Inference-by-eye using RA Fisher's Cat Data

Nathan Brouwer brouwern@gmail.com @lobrowR

2017-11-13

A an example of doing "inference by eye" using R.A. Fischer's cat data. A good summary of this idea is Cummings et al. 2007. Error bars in experimental biology. http://jcb.rupress.org/content/177/1/7.short

Load the data

```
library(MASS)
data("cats")
```

Look at the data

```
dim(cats)
```

```
## [1] 144   3
```

```
summary(cats)
```

```
##  Sex         Bwt             Hwt
##  F:47   Min.   :2.000   Min.   : 6.30
##  M:97   1st Qu.:2.300   1st Qu.: 8.95
##         Median :2.700   Median :10.10
##         Mean   :2.724   Mean   :10.63
##         3rd Qu.:3.025   3rd Qu.:12.12
##         Max.   :3.900   Max.   :20.50
```

Summarize the body weight (Bwt) data old-school using summaryBy()

A more modern way would be to use dplyr()

```
library(doBy)

#get the mean and SD
cat.df1 <- summaryBy(Bwt ~ Sex, data = cats, FUN = c(mean,sd))

#get the sample size using length()
cat.df2 <- summaryBy(Bwt ~ Sex, data = cats, FUN = c(length))

#make a combined dataframe
cat.df3 <- merge(cat.df1,cat.df2)

#calculate the standard error SE by hand

cat.df3$SE <- cat.df3$Bwt.sd/sqrt(cat.df3$Bwt.length)
```

Look at the results

```
cat.df3
```

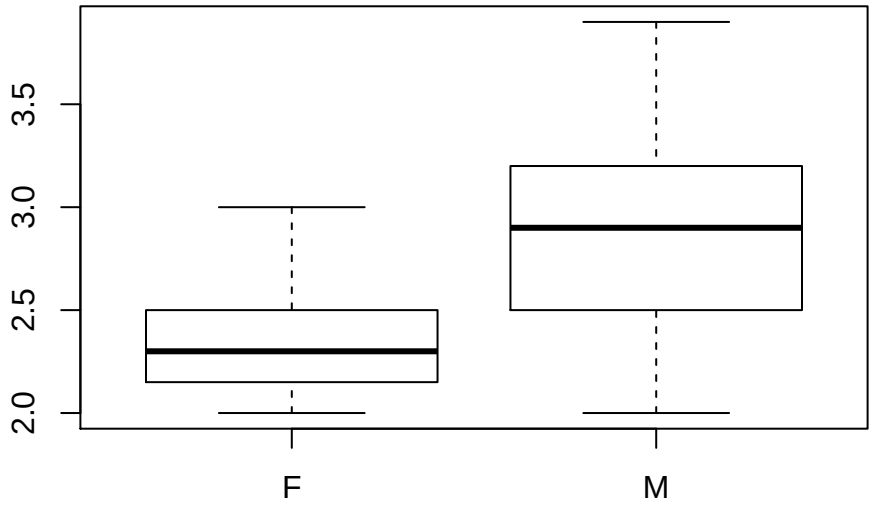
```
##   Sex Bwt.mean    Bwt.sd Bwt.length         SE
## 1   F 2.359574 0.2739879         47 0.03996525
## 2   M 2.900000 0.4674844         97 0.04746585
```

Plot the data

Visualize the raw data

```
par(mfrow = c(1,1),mar = c(3,3.5,1,1))

boxplot(Bwt ~ Sex, data = cats)
```



Plot the means with error bars

This uses the errbar() function. A modern contemporary way would use ggplot2 and possibly its extension using ggpubr.

