Class 9: Halloween Candy Project

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Today we will examine data from 538 on common Halloween candy. In particular we will use ggplot, dplyr, and PCA to make sense of this multivariate dataset.

1. Importing candy data

```r
candy <- read.csv("candy-data.csv", row.names=1)
head(candy)
```

```
             chocolate fruity caramel peanutyalmondy nougat crispedricewafer
100 Grand            1      0       1              0      0                1
3 Musketeers         1      0       0              0      1                0
One dime             0      0       0              0      0                0
One quarter          0      0       0              0      0                0
Air Heads            0      1       0              0      0                0
Almond Joy           1      0       0              1      0                0
             hard bar pluribus sugarpercent pricepercent winpercent
100 Grand       0   1        0        0.732        0.860   66.97173
3 Musketeers    0   1        0        0.604        0.511   67.60294
```

```
One dime          0   0         0         0.011         0.116   32.26109
One quarter       0   0         0         0.011         0.511   46.11650
Air Heads         0   0         0         0.906         0.511   52.34146
Almond Joy        0   1         0         0.465         0.767   50.34755
```

2. What is your favorite candy?

> Q1. How many different candy types are in this dataset?

```r
nrow(candy)
```

```
[1] 85
```

> Q2. How many fruity candy types are in the dataset?

```r
sum(candy$fruity)
```

```
[1] 38
```

> How many chocolate candy are there in the dataset?

```r
sum(candy$chocolate)
```

```
[1] 37
```

> Q3. What is your favorite candy in the dataset and what is it's winpercent value?

```r
candy["Snickers", "winpercent"]
```

```
[1] 76.67378
```

> Q4. What is the winpercent value for "Kit Kat"?

```r
candy["Kit Kat",]$winpercent
```

```
[1] 76.7686
```

> Q5. What is the winpercent value for "Tootsie Roll Snack Bars"?

```
candy["Tootsie Roll Snack Bars", "winpercent"]
```

```
[1] 49.6535
```

To get a quick overview of a new dataset the `skimr` package can be useful: Install `skimr` package in console

```
library("skimr")
skim(candy)
```

Table 1: Data summary

Name	candy
Number of rows	85
Number of columns	12
Column type frequency:	
numeric	12
Group variables	None

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
chocolate	0	1	0.44	0.50	0.00	0.00	0.00	1.00	1.00	
fruity	0	1	0.45	0.50	0.00	0.00	0.00	1.00	1.00	
caramel	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
peanutyalmondy	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
nougat	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
crispedricewafer	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
hard	0	1	0.18	0.38	0.00	0.00	0.00	0.00	1.00	
bar	0	1	0.25	0.43	0.00	0.00	0.00	0.00	1.00	
pluribus	0	1	0.52	0.50	0.00	0.00	1.00	1.00	1.00	
sugarpercent	0	1	0.48	0.28	0.01	0.22	0.47	0.73	0.99	
pricepercent	0	1	0.47	0.29	0.01	0.26	0.47	0.65	0.98	
winpercent	0	1	50.32	14.71	22.45	39.14	47.83	59.86	84.18	

> Q6. Is there any variable/column that looks to be on a different scale to the majority of the other columns in the dataset?

It looks like the `winpercent` column is on a different scale that the others; it is from 0-100% while all other columns are from 0-1. I will need to scale this dataset before analysis like PCA.

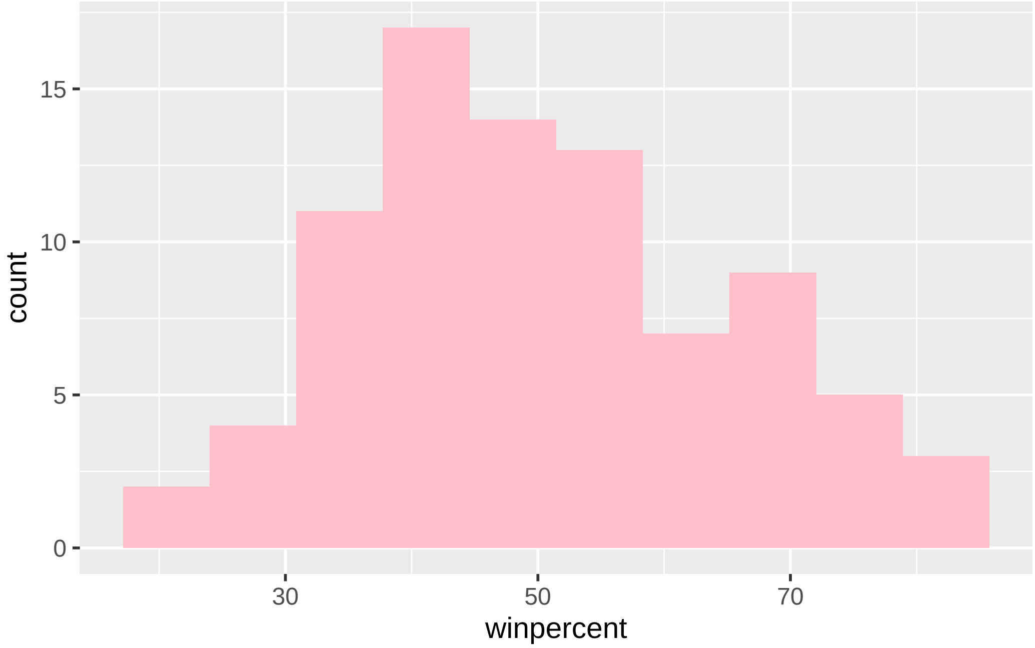
> Q7. What do you think a zero and one represent for the candy$chocolate column?

