Statistics with Sparrows - many models, matrices, and some magic

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Linear mixed models - Part 1

Before we begin, we clear our workspace. I will never stop writing this. And I hope you will never stop doing this!

```
rm(list=ls())
setwd("~/Box Sync/Teaching/MagicalStats")
```

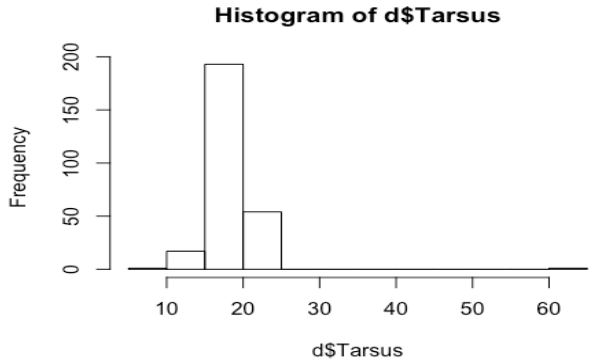
We will now use the dataset we collected in the first Stats with Sparrows week - remember, when we measured tarsus and bill width in the set up sparrow? I've compiled that dataset and we'll evaluate how much variance differences between observers explain, and how much variance is explained by group - I've collected this data in earlier years and you're grouped into morning/afternoon and by year - I've named each group with a letter A-I.

```
d<-read.table("ObserverRepeatability.txt", header=T)
str(d)
```

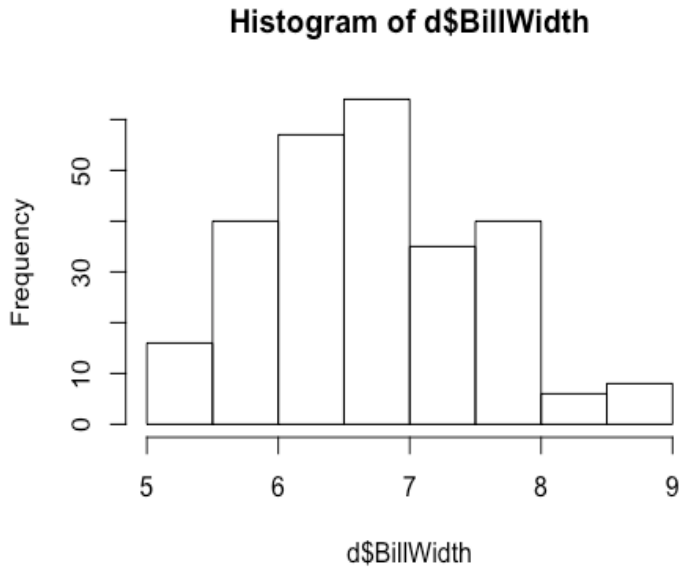
```
## 'data.frame':    266 obs. of  6 variables:
##  $ StudentID : Factor w/ 113 levels "1JC7394","2JC7394",..: 1 2 3 4 5 6 6
6 6 6 ...
##  $ Tarsus    : num  17.8 17.4 17.9 15.2 14.7 22.4 16.2 16.6 22.4 16.2 ...
##  $ Leg       : Factor w/ 2 levels "left","right": 2 1 2 1 1 2 2 2 2 2 ...
##  $ BillWidth : num  5.6 5.6 5.6 7.9 5.9 7.2 5.8 6.5 7.2 5.8 ...
##  $ GroupN    : Factor w/ 8 levels "A","B","C","D",..: 1 1 1 2 1 1 1 1 1 1
...
##  $ HandedNess: Factor w/ 3 levels "A","L","R": 3 3 3 3 2 2 2 2 2 2 ...
```

Here, the grouping factors StudentID and Group are already factors, so we don't have to re-code them. Useful! Now because we're interested in how much variance each group-level variable explains, it might be a good idea to first look at the spread of the data itself.

```
hist(d$Tarsus)
```

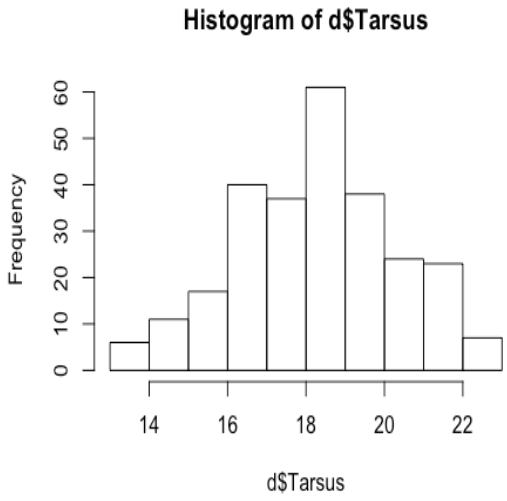



```
hist(d$BillWidth)
```



Ooops. Somebody seems to have made an error, typo, or joke. We better remove the outlier:

```
d<-subset(d, d$Tarsus<=40)
d<-subset(d, d$Tarsus>=10)
hist(d$Tarsus)
```



Better.