The real data

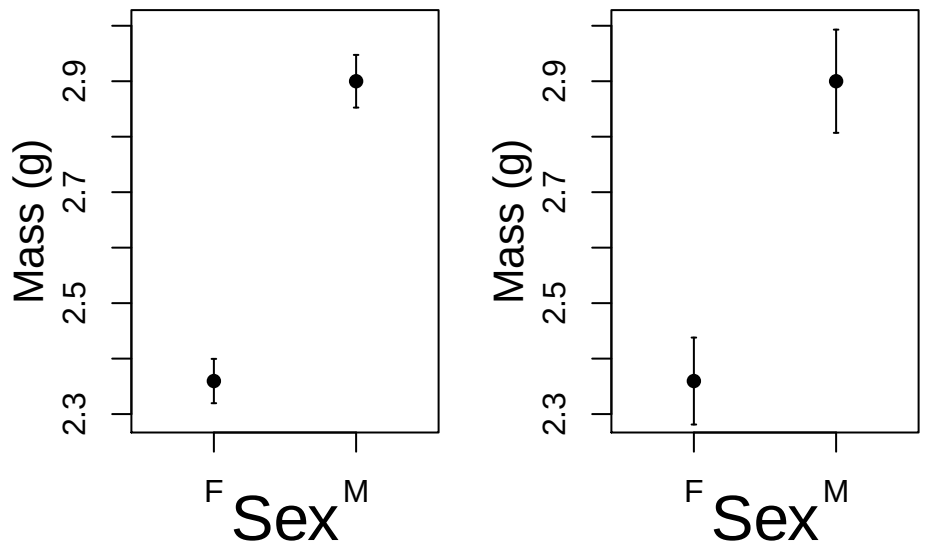
This is the actual data. The 95% confidence intervals do not overlap, which indicates that the p-value for the t-test will be less than 0.05.

```
library(Hmisc)
par(mfrow = c(1,2),mar = c(3,3.5,1,1))

y.lim <- c(2.295,3)
errbar(1:2,
       y = cat.df3$Bwt.mean,
       yplus =cat.df3$Bwt.mean + cat.df3$SE,
       yminus = cat.df3$Bwt.mean-cat.df3$SE,
       xlab = "",
```

```
       ylab = "",
       xlim=c(0.5,2.5),
       ylim = y.lim,
       xaxt="n",cex =1)
axis(side=1,at=1:2,labels=cat.df3$Sex)
mtext("Sex", side = 1, line = 2, cex = 2)
mtext("Mass (g)", side = 2, line = 2.1, cex = 1.3)

errbar(1:2,
       y = cat.df3$Bwt.mean,
       yplus =cat.df3$Bwt.mean + 1.96*cat.df3$SE,
       yminus = cat.df3$Bwt.mean-1.96*cat.df3$SE,
       xlab = "",
       ylab = "",
       xlim=c(0.5,2.5),
       ylim = y.lim,
       xaxt="n",cex =1)
axis(side=1,at=1:2,labels=cat.df3$Sex)
mtext("Sex", side = 1, line = 2, cex = 2)
mtext("Mass (g)", side = 2, line = 2.1, cex = 1.3)
```



Modified data with a non-significant different

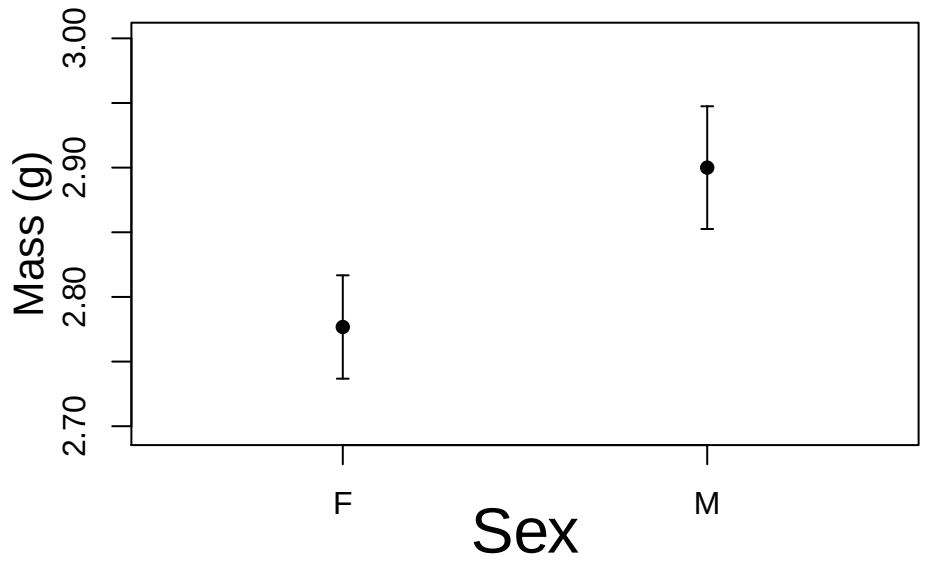
Make an alternative version of the data where there isn't a difference between the male and female cats

```
cat.df3.mod <- cat.df3
cat.df3.mod$Bwt.mean[1] <- cat.df3$Bwt.mean[2]-cat.df3$Bwt.mean[2]*0.0425
```