A 0 means that there it is not a chocolate candy while a 1 means that it is.

> Q8. Plot a histogram of winpercent values

```r
library(ggplot2)

ggplot(candy) +
  aes(x=winpercent) +
  geom_histogram(bins=10, fill="pink")
```



> Q9. Is the distribution of winpercent values symmetrical?

No, it is not symmetrical.

> Q10. Is the center of the distribution above or below 50%?

```r
summary(candy$winpercent)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  22.45   39.14   47.83   50.32   59.86   84.18 
```

The center of distribution is below 50%; the median is 47.83.

Q11. On average is chocolate candy higher or lower ranked than fruit candy?

- step 1: find all "chocolate" candy
- step 2: find their "winpercent" values
- step 3: summarize these values
- step 4: find all "fruity" candy
- step 5: find their "winpercent" values
- step 6: summarize these values
- step 7: compare the two summary values

1. Find all chocolate candy

```r
choc.inds <- candy$chocolate == 1
```

2. Find their winpercent values

```r
choc.win <- candy[choc.inds,]$winpercent
```

3. Summarize these values

```r
choc.mean <- mean(choc.win)
choc.mean
```

```
[1] 60.92153
```

Do the same thing for fruity candy

5. Find all fruity candy

```r
fruity.inds <- candy$fruity == 1
```

6. Find their winpercent values

```r
fruity.win <- candy[fruity.inds,]$winpercent
```

7. Summarize these values

```r
fruity.mean <- mean(fruity.win)
fruity.mean
```

```
[1] 44.11974
```

Clearly chocolate has a higher mean `winpercent` than fruity candy

```r
choc.mean
```

```
[1] 60.92153
```

```r
fruity.mean
```

```
[1] 44.11974
```

> Q12. Is this difference statistically significant?

```r
t.test(choc.win, fruity.win)
```

```

	Welch Two Sample t-test

data:  choc.win and fruity.win
t = 6.2582, df = 68.882, p-value = 2.871e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 11.44563 22.15795
sample estimates:
mean of x mean of y 
 60.92153  44.11974 
```

The p-value is extremely low (<0.05); the difference is statistically significant.

3. Overall Candy Rankings

> Q13. What are the five least liked candy types in this set?

```
# Not that useful - it just sorts the values
sort( candy$winpercent )
```

```
 [1] 22.44534 23.41782 24.52499 27.30386 28.12744 29.70369 32.23100 32.26109
 [9] 33.43755 34.15896 34.51768 34.57899 34.72200 35.29076 36.01763 37.34852
[17] 37.72234 37.88719 38.01096 38.97504 39.01190 39.14106 39.18550 39.44680
[25] 39.46056 41.26551 41.38956 41.90431 42.17877 42.27208 42.84914 43.06890
[33] 43.08892 44.37552 45.46628 45.73675 45.99583 46.11650 46.29660 46.41172
[41] 46.78335 47.17323 47.82975 48.98265 49.52411 49.65350 50.34755 51.41243
[49] 52.34146 52.82595 52.91139 54.52645 54.86111 55.06407 55.10370 55.35405
[57] 55.37545 56.49050 56.91455 57.11974 57.21925 59.23612 59.52925 59.86400
[65] 60.80070 62.28448 63.08514 64.35334 65.71629 66.47068 66.57458 66.97173
[73] 67.03763 67.60294 69.48379 70.73564 71.46505 72.88790 73.09956 73.43499
[81] 76.67378 76.76860 81.64291 81.86626 84.18029
```

```
x <- c(10, 1, 100)
order(x)
```

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

```
x[ order(x)]
```

```
[1]   1  10 100
```

The `order()` function tells us how to arrange the elements of the input to make them sorted - i.e. how to order them

