BIMM 143 Class 09

Xaler Lu (A17384854)

Background

Set up

```
candy <- read.csv("https://raw.githubusercontent.com/fivethirtyeight/data/master/candy-pow
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
```

2.1 What is in the dataset?

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

There are 85 observations or candy types.

```
str(candy)
```

```
'data.frame':   85 obs. of  12 variables:
 $ chocolate       : int  1 1 0 0 0 1 1 0 0 0 ...
 $ fruity          : int  0 0 0 0 1 0 0 0 0 1 ...
 $ caramel         : int  1 0 0 0 0 0 1 0 0 1 ...
 $ peanutyalmondy  : int  0 0 0 0 0 1 1 1 0 0 ...
 $ nougat          : int  0 1 0 0 0 0 1 0 0 0 ...
 $ crispedricewafer: int  1 0 0 0 0 0 0 0 0 0 ...
 $ hard            : int  0 0 0 0 0 0 0 0 0 0 ...
 $ bar             : int  1 1 0 0 0 1 1 0 0 0 ...
 $ pluribus        : int  0 0 0 0 0 0 0 1 1 0 ...
 $ sugarpercent    : num  0.732 0.604 0.011 0.011 0.906 ...
 $ pricepercent    : num  0.86 0.511 0.116 0.511 0.511 ...
 $ winpercent      : num  67 67.6 32.3 46.1 52.3 ...
```

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

There are 38 fruity candies.

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

```
[1] 38
```

2.2 What is your favorite candy?

We can search a specific cell in the data to find the preference of Twix.

```
candy["Twix", ]$winpercent
```

```
[1] 81.64291
```

Alternatively, we use dplyr to find the preference of Twix.

```
library(dplyr)
```

```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag
```

```
The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
  candy |>
    filter(row.names(candy)=="Twix") |>
    select(winpercent)
```

```
     winpercent
Twix   81.64291
```

Q3. What is your favorite candy (other than Twix) in the dataset and what is it's winpercent value?

```
  candy |>
    filter(row.names(candy)=="Milky Way") |>
    select(winpercent)
```

```
          winpercent
Milky Way   73.09956
```

```
  candy.win <- function(x) {
    candy |>
    filter(row.names(candy)== x) |>
    select(winpercent)
  }

  candy.win("Milky Way")
```

```
          winpercent
Milky Way   73.09956
```

Milky Way has a win percent value of 73.10%.

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

The percent is 76.77% for Kit Kat

```
  candy.win("Kit Kat")
```

```
          winpercent
Kit Kat      76.7686
```

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

```
candy.win("Tootsie Roll Snack Bars")
```

```
                        winpercent
Tootsie Roll Snack Bars    49.6535
```

Side-Note: The `skimr::skim()` function

```
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	

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
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?

The winpercent is on a different scale because it is a percentage while the other are proportions. This means we need to set `scale = T` during our PCA.

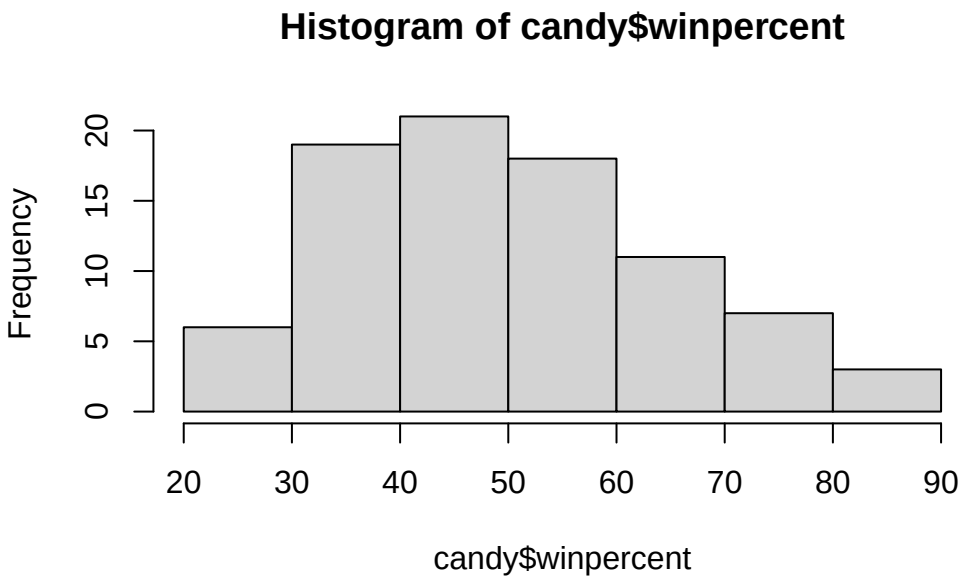
Q7. What do you think a zero and one represent for the candy$chocolate column?

The candy that is considered a chocolate candy.

3 Exploratory analysis

Q8. Plot a histogram of winpercent values