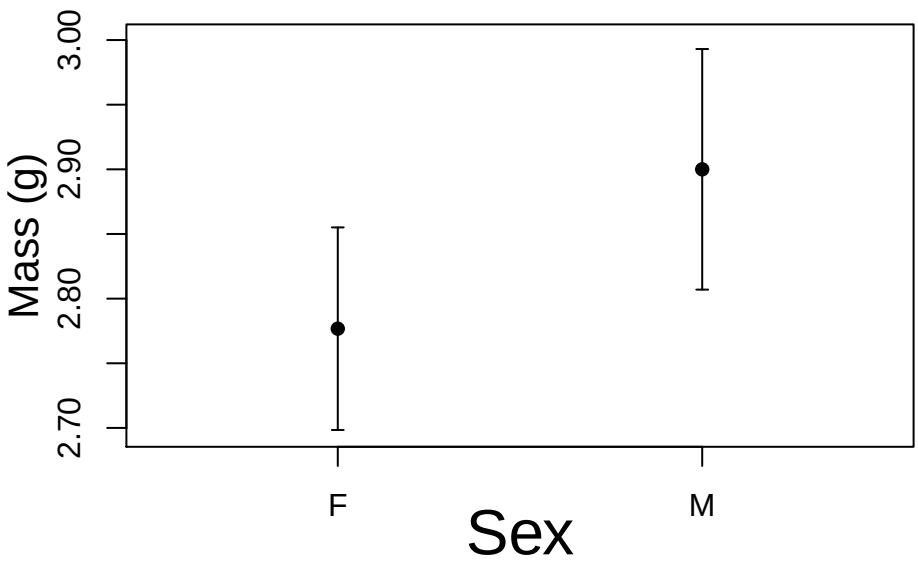
The overlap of the error bars here is greater than 1/2 the length of the bar; therefore the p-value for a t-test will be > 0.05.

```
y.lim <- c(2.6975,3)
par(mar = c(3,3.5,1,1))
errbar(1:2,
       y = cat.df3.mod$Bwt.mean,
       yplus =cat.df3.mod$Bwt.mean + cat.df3.mod$SE,
```

```
       yminus = cat.df3.mod$Bwt.mean-cat.df3.mod$SE,
       xlab = "",
       ylab = "",
       xlim=c(0.5,2.5),
       ylim = y.lim,
       xaxt="n",cex =1)
axis(side=1,at=1:2,labels=cat.df3.mod$Sex)
mtext("Sex", side = 1, line = 2, cex = 2)
mtext("Mass (g)", side = 2, line = 2.1, cex = 1.3)
```




```
errbar(1:2,
       y = cat.df3.mod$Bwt.mean,
       yplus =cat.df3.mod$Bwt.mean + 1.96*cat.df3.mod$SE,
       yminus = cat.df3.mod$Bwt.mean-1.96*cat.df3.mod$SE,
       xlab = "",
       ylab = "",
       xlim=c(0.5,2.5),
       ylim = y.lim,
       xaxt="n",cex =1)
axis(side=1,at=1:2,labels=cat.df3.mod$Sex)
mtext("Sex", side = 1, line = 2, cex = 2)
mtext("Mass (g)", side = 2, line = 2.1, cex = 1.3)
```



T-test

A t-test for the differenec between female and male cats.

```
t.test(Bwt ~ Sex, data = cats)
```

```
##
##  Welch Two Sample t-test
##
## data:  Bwt by Sex
## t = -8.7095, df = 136.84, p-value = 8.831e-15
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.6631268 -0.4177242
## sample estimates:
## mean in group F mean in group M
##        2.359574        2.900000
```

```
summary(lm(Bwt ~ -1+Sex, data = cats))
```

```
##
## Call:
## lm(formula = Bwt ~ -1 + Sex, data = cats)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.90000 -0.25957 -0.05957  0.30000  1.00000
##
## Coefficients:
##      Estimate Std. Error t value Pr(>|t|)
## SexF  2.35957    0.06051   39.00   <2e-16 ***
## SexM  2.90000    0.04212   68.86   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.4148 on 142 degrees of freedom
## Multiple R-squared:  0.9778, Adjusted R-squared:  0.9775
## F-statistic:  3131 on 2 and 142 DF,  p-value: < 2.2e-16
```