We can determine the order of winpercent to make them sorted and use that order to arrange the whole dataset.

```
ord.inds <- order(candy$winpercent)
head(candy[ord.inds,])
```

```
                   chocolate fruity caramel peanutyalmondy nougat
Nik L Nip                  0      1       0              0      0
Boston Baked Beans         0      0       0              1      0
Chiclets                   0      1       0              0      0
Super Bubble               0      1       0              0      0
Jawbusters                 0      1       0              0      0
Root Beer Barrels          0      0       0              0      0
```

```
                   crispedricewafer hard bar pluribus sugarpercent pricepercent
Nik L Nip                         0    0   0        1        0.197        0.976
Boston Baked Beans                0    0   0        1        0.313        0.511
Chiclets                          0    0   0        1        0.046        0.325
Super Bubble                      0    0   0        0        0.162        0.116
Jawbusters                        0    1   0        1        0.093        0.511
Root Beer Barrels                 0    1   0        1        0.732        0.069
                   winpercent
Nik L Nip            22.44534
Boston Baked Beans   23.41782
Chiclets             24.52499
Super Bubble         27.30386
Jawbusters           28.12744
Root Beer Barrels    29.70369
```

The top 5 least favorite candy are Nik L Nip, Boston Baked Beans, Chiclets, Super Bubble, Jawbusters, and Root Beer Barrels.

Q14. What are the top 5 all time favorite candy types out of this set?

```
tail(candy[ord.inds,])
```

```
                          chocolate fruity caramel peanutyalmondy nougat
Reese's pieces                    1      0       0              1      0
Snickers                          1      0       1              1      1
Kit Kat                           1      0       0              0      0
Twix                              1      0       1              0      0
Reese's Miniatures                1      0       0              1      0
Reese's Peanut Butter cup         1      0       0              1      0
                          crispedricewafer hard bar pluribus sugarpercent
Reese's pieces                           0    0   0        1        0.406
Snickers                                 0    0   1        0        0.546
Kit Kat                                  1    0   1        0        0.313
Twix                                     1    0   1        0        0.546
Reese's Miniatures                       0    0   0        0        0.034
Reese's Peanut Butter cup                0    0   0        0        0.720
                          pricepercent winpercent
Reese's pieces                   0.651   73.43499
Snickers                         0.651   76.67378
Kit Kat                          0.511   76.76860
Twix                             0.906   81.64291
Reese's Miniatures               0.279   81.86626
Reese's Peanut Butter cup        0.651   84.18029
```

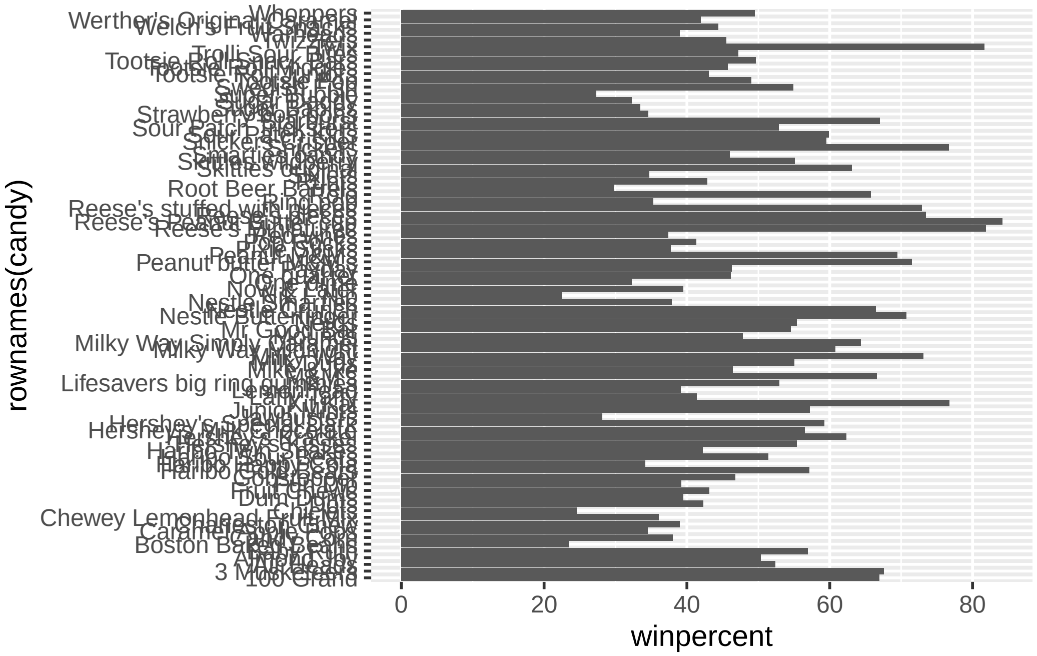
```
ord.inds2 <- order(candy$winpercent, decreasing = T)
head(candy[ord.inds2,])
```

```
                         chocolate fruity caramel peanutyalmondy nougat
Reese's Peanut Butter cup        1      0       0              1      0
Reese's Miniatures               1      0       0              1      0
Twix                             1      0       1              0      0
Kit Kat                          1      0       0              0      0
Snickers                         1      0       1              1      1
Reese's pieces                   1      0       0              1      0
                         crispedricewafer hard bar pluribus sugarpercent
Reese's Peanut Butter cup               0    0   0        0        0.720
Reese's Miniatures                      0    0   0        0        0.034
Twix                                    1    0   1        0        0.546
Kit Kat                                 1    0   1        0        0.313
Snickers                                0    0   1        0        0.546
Reese's pieces                          0    0   0        1        0.406
                         pricepercent winpercent
Reese's Peanut Butter cup        0.651   84.18029
Reese's Miniatures               0.279   81.86626
Twix                             0.906   81.64291
Kit Kat                          0.511   76.76860
Snickers                         0.651   76.67378
Reese's pieces                   0.651   73.43499
```

The top five favorite are Reese's Peanut Butter cup, Reese's Miniatures, Twix, Kit Kat, and Snickers.

