Boxplots

Intro to Stats, Fall 2018

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Learning Objectives

- Learn how to read boxplots
- Learn about the `boxplot()` function
- How to graph boxplots with `ggplot2`

Introduction

Quantitative variables can be summarized using two groups of measures: 1) center, and 2) spread. Just like there are various measures of center (e.g. average, median, mode), we also have several measures of spread or variability:

- range
- interquartile range
- standard deviation (and variance)

In this tutorial we'll use the data set `mtcars` that comes in R.

```
head(mtcars)
```

```
##                   mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

Let's analyze the variable `mpg` miles per gallon.

The function `summary()` produces basic summary statistics: the five-number summary, plus the mean:

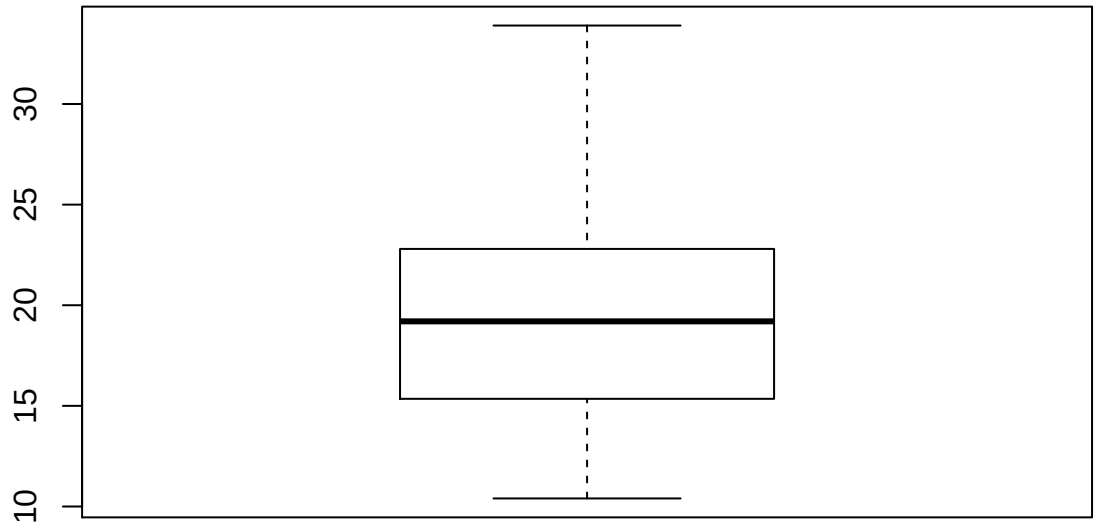
```
summary(mtcars$mpg)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   10.40   15.42   19.20   20.09   22.80   33.90
```

A boxplot, or more formally box-and-whisker plot, is based on the five-number summary: minimum, 1st quartile, median, 3rd quartile, and maximum.

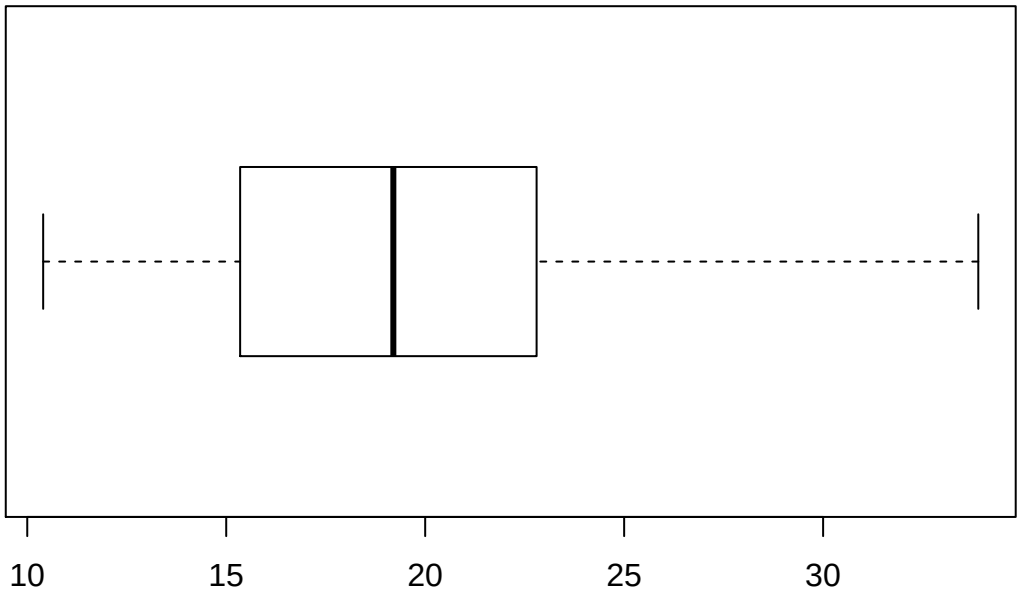
R has the built-in function `boxplot()` that allows you to make boxplots. You just need to pass it a vector, and R will graph a boxplot vertically oriented:

```
boxplot(mtcars$mpg)
```



You can set the argument `horizontal = TRUE` to get a boxplot horizontally oriented:

```
boxplot(mtcars$mpg, horizontal = TRUE)
```



In fact, you can actually store the output of `boxplot()`, for example:

```
bb = boxplot(mtcars$mpg)
```

The object `bb` is an object of class `"boxplot"` which contains various elements:

```
bb
```

```
## $stats
##       [,1]
## [1,] 10.40
## [2,] 15.35
## [3,] 19.20
## [4,] 22.80
## [5,] 33.90
##
## $n
## [1] 32
##
## $conf
##          [,1]
## [1,] 17.11916
## [2,] 21.28084
##
## $out
## numeric(0)
##
## $group
## numeric(0)
##
## $names
## [1] "1"
```

The first element `stats` contains the five-number summary:

```
# five number summary
bb$stats
```

```
##       [,1]
## [1,] 10.40
## [2,] 15.35
## [3,] 19.20
## [4,] 22.80
## [5,] 33.90
```

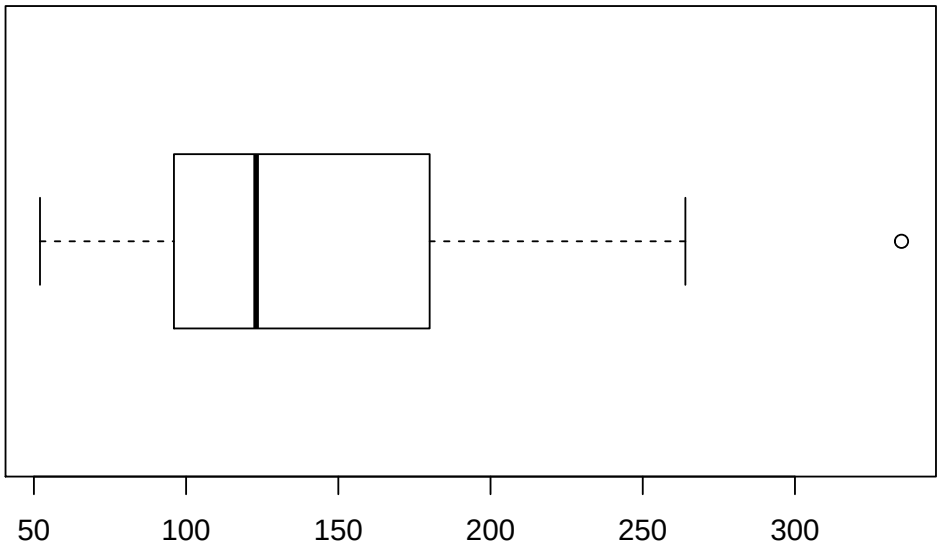
```
# compare to summary()
summary(mtcars$mpg)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   10.40   15.42   19.20   20.09   22.80   33.90
```

Fences

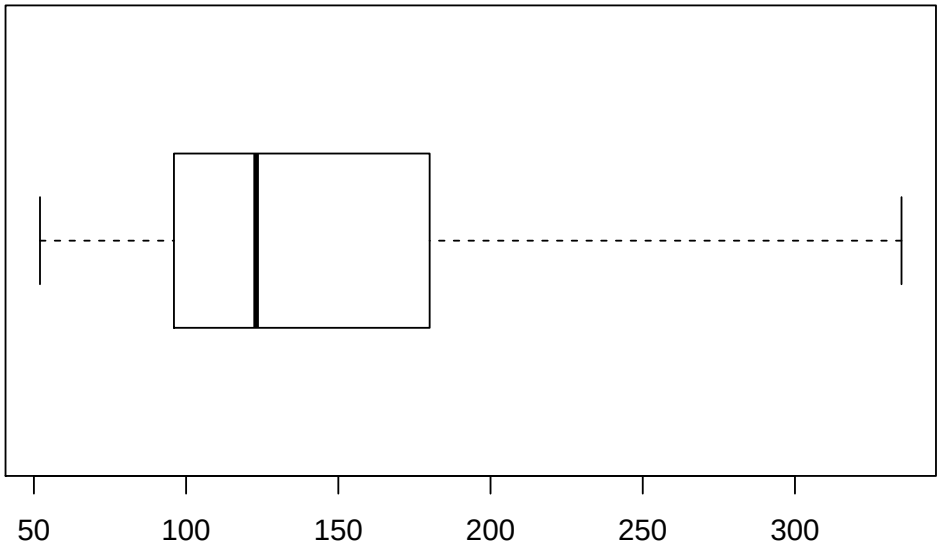
The function `boxplot()` has an argument `range`. This argument determines how far the plot whiskers extend out from the box. By default `range = 1.5`, this means that the whiskers extend to the most extreme data point which is no more than 1.5 times the interquartile range from the box.

