

BIOS 545 Lecture 5

Department of Biostatistics and Bioinformatics

Steve Pittard wsp@emory.edu

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Data Frames - Merge

- Merging data frames is possible
- But we don't often encounter two or more similar enough data frames that we can merge them easily.
- Usually we pick and choose columns from a number of data frames to build a new data frame.
- But this isn't easy either since not all observations are from the same population.
- Always work with the *minimum* amount of data necessary for a given analysis
- There is no reason to create a big data frame if you are only going to be using 20 percent of the attributes/columns.

Data Frames - Merge

Merging data frames is possible. You have to select a “key” that is common to both data frames to make this work. Pick a column(s) that links the two data frames

```
df1 <- data.frame(indiv_id = 1:4, snp1 = c(1,1,0,1), snp2 = c(1,1,0,0))
```

```
df2 <- data.frame(indiv_id = c(1,3,4,6), cov1 = c(1.14,4.50,0.80,1.39),  
                  cov2 = c(74.6,79.4,48.2,68.1))
```

df1

indiv_id	snp1	snp2
1	1	1
2	1	1
3	0	0
4	1	0

df2

indiv_id	cov1	cov2
1	1.14	74.6
3	4.50	79.4
4	0.80	48.2
6	1.39	68.1

Data Frames - Merge

The “indiv_id” column looks like it will do the trick

df1

indiv_id	snp1	snp2
1	1	1
2	1	1
3	0	0
4	1	0

df2

indiv_id	cov1	cov2
1	1.14	74.6
3	4.50	79.4
4	0.80	48.2
6	1.39	68.1

```
merge(df1, df2, by="indiv_id", all=TRUE)
```

indiv_id	SNP1	SNP2	cov1	cov2
1	1	1	1.14	74.6
2	1	1	NA	NA
3	0	0	4.50	79.4
4	1	0	0.80	48.2
6	NA	NA	1.39	68.1

Data Frames - Merge

Pay attention to the “all.x” and “all.y” arguments as it helps you specify which records you want to include

df1

indiv_id	snp1	snp2
1	1	1
2	1	1
3	0	0
4	1	0

df2

indiv_id	cov1	cov2
1	1.14	74.6
3	4.50	79.4
4	0.80	48.2
6	1.39	68.1

```
merge(df1, df2, by="indiv_id", all.y=T)
```

	indiv_id	snp1	snp2	cov1	cov2
1	1	1	1	1.14	74.6
2	3	0	0	4.50	79.4
3	4	1	0	0.80	48.2
4	6	NA	NA	1.39	68.1

Data Frames - Merge

Note that the merge columns do not have to be named the same thing in each data frame as long as they refer to the same thing

```
names(df2) <- c("id","cov1","cov2")
```

```
head(df1,2)
```

	indiv_id	snp1	snp2
1	1	1	1
2	2	1	1

```
head(df2,2)
```

	id	cov1	cov2
1	1	1.14	74.6
2	3	4.50	79.4

```
merge(df1,df2,by.x="indiv_id",by.y="id",all=TRUE)
```

	indiv_id	snp1	snp2	cov1	cov2
1	1	1	1	1.14	74.6
2	2	1	1	NA	NA
3	3	0	0	4.50	79.4
4	4	1	0	0.80	48.2
5	6	NA	NA	1.39	68.1

Data Frames - split

- The split function lets us break up a data frame based on a grouping variable
- Let's say we want to split up mtcars based on the number of cylinders which take on the values 4,6,8
- Use the split command which gives back a list with each element containing a part of the data frame corresponding to each cylinder group
- Without using split you could do:

```
eight.cyl <- mtcars[mtcars$cyl == 8,]
```

```
six.cyl <- mtcars[mtcars$cyl == 6, ]
```

```
four.cyl <- mtcars[mtcars$cyl == 4, ]
```

Data Frames - split

But what if we had 10 categories we wanted to split by ? The **split** function does scale well so use it !

```
hold <- split(mtcars, mtcars$cyl)
```

```
str(hold,max.level=1)
```

List of 3

```
$ 4:'data.frame': 11 obs. of 11 variables:
```

```
$ 6:'data.frame': 7 obs. of 11 variables:
```

```
$ 8:'data.frame': 14 obs. of 11 variables:
```

```
head(hold[[1]],3) # Show the first 3 lines of the first list element
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Datsun 710	22.8	4	108.0	93	3.85	2.32	18.61	1	1	4	1
Merc 240D	24.4	4	146.7	62	3.69	3.19	20.00	1	0	4	2
Merc 230	22.8	4	140.8	95	3.92	3.15	22.90	1	0	4	2

Data Frames - split

Why is this useful ? Well we might want to focus in on only the cars occupying a certain cylinder group while ignoring the rest. So if we wanted only the 8 cylinder cars:

```
hold <- split(mtcars, mtcars$cyl)
```

```
sapply(hold,nrow)
```

```
  4   6   8  
11  7 14
```

```
eight.cyl <- hold$`8`
```

```
# -OR-
```

```
eight.cyl <- hold[[3]]
```

Data Frames - split

Because what we get back is a list we can use lapply to look at the first few records of each element which is a data frame

```
hold <- split(mtcars, mtcars$cyl)
```

```
str(hold,max.level=1)
```

```
List of 3
```

```
$ 4:'data.frame':  11 obs. of  11 variables:
```

```
$ 6:'data.frame':  7 obs. of  11 variables:
```

```
$ 8:'data.frame': 14 obs. of  11 variables:
```

Data Frames - split

```
lapply(hold, head, 3)
```

```
$`4`
```

		mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Datsun	710	22.8	4	108.0	93	3.85	2.32	18.61	1	1	4	1
Merc	240D	24.4	4	146.7	62	3.69	3.19	20.00	1	0	4	2
Merc	230	22.8	4	140.8	95	3.92	3.15	22.90	1	0	4	2

```
$`6`
```

		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
Hornet	4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1

```
$`8`
```

		mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Hornet	Sportabout	18.7	8	360.0	175	3.15	3.44	17.02	0	0	3	2
Duster	360	14.3	8	360.0	245	3.21	3.57	15.84	0	0	3	4
Merc	450SE	16.4	8	275.8	180	3.07	4.07	17.40	0	0	3	3

Data Frames - split

We could write our own summary function. While it is an advanced idea at this point, it is good for you too see this kind of approach as it is common in R. This example gives the mean MPG for each cylinder group:

```
# We create our own function and apply it to each element of "hold"
```

```
hold <- split(mtcars,mtcars$cyl)
sapply(hold, function(x) mean(x$mpg))
```

4	6	8
26.66364	19.74286	15.10000

Data Frames - order/sort

Let's take a look at what the order command does. It returns the record/row numbers of the data frame from lowest MPG to highest. So record #15 must be the lowest MPG automobile in the set. And record #20 must have the highest MPG

```
order(mtcars$mpg)
```

```
[1] 15 16 24 7 17 31 14 23 22 29 12 13 11 6 5 10 25 30  
[19] 1 2 4 32 21 3 9 8 27 26 19 28 18 20
```

```
mtcars[15,]
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Cadillac Fleetwood	10.4	8	472	205	2.93	5.25	17.98	0	0	3	4

```
mtcars[20,]
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Toyota Corolla	33.9	4	71.1	65	4.22	1.835	19.9	1	1	4	1

Data Frames - order/sort

Ordering and sorting data frames is an important technique

```
# sort by mpg (ascending)
newdata <- mtcars[order(mtcars$mpg),]
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Cadillac Fleetwood	10.4	8	472.0	205	2.93	5.250	17.98	0	0	3	4
Lincoln Continental	10.4	8	460.0	215	3.00	5.424	17.82	0	0	3	4
Camaro Z28	13.3	8	350.0	245	3.73	3.840	15.41	0	0	3	4
Duster 360	14.3	8	360.0	245	3.21	3.570	15.84	0	0	3	4

```
newdata <- mtcars[rev(order(mtcars$mpg)),]
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Toyota Corolla	33.9	4	71.1	65	4.22	1.835	19.90	1	1	4	1
Fiat 128	32.4	4	78.7	66	4.08	2.200	19.47	1	1	4	1
Honda Civic	30.4	4	75.7	52	4.93	1.615	18.52	1	1	4	2
Lotus Europa	30.4	4	95.1	113	3.77	1.513	16.90	1	1	5	2

Data Frames - order/sort

Ordering and sorting data frames is an important technique

```
newdata <- mtcars[order(-mtcars$mpg),]
```

```
head(newdata)
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Toyota Corolla	33.9	4	71.1	65	4.22	1.835	19.90	1	1	4	1
Fiat 128	32.4	4	78.7	66	4.08	2.200	19.47	1	1	4	1
Honda Civic	30.4	4	75.7	52	4.93	1.615	18.52	1	1	4	2
Lotus Europa	30.4	4	95.1	113	3.77	1.513	16.90	1	1	5	2

Data Frames - sample

The **sample()** function is quite useful when you want to take, well, a sample of your data. You can sample with or without replacement. The basic function works as follows:

```
# Create a vector of numbers from 1 to 20
my_vec <- 1:20
```

```
sample(my_vec,10,replace=TRUE)    # Repetition is possible
[1]  3 20 16 14 16 10 18  7  7  6
```

```
sample(my_vec, 10, replace=TRUE) # Different results each time
[1]  5  1  2  2 19  8 20 11  3 19
```

```
sample(my_vec, 10, replace=FALSE) # Don't replace sampled numbers
[1]  2  8  9  6 17 18  3  5 14 15
```

```
sample(1:20, 10, replace=FALSE)  # Short cut
[1] 13  6  4 14  3 19 16 17 20 12
```