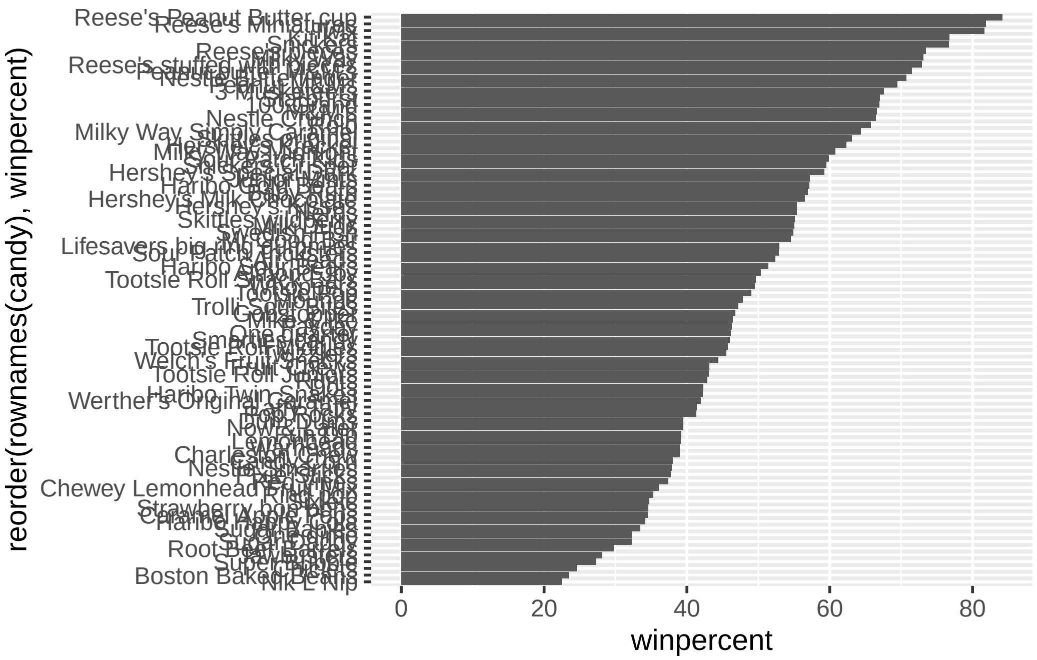
> Q15. Make a first barplot of candy ranking based on winpercent values.

```
ggplot(candy) +
  aes(x=winpercent, y=rownames(candy)) +
  geom_col()
```



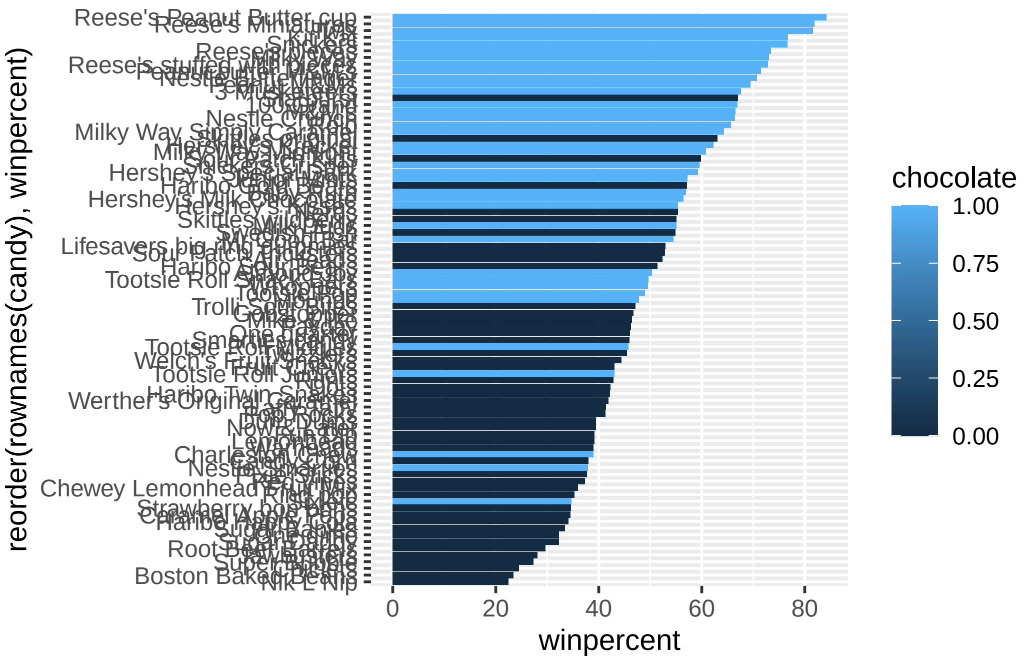
Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent?

```
ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent)) +
  geom_col()
```