```
# default boxplot
# (whiskers may not extend to the most extreme data points)
boxplot(mtcars$hp, horizontal = TRUE)
```



A value of zero (e.g. `range = 0`) causes the whiskers to extend to the data extremes.

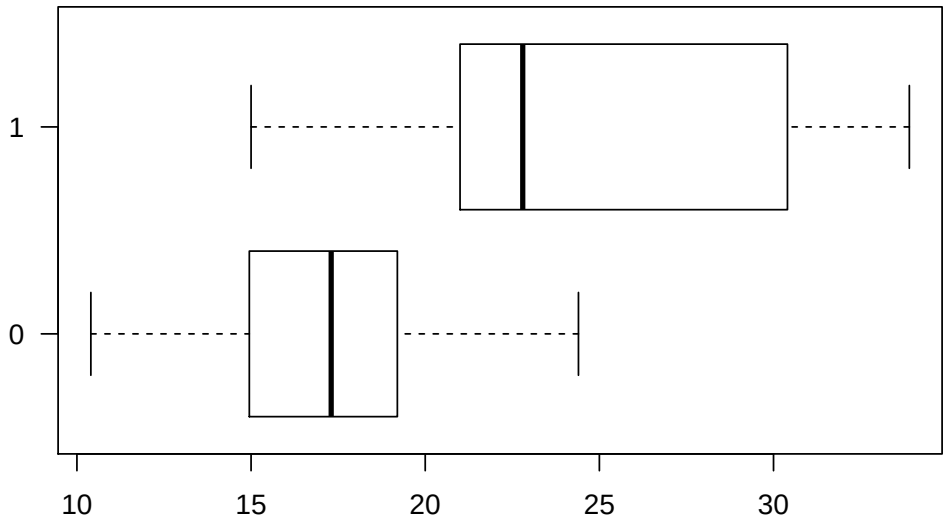
```
# boxplot with unmodified whiskers
# (whiskers extend to the most extreme data points)
boxplot(mtcars$hp, horizontal = TRUE, range = 0)
```



Formulas with `boxplot()`

An interesting feature of `boxplot()` is that you can pass R formulas. For example the variable (column) `am` refers to the automatic transmission. This variable takes two values: 0 if a car is automatic, 1 if the transmission is manual (stick).

```
# boxplots of mpg by transmission
boxplot(mpg ~ am, data = mtcars, horizontal = TRUE, las = 1)
```



A similar boxpot can be produced for the number of cylinders `cyl`

```
# boxplots of mpg by cylinders
boxplot(mpg ~ cyl, data = mtcars, horizontal = TRUE, las = 1)
```