section 4.3: Re-Expressing Data: A First Look

Re-Expressing to Improve Symmetry

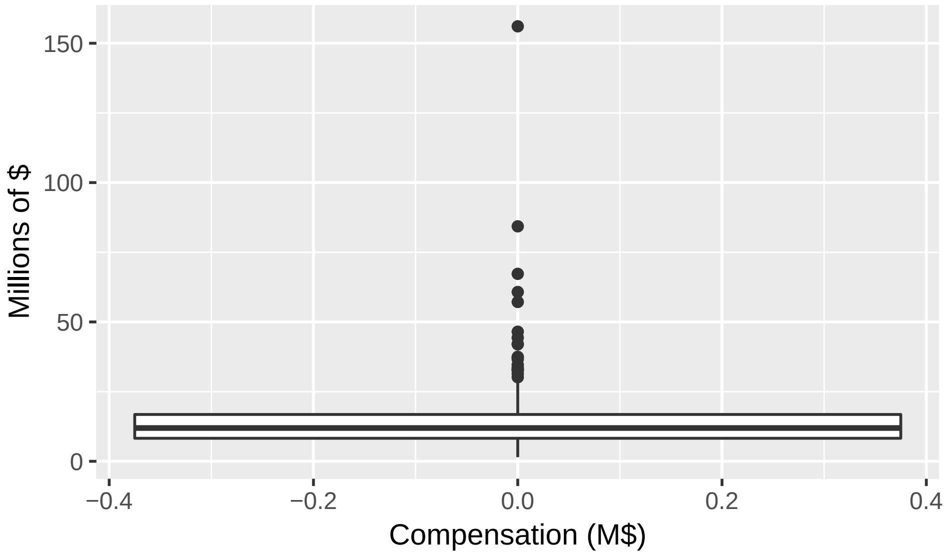
```
CEOComp <- read_csv("http://nhorton.people.amherst.edu/is5/data/CEO_Compensation_2014.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   Employer = col_character(),
##   CEO = col_character(),
##   CEO_Compensation = col_integer(),
##   Median_Worker_Comp = col_integer(),
##   Ratio = col_integer(),
##   Company_Rating = col_double(),
##   `CEO_Compensation_($M)` = col_double()
## )
```

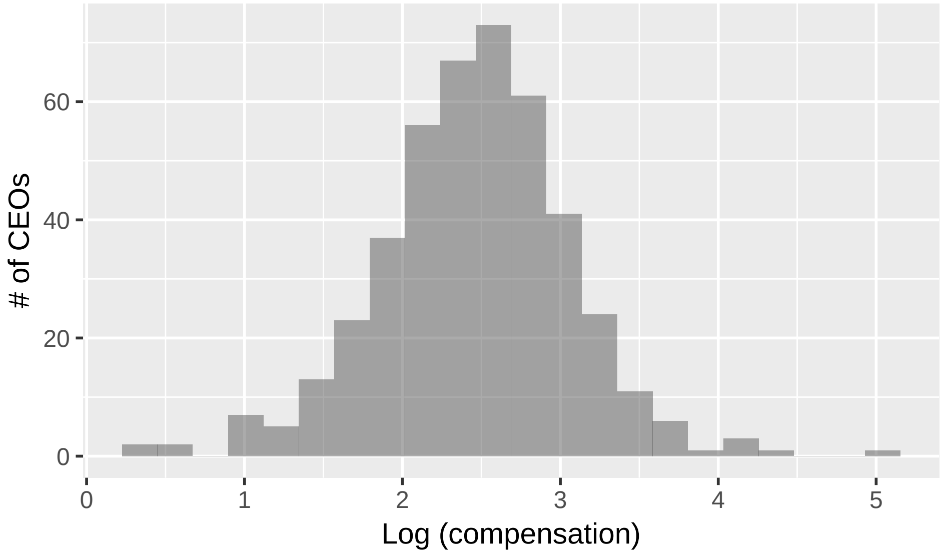
```
# Figure 4.6, page 105
gf_histogram(~ ceo_compensation_m, data = CEOComp, binwidth = 2.5, center = 2.5/2) %>%
  gf_labs(x = "Compensation (M$)", y = "Millions of $")
```



```
gf_boxplot(~ ceo_compensation_m, data = CEOComp) %>%
  gf_labs(x = "Compensation (M$)", y = "Millions of $")
```



```
# Figure 4.7, page 106
gf_histogram(~ log(ceo_compensation_m), data = CEOComp, binwidth = .224, center = .112) %>%
  gf_labs(x = "Log (compensation)", y = "# of CEOs")
```