```
hist(candy$winpercent)
```

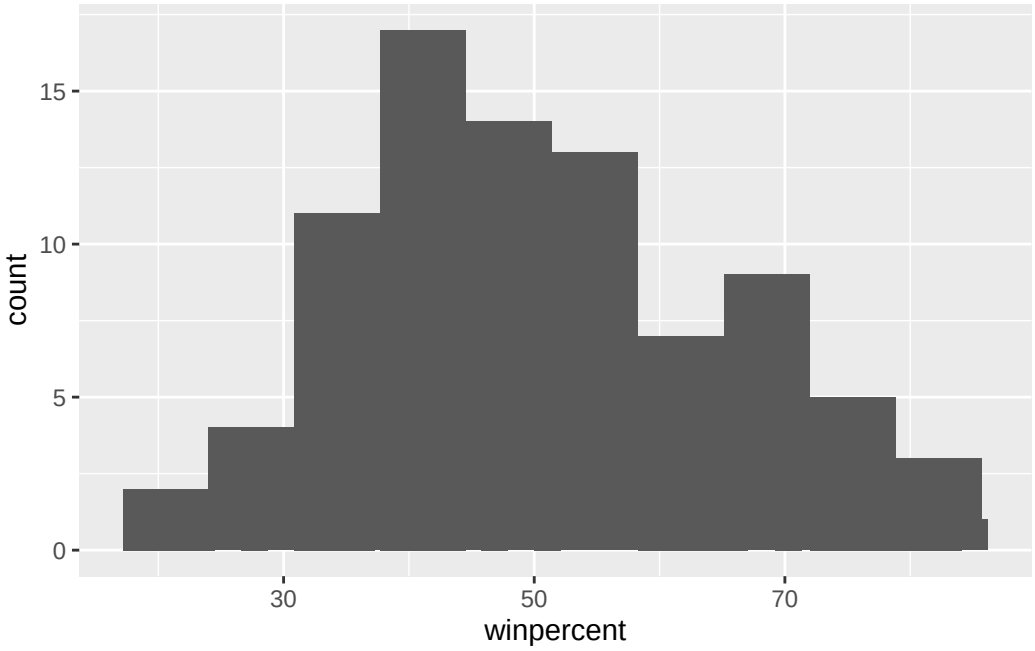



```
library(ggplot2)
```

```
Warning: package 'ggplot2' was built under R version 4.3.3
```

```
  ggplot(candy, aes(winpercent)) + geom_histogram() + stat_bin(bins=10)
```

```
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Q9. Is the distribution of winpercent values symmetrical?

The histogram is ever-so-slightly skewed to the right, but I see one peak.

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

The center distribution is below 50%.

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

Chocolate is ranked higher than fruit candy

```
  mean(candy$winpercent[as.logical(candy$chocolate)])
```

```
[1] 60.92153
```

```
mean(candy$winpercent[as.logical(candy$fruity)])
```

```
[1] 44.11974
```

Q12. Is this difference statistically significant?

Welch Two Sample T-Test: Comparing Chocolate with Fruity Candy

The p-value of 0.006 means we would reject the null hypothesis and conclude that there is a statistical difference between chocolate and fruity candy.

```
t.test(candy$winpercent[candy$fruity], candy$winpercent[as.logical(candy$chocolate)])
```

```
    Welch Two Sample t-test

data:  candy$winpercent[candy$fruity] and candy$winpercent[as.logical(candy$chocolate)]
t = 2.8727, df = 36, p-value = 0.006785
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  1.778754 10.321637
sample estimates:
mean of x mean of y
 66.97173  60.92153
```

4 Overall Candy Rankings

Use "Base R" `order()` to sort winpercent. This is the top five candy. Either the Base R and dplyr are fine for this function.

