

Chapter 14 - Error Bars

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What this chapter covers

- ▶ SD versus SEM
- ▶ Which kind of error bar should I plot?
- ▶ The appearance of error bars
- ▶ How are SD and SEM related to sample size?
- ▶ Common mistakes: error bars

SD VERSUS SEM

- ▶ standard deviation, SD, quantifies variation among values
- ▶ standard error of the mean (SEM), or just standard error, quantifies how precisely you know the population mean
 - ▶ $SEM = \frac{SD}{\sqrt{n}}$
- ▶ the SD will always be larger than the SEM
- ▶ SD can be computed from the SEM
 - ▶ $SD = SEM \times \sqrt{n}$

WHICH KIND OF ERROR BAR SHOULD I PLOT?

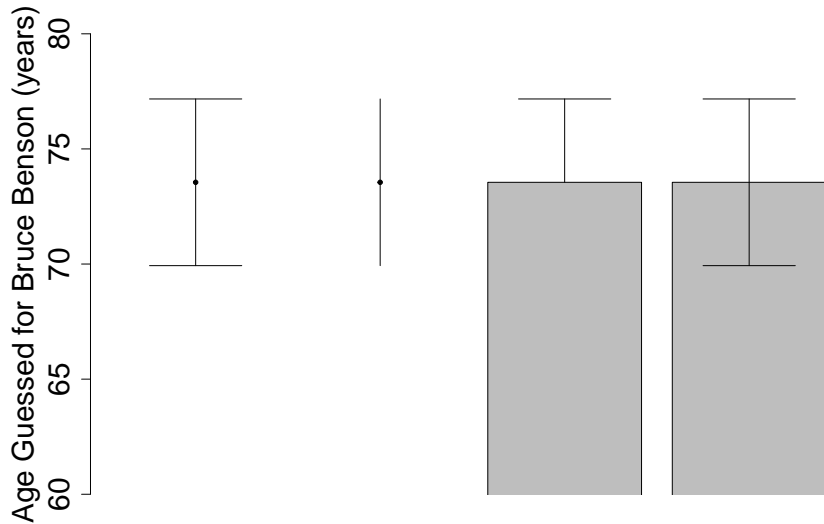
Goal: To show the variation among values

- ▶ use SD
- ▶ Often a box plot or histogram may be more informative though

Goal: To show how precisely you have determined the population mean

- ▶ use SEM
- ▶ Often a 95% CI may be more informative

THE APPEARANCE OF ERROR BARS



Plotting Error Bars in R

Create Histogram

```
x_values = barplot(meanAges,ylim=c(30,70),xpd=FALSE,  
                    cex.axis=2,cex.lab=2,cex.names=2,  
                    ylab = "Mean Age Estimates with SEM")
```

Draw vertical part of error bar

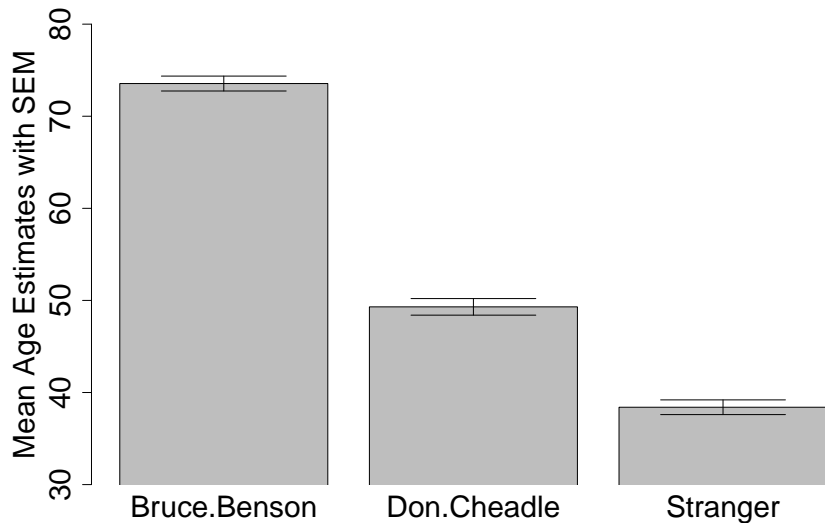
```
segments(x_values,meanAges+semAges,  
          x_values,meanAges-semAges)
```

Draw top and bottom caps

```
segments(x_values-0.3,meanAges+semAges,  
          x_values+0.3,meanAges+semAges)
```

```
segments(x_values-0.3,meanAges-semAges,  
          x_values+0.3,meanAges-semAges)
```

Plotting Error Bars in R



HOW ARE SD AND SEM RELATED TO SAMPLE SIZE?

- ▶ If you increase the sample size, is the **SEM** expected to get larger, get smaller, or stay the same?
 - ▶ It is expected to get smaller
- ▶ If you increase the sample size, is the **SD** expected to get larger, get smaller, or stay the same?
 - ▶ It is equally likely to get larger or to get smaller as the sample size increases.

COMMON MISTAKES: ERROR BARS

- ▶ Plotting mean and error bars instead of plotting a frequency distribution
 - ▶ Often a frequency plot is more informative
- ▶ Assuming that all distributions are Gaussian
 - ▶ Often our first intuition is to assume the data are Gaussian when only a mean and SD are shown
- ▶ Plotting a mean and error bar without defining how the error bars are computed

What did we learn

- ▶ SD quantifies variation
- ▶ SEM quantifies how precisely you know the population mean
- ▶ SEM is always smaller than SD
- ▶ Graphs are often plotted as means and error bars, which are usually either the SD or the SEM
- ▶ You can calculate the SD from the SEM and n
- ▶ Sometimes, the choice of SD or SEM is based on traditions in a particular field. Often, SEMs are chosen simply because they are smaller.
- ▶ Graphs with error bars should always indicate whether they are SD, SEM, or something else.