Time to add some useful color

```
ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent), fill=chocolate) +
  geom_col()
```



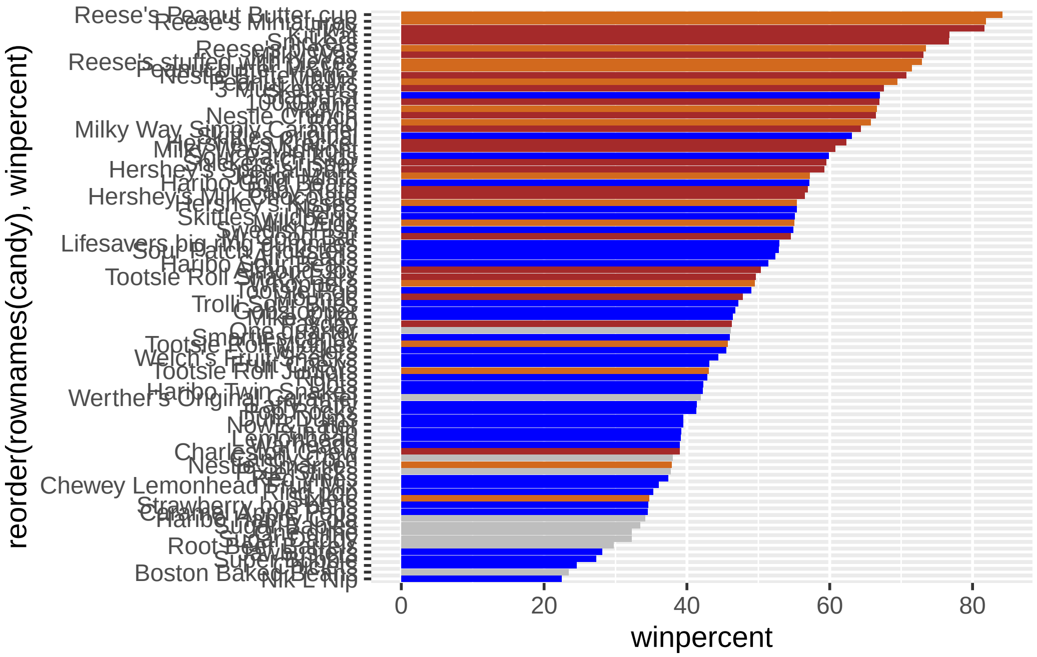
We need to make our own separate color vector where we can spell out what candy is colored a particular color.

```
mycols <- rep("gray", nrow(candy))
mycols[candy$chocolate == 1] <- "chocolate"
mycols[candy$bar == 1] <- "brown"
mycols[candy$fruity == 1] <- "blue"
mycols
```

```
 [1] "brown"     "brown"     "gray"      "gray"      "blue"      "brown"    
 [7] "brown"     "gray"      "gray"      "blue"      "brown"     "blue"     
[13] "blue"      "blue"      "blue"      "blue"      "blue"      "blue"     
[19] "blue"      "gray"      "blue"      "blue"      "chocolate" "brown"    
[25] "brown"     "brown"     "blue"      "chocolate" "brown"     "blue"     
[31] "blue"      "blue"      "chocolate" "chocolate" "blue"      "chocolate"
[37] "brown"     "brown"     "brown"     "brown"     "brown"     "blue"     
[43] "brown"     "brown"     "blue"      "blue"      "brown"     "chocolate"
[49] "gray"      "blue"      "blue"      "chocolate" "chocolate" "chocolate"
[55] "chocolate" "blue"      "chocolate" "gray"      "blue"      "chocolate"
[61] "blue"      "blue"      "chocolate" "blue"      "brown"     "brown"    
[67] "blue"      "blue"      "blue"      "blue"      "gray"      "gray"     
[73] "blue"      "blue"      "blue"      "chocolate" "chocolate" "brown"    
[79] "blue"      "brown"     "blue"      "blue"      "blue"      "gray"     
```

```
[85] "chocolate"
```

```
ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent)) +
  geom_col(fill=mycols)
```



Q17. What is the worst ranked chocolate candy?