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

In winpercent, the bottom five are below.

```
candy |>
  arrange(winpercent) |> head(5)
```

```
                  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
                   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
                   winpercent
Nik L Nip            22.44534
Boston Baked Beans   23.41782
Chiclets             24.52499
Super Bubble         27.30386
Jawbusters           28.12744
```

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

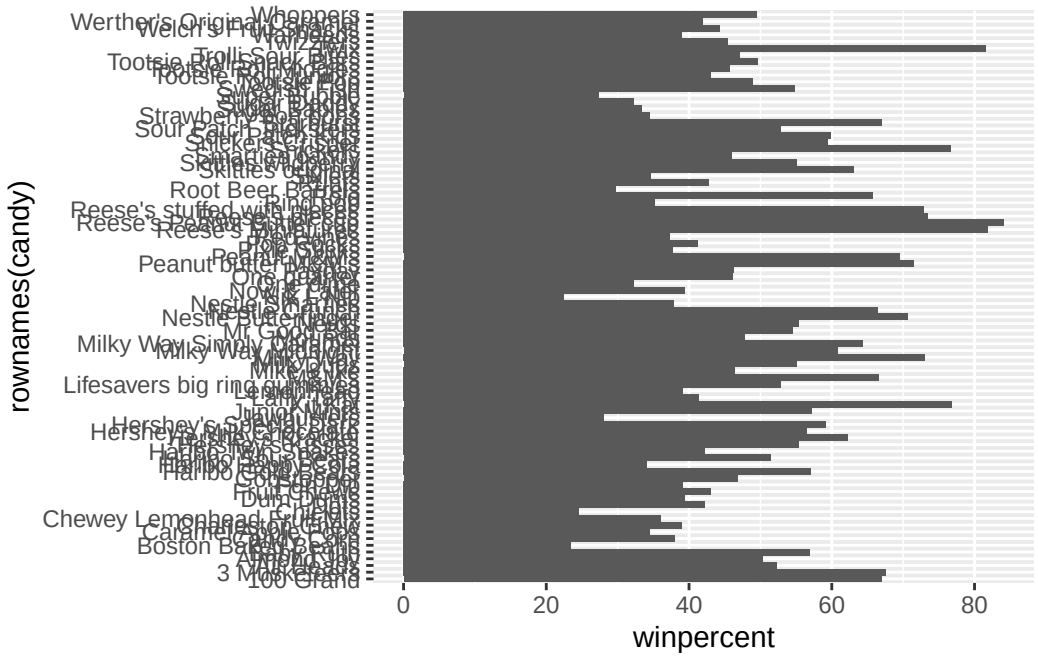
The top favorite candies.

```
candy |>
  arrange(winpercent) |> tail(5)
```

```
                         chocolate fruity caramel peanutyalmondy nougat
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
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
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
```

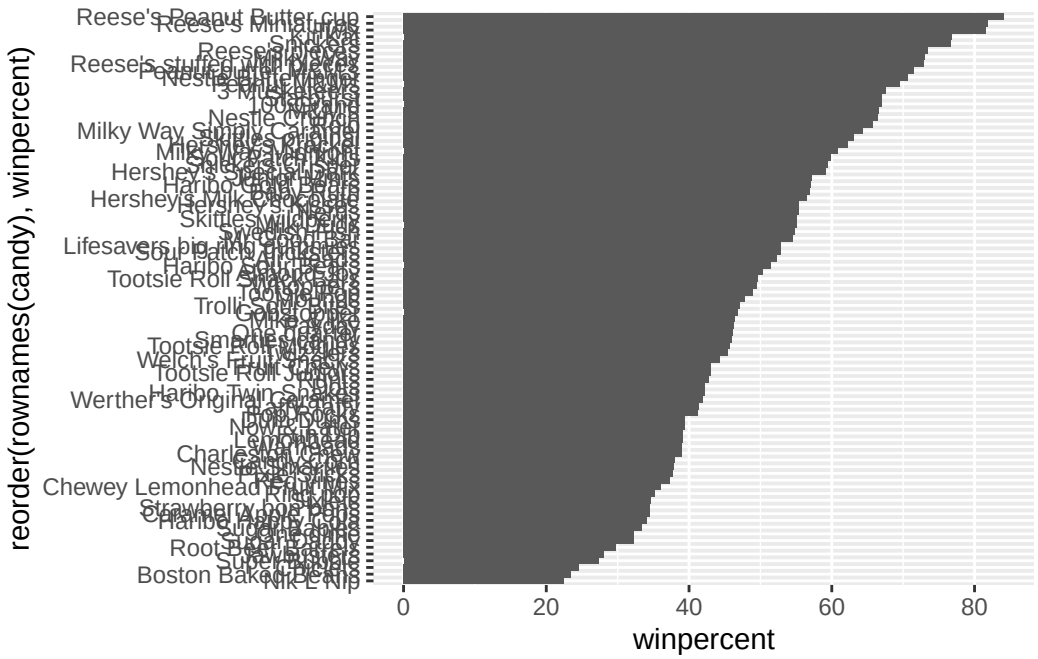
Q15. Make a first barplot of candy ranking based on winpercent values.

```
ggplot(candy) +
  aes(winpercent, 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()
```