Now back to the task at hand:

```
summary(d$Tarsus)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   13.05   16.89   18.40   18.35   19.60   23.00

var(d$Tarsus)

## [1] 4.152135

summary(d$BillWidth)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   5.000   6.200   6.800   6.756   7.300   9.000

var(d$BillWidth)

## [1] 0.7508114
```

Now we have a good idea what the total variance is. Clear is also that we are not very reliable observers given that we all tried to measure the same thing... However, we do suspect that individual students are more consistent in measuring tarsus and bill length than between students. We also don't think that groups will explain much variance. Now we will test for that. Here's how the methods would look like were this a paper:

Methods: We are interested in how much variation we introduce as observers when we measure morphological features. As traits we use the length of a stuffed sparrow's (Passer domesticus) tarsus, and the width of its bill. Every year during the Stats With Sparrows course at Imperial College, master students measure these traits repeatedly, using a calliper. Both traits are measured in mm to the nearest 0.1 mm. We have now ammased data from eight groups, totalling to 266 observations of 113 students.

To test how much variance is explained by observer and group, we run two mixed-effects linear models, one for tarsus length, and one for bill length as response variables. Both models will have a similar structure, and the procedure to determine the final model is the same for both traits. We model student identity, and group identity, as random effects on the intercept. We added no fixed effects, and thus fixed the intercept to 1. We use likelihood-ratio tests to test for the statistical significance of each random effect, by testing a model including the effect to test against one where this random effect is removed.

```
## Loading required package: lme4

## Loading required package: Matrix

require(lme4)
#this is a package that we can use for lmms.

require(lmtest)

## Loading required package: lmtest

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

mT1<-lmer(Tarsus~1+(1|StudentID), data=d)
mT2<-lmer(Tarsus~1+(1|StudentID)+(1|GroupN), data=d)
lrtest(mT1,mT2)

## Likelihood ratio test
##
## Model 1: Tarsus ~ 1 + (1 | StudentID)
## Model 2: Tarsus ~ 1 + (1 | StudentID) + (1 | GroupN)
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1   3 -506.72
## 2   4 -505.08  1 3.2809    0.07009 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The LRT test is not statistically significant for tarsus, so the more complex model (mT2) does not explain the data better. However, it is worth to note that it's close, so maybe if I keep measuring it I need to keep an eye on it.

```
summary(mT1)

## Linear mixed model fit by REML ['lmerMod']
## Formula: Tarsus ~ 1 + (1 | StudentID)
##    Data: d
##
```

```
## REML criterion at convergence: 1013.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.5836 -0.3026 -0.0246  0.3387  4.0576
##
## Random effects:
##  Groups    Name        Variance Std.Dev.
##  StudentID (Intercept) 3.209    1.791
##  Residual              1.228    1.108
## Number of obs: 264, groups:  StudentID, 112
##
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept)  18.4041     0.1856   99.18
```

```
3.21/(3.21+1.23)
```

```
## [1] 0.722973
```

The results section for this part would read as follows:

We tested whether student identiy and group identity explained variance in a dataset of 264 measurements of a stuffed sparrow's tarsus. The likelihood ratio test revealed that group identity did not explain statistically significant amounts of variance (chi square = 3.29, df = 1, p=0.07), and was thus removed from the final model. Accounting for student identity, the final model revealed that the measurement of tarsus was on average 18.4mm (0.19SE, Table 1). Student identity explained 73% of all variance in the dataset (Table 1).

Variable	Estimate	Precision
Fixed effects	b	SE
Intercept (female)	18.40	0.19
Random effects	Variance	Standard Deviation
Individual	3.21	1.79
Residual	1.23	1.11

Now you are tasked to do the same for bill length! Write a results section! Why do you think the group variance does not come out? What is a general problem with this dataset? Think variances and do look at their precision!