Data Frames - sample

But how do you sample from a data frame ? We want a random sample of 10 records from mtcars

```
my_records <- sample(1:nrow(mtcars), 10, replace = FALSE)
```

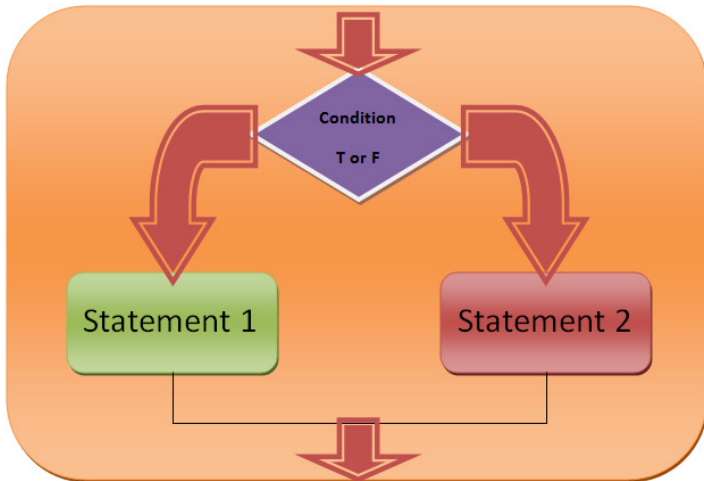
```
my_records
```

```
[1] 21  6  9 30 29 28  3 11 12  1
```

```
sample_of_ten <- mtcars[my_records,]
```

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Toyota Corona	21.5	4	120.1	97	3.70	2.465	20.01	1	0	3	1
Valiant	18.1	6	225.0	105	2.76	3.460	20.22	1	0	3	1
Merc 230	22.8	4	140.8	95	3.92	3.150	22.90	1	0	4	2
Ferrari Dino	19.7	6	145.0	175	3.62	2.770	15.50	0	1	5	6
Ford Pantera L	15.8	8	351.0	264	4.22	3.170	14.50	0	1	5	4
Lotus Europa	30.4	4	95.1	113	3.77	1.513	16.90	1	1	5	2
Datsun 710	22.8	4	108.0	93	3.85	2.320	18.61	1	1	4	1
Merc 280C	17.8	6	167.6	123	3.92	3.440	18.90	1	0	4	4
Merc 450SE	16.4	8	275.8	180	3.07	4.070	17.40	0	0	3	3
Mazda RX4	21.0	6	160.0	110	3.90	2.620	16.46	0	1	4	4

Programming Structures



Programming Structures

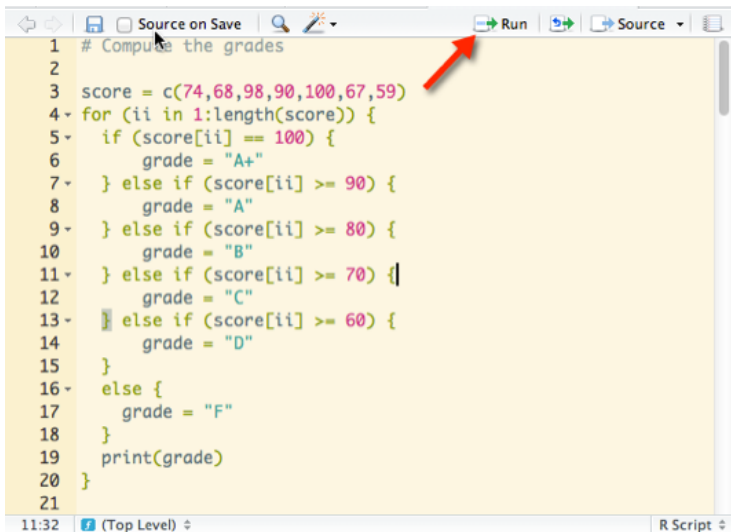
Goals for this Session:

- Understand the for-loop structure and how to use it
- "Walk" through a vector while accumulating a sum, computing a product, or some other operation.
- "Walk" through a matrix by row, (or column), while accumulating a sum, computing a product or some other arithmetic operation.
- "Walk" through a data frame by row to compute something. Also process the results of a previous "split" operation.
- Understand the if statement and how to branch based on the value of a vector or matrix element.
- Also use the if statement in conjunction with the for loop to do some processing.