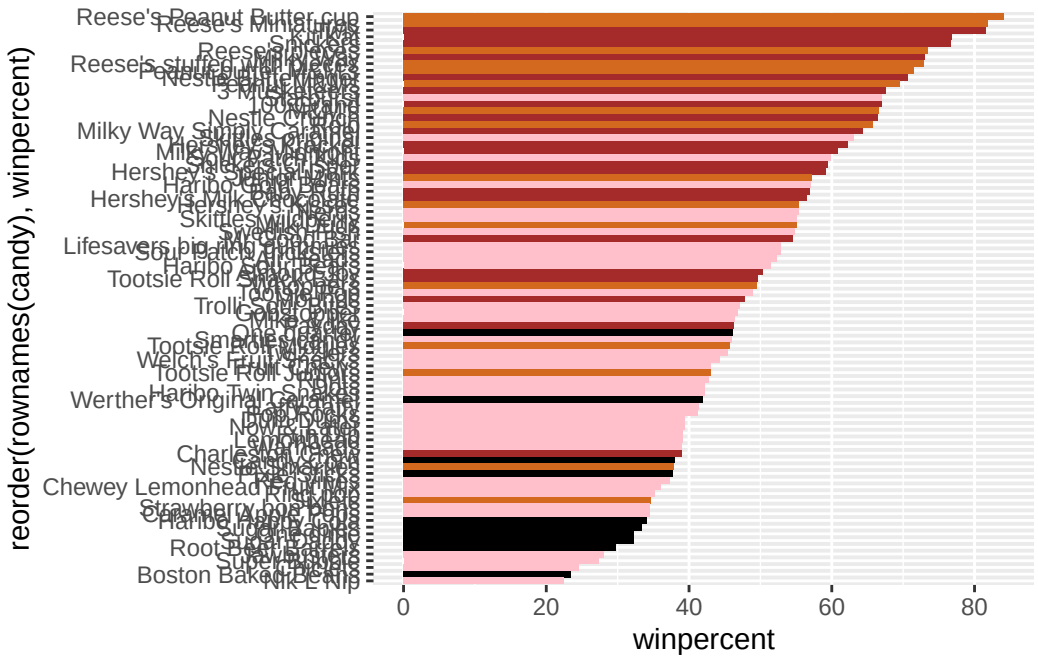
4.0.1 Time to add some useful color

Color vectors for candy type.

```
my_cols=rep("black", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "chocolate"
my_cols[as.logical(candy$bar)] = "brown"
my_cols[as.logical(candy$fruity)] = "pink"
```

Use `fill=my_cols` in `geom_col()`

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



Q17. What is the worst ranked chocolate candy?

The worst ranked chocolate candy is Sixlets.

Q18. What is the best ranked fruity candy?

The best ranked fruity candy is Starburst.