Sixlets

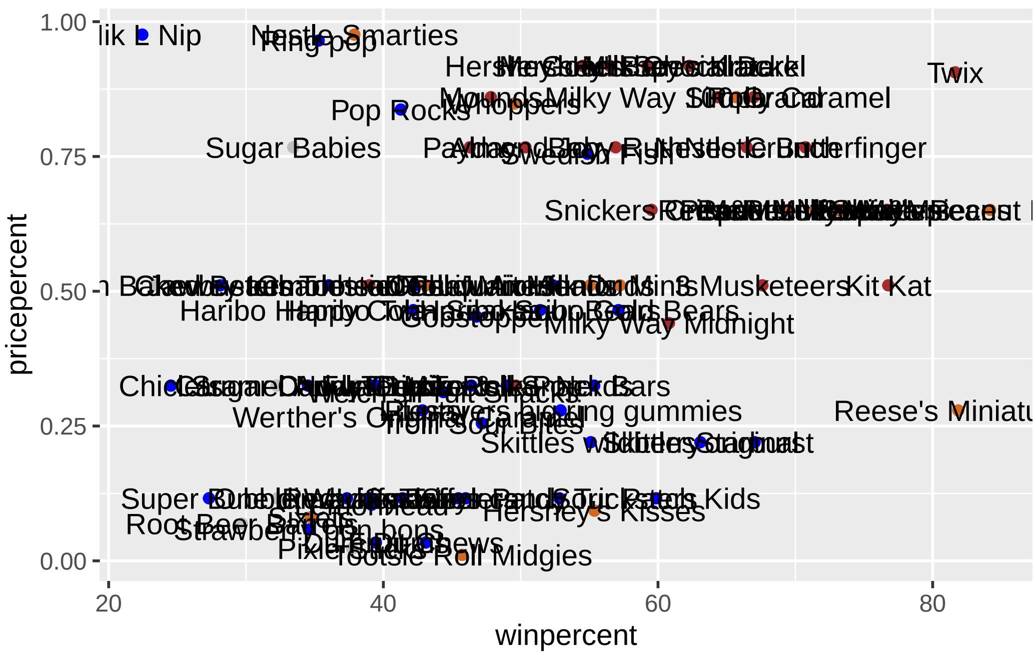
Q18. What is the best ranked fruity candy?

Starburst

4. Taking a look at pricepercent

Make a plot of winpercent (x-axis) vs pricepercent (y-axis)

```
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=mycols) +
  geom_text()
```

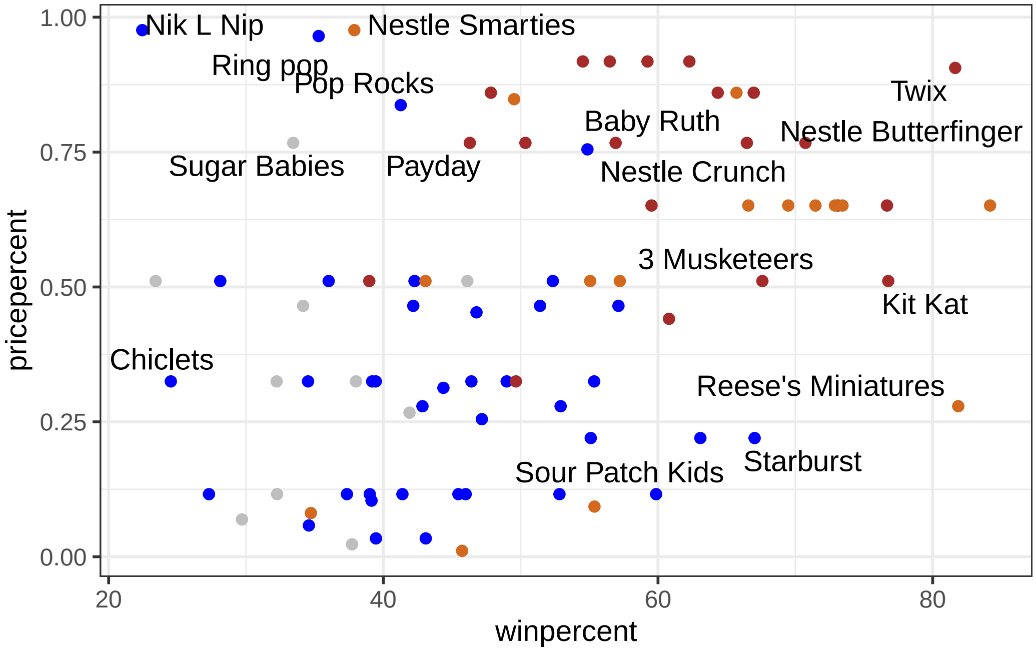


To avoid the overplotting of the text labels, we can use the add on package **ggrepel**

```
library(ggrepel)

ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=mycols) +
  geom_text_repel(max.overlaps = 6) +
  theme_bw()
```

```
Warning: ggrepel: 69 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



> Q19. Which candy type is the highest ranked in terms of winpercent for the least money - i.e. offers the most bang for your buck?

Reese’s Miniatures

> Q20. What are the top 5 most expensive candy types in the dataset and of these which is the least popular?