Programming Structures

Some things to keep in mind for getting better with programming structures

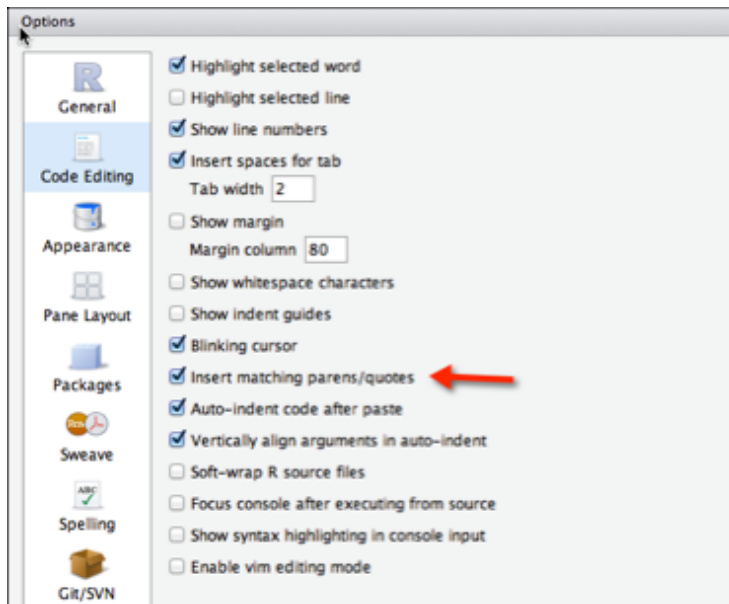
- Put the statements in the Editor window of RStudio and perfect them there. You can highlight sections of code and hit the "run" button
- You will most definitely make mistakes when writing loops. It is guaranteed. Better to get familiar with the most common mistakes ahead of time
- Work through the labs !
- The next assignment will assume facility with these structures



```
1 # Compute the grades
2
3 score = c(74,68,98,90,100,67,59)
4 for (ii in 1:length(score)) {
5   if (score[ii] == 100) {
6     grade = "A+"
7   } else if (score[ii] >= 90) {
8     grade = "A"
9   } else if (score[ii] >= 80) {
10    grade = "B"
11  } else if (score[ii] >= 70) {
12    grade = "C"
13  } else if (score[ii] >= 60) {
14    grade = "D"
15  }
16  else {
17    grade = "F"
18  }
19  print(grade)
20 }
21
```

The screenshot shows the RStudio interface. The top toolbar contains buttons for navigation and execution. A red arrow points to the 'Run' button, which is represented by a green arrow icon. The script in the editor is an R function to compute grades based on a vector of scores. The scores are 74, 68, 98, 90, 100, 67, and 59. The grades are assigned as follows: A+ for 100, A for 90-99, B for 80-89, C for 70-79, D for 60-69, and F for scores below 60. The script uses a for loop to iterate over each score and print the corresponding grade.

Go to Preferences -> Code Editing to turn on “insert matching parens/braces”



Programming Structures - for

This is a looping construct that let's you do some things for a specific number of times.

“name” is some index variable that takes on values returned by “expr_1”, which is almost always some type of sequence. It could represent the length of a vector or a row of a matrix.

```
for (name in expr_1) {  
    expr_2  
}
```

```
for (ii in 1:3) {  
    print(ii)  
}
```

```
[1] 1  
[1] 2  
[1] 3
```

Programming Structures - for

Better to generalize this - use the **length()** function so the loop will work with a vector of any size

```
x <- rnorm(3)
for (ii in 1:length(x)) {
  print(ii)
}
```

```
[1] 1
[1] 2
[1] 3
```

Here we access the actual values of x

```
x <- rnorm(3)
for (ii in 1:length(x)) {
  print(x[ii])
}
```

```
[1] -0.6257547
[1] 0.39524
[1] -1.955594
```


Programming Structures - for

Consider the example wherein we have a x values that we want to provide as input into some function that will generate y values.

```
y <- vector() # A blank vector
x <- 1:6
for (ii in 1:length(x)) {
  y[ii] <- x[ii]^2
}
```

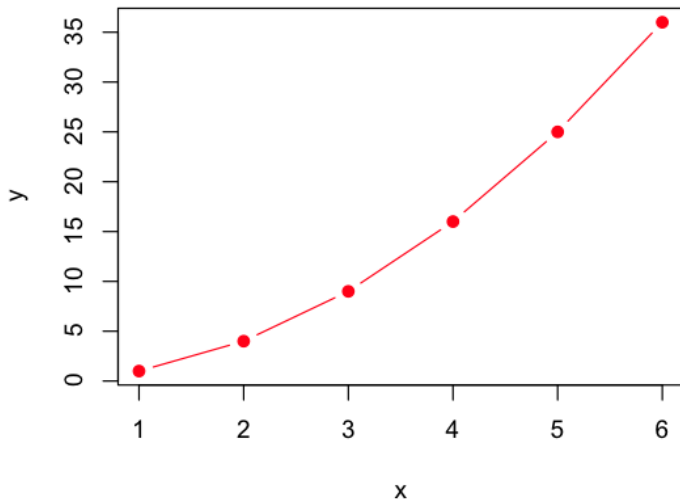
```
x
[1] 1 2 3 4 5 6

y
[1] 1 4 9 16 25 36

plot(x,y,main="Super Cool Data Plot",type="b",pch=19,col="red")
```