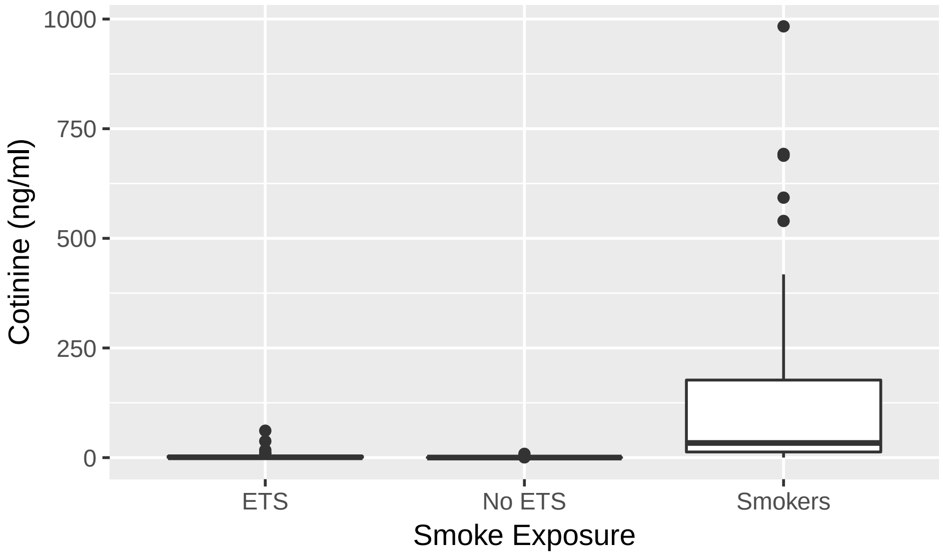


Re-Expression to Equalize Spread Across Groups

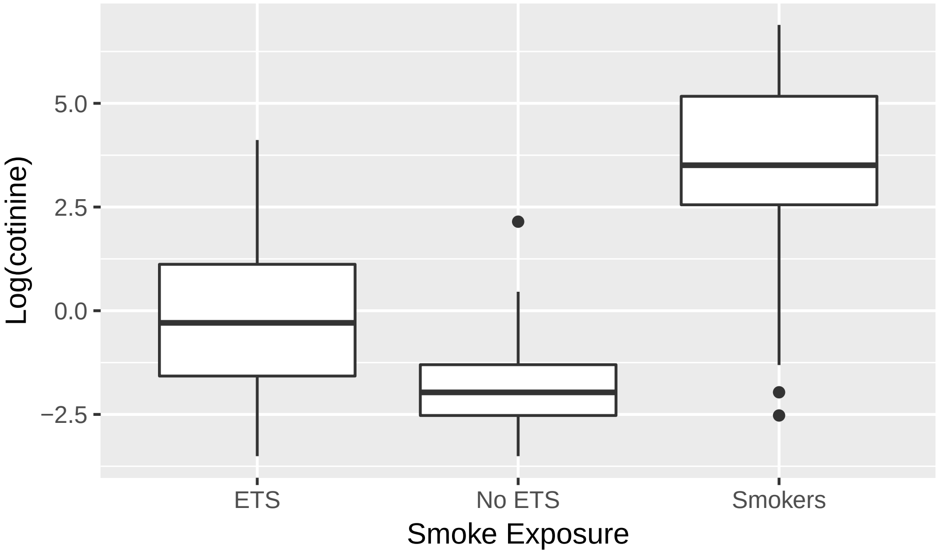
```
PassiveSmoke <- read_csv("http://nhorton.people.amherst.edu/is5/data/Passive_smoke.csv")
```

```
## Parsed with column specification:
## cols(
##   cotinine = col_double(),
##   smoke_exposure = col_character()
## )
```

```
# Figure 4.8, page 107
gf_boxplot(cotinine ~ smoke_exposure, data = PassiveSmoke) %>%
  gf_labs(x = "Smoke Exposure", y = "Cotinine (ng/ml)")
```



```
# Figure 4.9
gf_boxplot(log(cotinine) ~ smoke_exposure, data = PassiveSmoke) %>%
  gf_labs(x = "Smoke Exposure", y = "Log(cotinine)")
```


Log(cotinine)
ETS
No ETS
Smokers
Smoke Exposure