```
ord.price <- order(candy$pricepercent, decreasing = TRUE)
head( candy[ord.price,c(11,12)], n=5 )
```

```
                         pricepercent winpercent
Nik L Nip                       0.976   22.44534
Nestle Smarties                 0.976   37.88719
Ring pop                        0.965   35.29076
Hershey's Krackel               0.918   62.28448
Hershey's Milk Chocolate        0.918   56.49050
```

Nik L Nip, Nestle Smarties, Ring pop, Hershey’s Krackel, and Hershey’s Milk Chocolate are the top 5 most expensive candy types. Nik L Nip is the least popular; it has the lowest winpercent.

5. Exploring the correlation structure

Now that we have explored the dataset a little, we will see how the variables interact with one another.

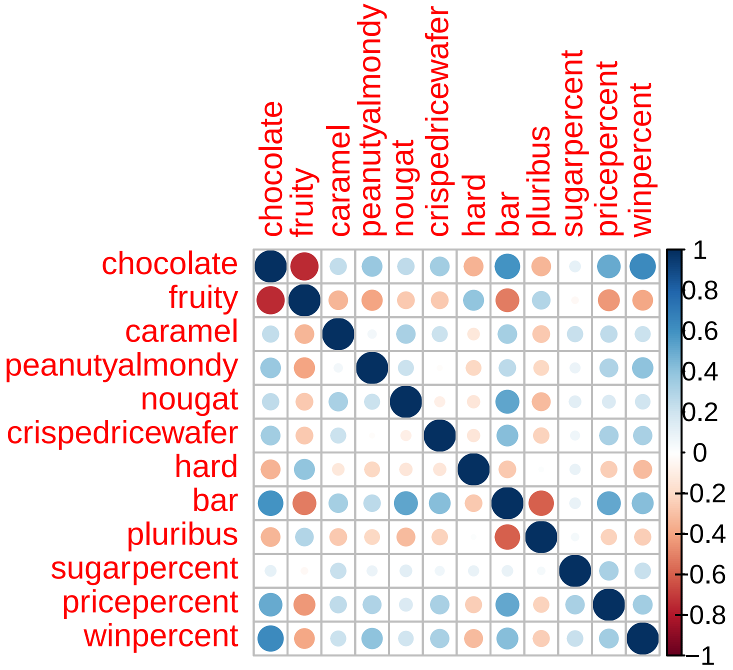
First, we will use correlation and view the results with the **corrplot** package to plot a correlation matrix.

```
cij <- cor(candy)
```

```
library(corrplot)
```

```
corrplot 0.95 loaded
```

```
corrplot(cij)
```



Q22. Examining this plot what two variables are anti-correlated (i.e. have minus values)?

Chocolate and fruity are anti-correlated. Pluribus and bar, and fruity and bar are also anti-correlated.

Q23. Similarly, what two variables are most positively correlated?

Chocolate and winpercent are postiviely correlated

6. Principal Component Analysis

Let's apply PCA using the `prcomp()` function to our candy dataset remembering to set the **scale=TRUE** argument.

```
pca <- prcomp(candy, scale=TRUE)
summary(pca)
```

```
Importance of components:
                          PC1    PC2    PC3     PC4    PC5     PC6     PC7
Standard deviation     2.0788 1.1378 1.1092 1.07533 0.9518 0.81923 0.81530
Proportion of Variance 0.3601 0.1079 0.1025 0.09636 0.0755 0.05593 0.05539
Cumulative Proportion  0.3601 0.4680 0.5705 0.66688 0.7424 0.79830 0.85369
                           PC8     PC9    PC10    PC11    PC12
Standard deviation     0.74530 0.67824 0.62349 0.43974 0.39760
Proportion of Variance 0.04629 0.03833 0.03239 0.01611 0.01317
Cumulative Proportion  0.89998 0.93832 0.97071 0.98683 1.00000
```

```
attributes(pca)
```

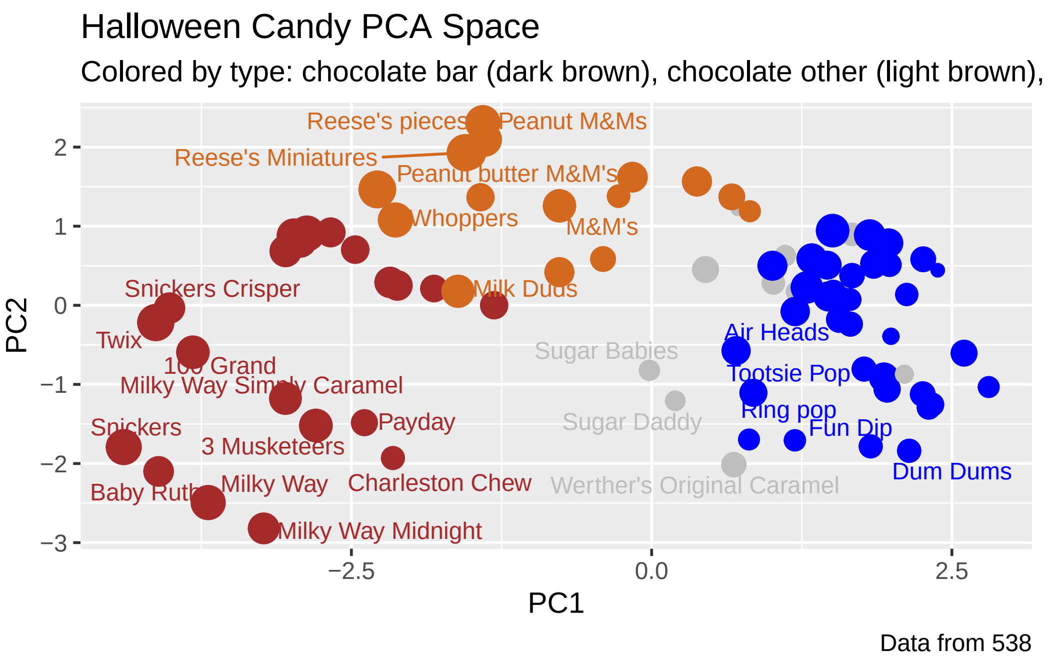
```
$names
[1] "sdev"     "rotation" "center"   "scale"    "x"       