Programming Structures - for

Super Cool Data Plot



Programming Structures - for

Here we use a for-loop to add up the elements in a vector and find the average. There are already functions in R to do this but knowing how to do it yourself is important

```
x <- rnorm(1000,20,4) # 1,000 random elements from a N(20,4)
```

```
mysum <- 0
for (ii in 1:length(x)) {
  mysum <- mysum + x[ii]
}
avg <- mysum / length(x)
cat("The average of this vector is:",avg,"\n")
```

```
[1] "The average of this vector is: 20.1320691898645"
```

We could clean up the output a little bit

```
cat("The average of this vector is:",round(avg,2),"\n")
[1] "The average of this vector is: 20.13"
```

Programming Structures - for

Given a vector find the smallest value without using the "min" function:

```
set.seed(188)
x <- rnorm(1000) # 1,000 random elements from a N(20,4)

# Set the min to the first element of x. Unless we are very lucky then
# this will change as we walk through the vector

mymin <- x[1]
for (ii in 1:length(x)) {
  if (x[ii] < mymin) {
    mymin <- x[ii]
  }
}

mymin
[1] -3.422185

min(mymin)      # The internal R function matches what we got
[1] -3.422185
```

Programming Structures - for

We can loop through data frames also. Let's see if we can compute the mean of the MPG for all cars. Note that we use the **nrow** function to get the number of rows to loop over

```
mpgsum <- 0
for (ii in 1:nrow(mtcars)) {
  mpgsum <- mpgsum + mtcars[ii,"mpg"]
}

mpgmean <- mpgsum/nrow(mtcars)   # Divide the sum by the # of records

cat("Mean MPG for all cars is:",mpgmean,"\n")
Mean MPG for all cars is: 20.09062

mean(mtcars$mpg)
[1] 20.09062
```

Programming Structures - for

Remember the split command ? We can work with the output of that also. Relative to mtcars we let's split up the data frame by cylinder number, which is (4,6, or 8)

```
mysplits <- split(mtcars, mtcars$cyl)
```

```
str(mysplits, max.level=1)
```

```
List of 3
```

```
$ 4:'data.frame': 11 obs. of 11 variables:
```

```
$ 6:'data.frame': 7 obs. of 11 variables:
```

```
$ 8:'data.frame': 14 obs. of 11 variables:
```

We get back a list that contains 3 elements each of which has a data frame corresponding to the number of cylinders. We could summarize each of these data frame elements using a for loop

Programming Structures - for

```
mysplits
```

```
$`4`  
  
      mpg cyl  disp  hp drat   wt  qsec vs am gear carb  
Merc 240D   24.4  4 146.7  62 3.69 3.190 20.00 1  0   4   2  
Merc 230    22.8  4 140.8  95 3.92 3.150 22.90 1  0   4   2  
Toyota Corona 21.5  4 120.1  97 3.70 2.465 20.01 1  0   3   1  
..  
..
```

```
$`6`  
  
      mpg cyl  disp  hp drat   wt  qsec vs am gear carb  
Hornet 4 Drive 21.4  6 258.0 110 3.08 3.215 19.44 1  0   3   1  
Valiant        18.1  6 225.0 105 2.76 3.460 20.22 1  0   3   1  
Merc 280        19.2  6 167.6 123 3.92 3.440 18.30 1  0   4   4  
Merc 280C       17.8  6 167.6 123 3.92 3.440 18.90 1  0   4   4  
..  
..
```

```
$`8`  
  
      mpg cyl  disp  hp drat   wt  qsec vs am gear carb  
Hornet Sportabout 18.7  8 360.0 175 3.15 3.440 17.02 0  0   3   2  
Duster 360        14.3  8 360.0 245 3.21 3.570 15.84 0  0   3   4  
Merc 450SE        16.4  8 275.8 180 3.07 4.070 17.40 0  0   3   3  
Merc 450SL        17.3  8 275.8 180 3.07 3.730 17.60 0  0   3   3  
..  
..
```

Programming Structures - for

```
mysplit <- split(mtcars,mtcars$cyl)
```

```
for (ii in 1:length(mysplit)) {  
  print(nrow(mysplit[[ii]]))  
}
```

```
[1] 11
```

```
[1] 7
```

```
[1] 14
```

```
# This is equivalent to
```

```
sapply(mysplit, nrow)
```

```
4 6 8
```

```
11 7 14
```


Programming Structures - for

```
mysplit <- split(mtcars,mtcars$cyl)

for (ii in 1:length(mysplit)) {
  splitname <- names(mysplit[ii])
  cat("mean for",splitname,"cylinders is",mean(mysplit[[ii]]$mpg),"\n")
}

mean for 4 cylinders is 26.66364
mean for 6 cylinders is 19.74286
mean for 8 cylinders is 15.1

# This is basically equivalent to

apply(mysplit, function(x) mean(x$mpg))
      4      6      8
26.66364 19.74286 15.10000
```

Programming Structures - for

What about looping over each split and pulling out only those cars with an manual transmission ? ($am == 1$)

```
data(mtcars)
```

```
mysplit <- split(mtcars,mtcars$cyl)
```

```
mylist <- list() # Setup a blank list to contain the subset results
```

```
for (ii in 1:length(mysplit)) {  
  mylist[[ii]] <- subset(mysplit[[ii]], am == 1)  
}
```

```
mylist
```

```
# Equivalent to:
```

```
lapply(mysplit, subset, am == 1)
```

Programming Structures - for

Let's say we want to plot MPG vs. Weight for each cylinder group. Check it out:

```
mysplits <- split(mtcars, mtcars$cyl)

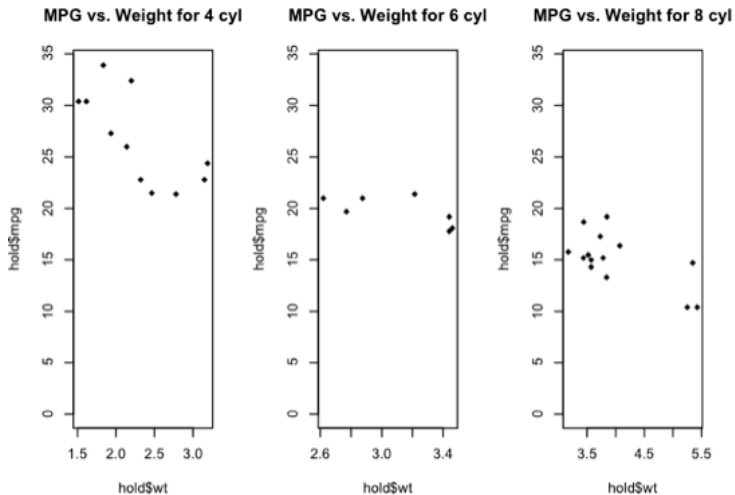
par(mfrow=c(1,3))    # This relates to plotting

for (ii in 1:length(mysplits)) {
  hold <- mysplits[[ii]]
  plot(hold$wt, hold$mpg, pch = 18, main=paste("MPG vs. Weight for",
    names(mysplits[ii]), "cyl",sep=" "),ylim=c(0,34))
}
```

NOTE:

```
names(mysplits[1])
[1] "4"
names(mysplits[2])
[1] "6"
names(mysplits[3])
[1] "8"
```

Programming Structures - for



Programming Structures - Using for with matrices

The for loop structure generalizes to matrices.

```
set.seed(123)
mymat <- matrix(round(rnorm(6),2),3,2)

for (ii in 1:nrow(mymat)) {
  cat("The sum of row",ii,"is",sum(mymat[ii,]),"\n")
}
```

The sum of row 1 is -0.49

The sum of row 2 is -0.1

The sum of row 3 is 3.28

Programming Structures - if

This is an easy structure. It tests a logical expression, which results in either a TRUE or FALSE condition, and, based on that, executes a specific block of code

```
if (logical_expression) {  
    do something  
    ...  
}
```

```
if (logical_expression) {  
    do something  
    ..  
} else {  
    do something else  
    ...  
}
```

Programming Structures - if

Here is a basic example

```
( x <- 3)
```

```
[1] 3
```

```
if (is.numeric(x)) {  
  print("x is a number")  
}
```

```
[1] "x is a number"
```

```
if (x != 3) {  
  print("x is not equal to 3")  
} else {  
  print("guess what ? x is in fact equal to 3")  
}  
[1] "guess what ? x is in fact equal to 3"
```

Programming Structures - if/else

Here is a more involved if statement that tests for several conditions. It uses the “else” keyword in addition to “if”. Note that an “if” statement does not require an “else” statement but an “else” statement requires a “parent” if statement.

```
some.num <- 3
```

```
if (some.num < 3) {           # A more involved if statement
  print("Less than 3")
} else if (some.num > 3) {
  print("Greater than 3")
} else {
  print("Must be equal to 3")
}
[1] "Must be equal to 3"
```


Programming Structures - if/else

if/else statements show up a lot in functions. Checking for valid arguments is a common practice.

```
x <- 4  
y <- 5
```

```
if (!is.numeric(x) | !is.numeric(y)) {  
  stop("I need numeric values to do this")  
} else {  
  if (x == y) {  
    print("Equal")  
  } else {  
    print("Not equal")  
  }  
}
```

```
[1] "Not equal"
```