$class
[1] "prcomp"
```

Let's plot our main results as our PCA "score plot"

```
my_data <- cbind(candy, pca$x[,1:3])
ggplot(my_data) +
  aes(PC1, PC2, size=winpercent/100, label=rownames(pca$x)) +
  geom_point(col=mycols) +
  geom_text_repel(size=3.3, col=mycols, max.overlaps = 7) +
  theme(legend.position = "none") +
  labs(title="Halloween Candy PCA Space",
       subtitle="Colored by type: chocolate bar (dark brown), chocolate other (light brown),
       caption="Data from 538")
```

```
Warning: ggrepel: 59 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



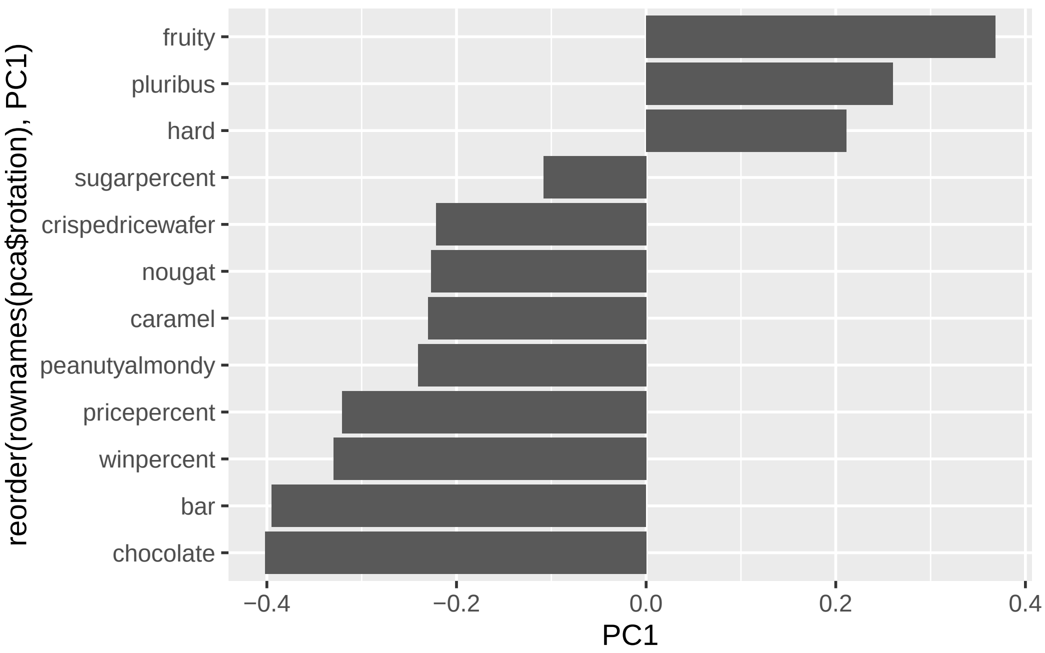
Using plotly to generate an interactive plot; use `install.packages()` in console (**Can not add ggplotly to pdf**)

```
#p <- ggplot(my_data) +
#  aes(PC1, PC2, size=winpercent/100, label=rownames(pca$x)) +
#  geom_point(col=mycols)

#library(plotly)
#ggplotly(p)
```

Finally let's look at how the original variables contribute to the PCs, starting with PC1

```
ggplot(pca$rotation) +
  aes(PC1, reorder( rownames(pca$rotation), PC1)) +
  geom_col()
```



> Q24. What original variables are picked up strongly by PC1 in the positive direction? Do these make sense to you?

The variables fruity, pluribus, and hard are picked up strongly by PC1 in the positive direction. This makes sense because in the plot of PC1 vs PC2, the points on the positive end of the PC1 axis tend to possess these traits. Additionally, when looking at the correlation matrix, these three original variables are correlated to each other.