Programming Structures - ifelse

- R supports a command called **ifelse** that is designed to work specifically on vectors.
- It works well for very large vectors. The format is **ifelse(test,yes,no)** where “test” is a logical expression to be evaluated.
- If it is TRUE then the action specified in the “yes” position will be executed. If the evaluated expression is FALSE then the action specified in the “no” position is executed.

```
some.data = rnorm(10000,0,2)
colors = ifelse(some.data < 0,"RED","GREEN")
plot(some.data,col=colors)
```

This would be the same as:

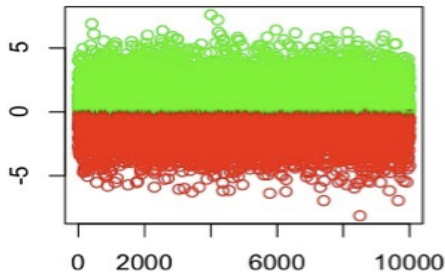
```
for (ii in 1:length(some.data)) {
  if (some.data[ii] < 0) {
    colors[ii] = "RED"
  } else {
    colors[ii] = "GREEN"
  }
}
```

Programming Structures - ifelse

```
some.data <- rnorm(10000,0,2)
colors <- ifelse(some.data < 0,"RED","GREEN")
plot(some.data,col=colors)
```

This would be the same as:

```
for (ii in 1:length(some.data)) {
  if (some.data[ii] < 0) {
    colors[ii] <- "RED"
  } else {
    colors[ii] <- "GREEN"
  }
}
```



Programming Structures - ifelse

We can use ifelse when we want to turn some continuous quantity within a data frame into a factor that we can then use to group by

```
mtcars$rating <- ifelse(mtcars$mpg >= mean(mtcars$mpg), "blue", "red")
```

```
head(mtcars)
```

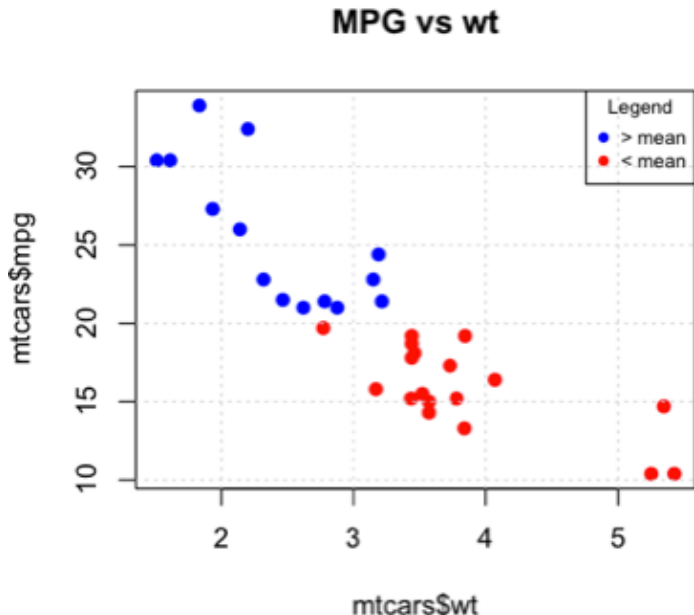
	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb	rating
Mazda RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4	blue
Mazda RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4	blue
Datsun 710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1	blue
Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1	blue
Hornet Sportabout	18.7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

```
plot(mtcars$mpg~mtcars$wt,col=mtcars$rating,pch=19, main="MPG vs wt")
```

```
grid()
```

```
legend("topright", c("> mean","< mean"), pch=19,  
      col=c("blue","red"),title="Legend",cex=0.7)
```

Programming Structures - ifelse



Programming Structures - ifelse

We can use ifelse when we want to turn some continuous quantity within a data frame into a factor that we can then use to group by

```
mtcars$rating <- ifelse(mtcars$mpg >= mean(mtcars$mpg), "blue", "red")
```

```
head(mtcars)
```

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

```
plot(mtcars$mpg~mtcars$wt,col=mtcars$rating,pch=19, main="MPG vs wt")
```

```
grid()
```

```
legend("topright", c("> mean","< mean"), pch=19,  
      col=c("blue","red"),title="Legend",cex=0.7)
```

Programming Structures - if statements and for loops

```
score <- c(74,68,98,90,100,67,59) # Exam scores to be graded
for (ii in 1:length(score)) {
  if (score[ii] == 100) {
    grade <- "A+"
  } else if (score[ii] >= 90) {
    grade <- "A"
  } else if (score[ii] >= 80) {
    grade <- "B"
  } else if (score[ii] >= 70) {
    grade <- "C"
  } else if (score[ii] >= 60) {
    grade <- "D"
  }
  else {
    grade <- "F"
  }
  print(grade)
}
```

[1] "C"
[1] "D"
[1] "A"
[1] "A"
[1] "A+"
[1] "D"
[1] "F"

Programming Structures - if statements and for loops

```
set.seed(123)
x <- round(runif(9,1,20))          # Are the elements in x odd or even
[1]  6 16  9 18 19  2 11 18 11

for (ii in 1:length(x)) {
  if (x[ii] %% 2 == 0) {
    print(TRUE)
  }
  else {
    print(FALSE)
  }
}

[1] TRUE
[1] TRUE
[1] FALSE
[1] TRUE
[1] FALSE
[1] TRUE
[1] FALSE
[1] TRUE
[1] FALSE
```


Programming Structures - if statements and for loops

This example mimics the bracket notation

```
set.seed(123)
x <- round(runif(10,1,20))
[1] 7 13 16 8 13 19 9 11 13 11

logvec <- vector()           # Setup an empty vector
for (ii in 1:length(x)) {
  if (x[ii] %% 2 == 0) {
    logvec[ii] <- TRUE
  }
  else {
    logvec[ii] <- FALSE
  }
}
logvec
[1] TRUE TRUE FALSE TRUE FALSE TRUE FALSE TRUE FALSE TRUE

x[logvec]
[1] 6 16 18 2 18 10
```

Programming Structures - if statements and for loops

One can easily “break” out of a for loop based on some condition.
Normally you should clean your data before processing but perhaps not

Let's say that you are processing elements of a vector and if you encounter a value of NA then you want to stop the for loop

```
my.vec <- c(1,2,3,NA,5,6,7,8,9,10)
```

```
for (ii in 1:length(my.vec)) {  
  if (is.na(my.vec[ii])) {  
    break  
  }  
  cat("element is ",ii,"\n")  
}
```

```
element is 1  
element is 2  
element is 3
```

Programming Structures - if statements and for loops

Here we want to “catch” the the missing value and then “skip over it”. To do this we would use the “next” statement.

```
my.vec <- c(1,2,3,NA,5,6,7,8,9,10)
```

```
for (ii in 1:length(my.vec)) {  
  if (is.na(my.vec[ii])) {  
    next  
  }  
  cat("element is ",ii,"\n")  
}
```

```
element is  2  
element is  3  
element is  5  
element is  6  
element is  7  
element is  8  
element is  9  
element is 10
```

Programming Structures - if statements and for loops

Here is an example that will be useful when processing things like genetic sequences. Let's say we have a string of text we wish to "encode" by changing all vowels to something else. This would not be a tough code to break but let's see what is involved. In our code we:

```
We'll change      a to s,  
                   e to t,  
                   i to u,  
                   o to v,  
                   u to w
```

So a string like:

```
sequence <- "Hello my name is Ed. Happy to meet you"
```

would come out like:

```
"Htllv my nsmt us td. Hsppy tv mttt yvw"
```

Programming Structures - if statements and for loops

```
sequence <- "Hello my name is Ed. Happy to meet you"
```

```
seq <- unlist(strsplit(sequence,""))
```

```
[1] "H" "e" "l" "l" "o" " " "m" "y" " " "n" "a" "m" "e" " " "  
    "i" "s" " " "E" "d" "." " " "H" "a" "p" "p" "y" " " "t"  
    "o" " " "m" "e" "e" "t" " " "y" "o" "u"
```

```
sequence <- "Hello my name is Ed. Happy to meet you"
```

```
seq <- unlist(strsplit(sequence,""))
```

```
for (ii in 1:length(seq)) {
```

```
  # Write code to inspect each element of seq to determine if it is  
  # a candidate for changing.
```

```
}
```

```
"Htllv my nsmt us Ed. Hsppy tv mttt yvw"
```

Programming Structures - while

The **while** loop is similar to the for loop. We have some expression that must be evaluated until some condition is met. This is useful when we are writing code that must converge on something.

```
sum <- 0
n <- 1000
i <- 1
while (i <= n) {
  sum <- sum + i
  i <- i + 1
}
sum
[1] 500500
# The following is equivalent
sum <- 0
n <- 1000
for (i in 1:n) {
  sum <- sum + 1
}
sum
```

Programming Structures - while

Taking the square root of a number and then taking the square root of that result and so will eventually converge to 1. We can use a while loop to do this

```
num <- 13
sqrtval <- sqrt(num)

# Loop until the sqrt value becomes equal to 1

while ( sqrtval != 1) {
  sqrtval <- sqrt(sqrtval)

# sprintf allows us to format a variable according to a pattern
# See http://www.cookbook-r.com/Strings/Creating\_strings\_from\_variables/

  print(sprintf("%.12f",sqrtval))
}
```