5 Taking a look at pricepercent

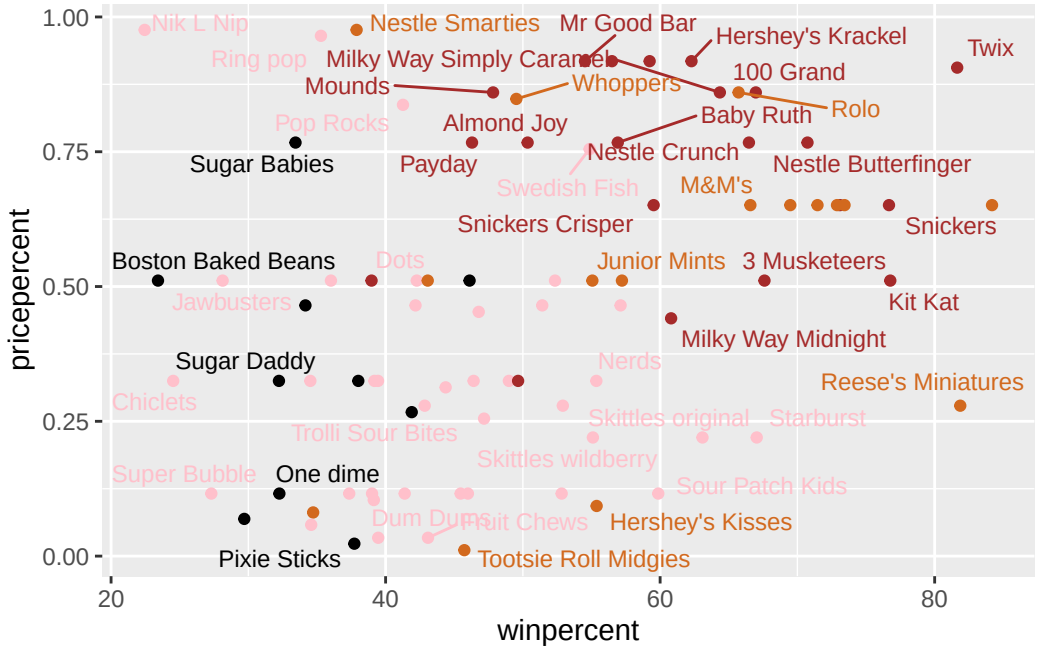
Let's analyze the cost vs win percentages.

```
library(ggrepel)
```

```
Warning: package 'ggrepel' was built under R version 4.3.3
```

```
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols, size=3.3, max.overlaps = 10)
```

```
Warning: ggrepel: 40 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?

The cheapest and most favorite candy is the tootsie roll midgies.

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

```
                    pricepercent winpercent
Tootsie Roll Midgies        0.011   45.73675
Pixie Sticks                0.023   37.72234
Dum Dums                    0.034   39.46056
Fruit Chews                 0.034   43.08892
Strawberry bon bons         0.058   34.57899
```

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

The most expensive is both the Nik L Nip and the Nestle Smarties. The least popular is the Nik L Nip with a win percent of 22.44%.

```
tail( candy[ord,c(11,12)], n=5 )
```

```
                      pricepercent winpercent
Hershey's Special Dark        0.918   59.23612
Mr Good Bar                   0.918   54.52645
Ring pop                      0.965   35.29076
Nik L Nip                     0.976   22.44534
Nestle Smarties               0.976   37.88719
```

6 Exploring the Correlation Structure

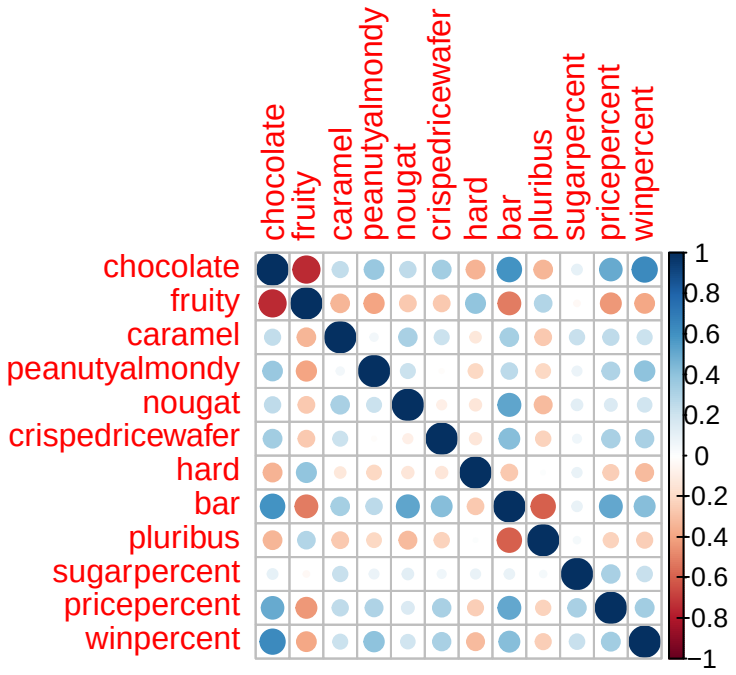
Lets look at the correlation with the `corrplot` package

```
library(corrplot)
```

```
Warning: package 'corrplot' was built under R version 4.3.3
```

```
corrplot 0.95 loaded
```

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



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

Chocolate and fruity, bar and fruity, pluribus and bar are anti-correlated.

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

Chocolate and bar are positively correlated. Chocolate and win percent, too, meaning people tend to enjoy chocolate candy more. I don't know if I ever seen a chocolaty fruity candy before.

7 Principal Component Analysis

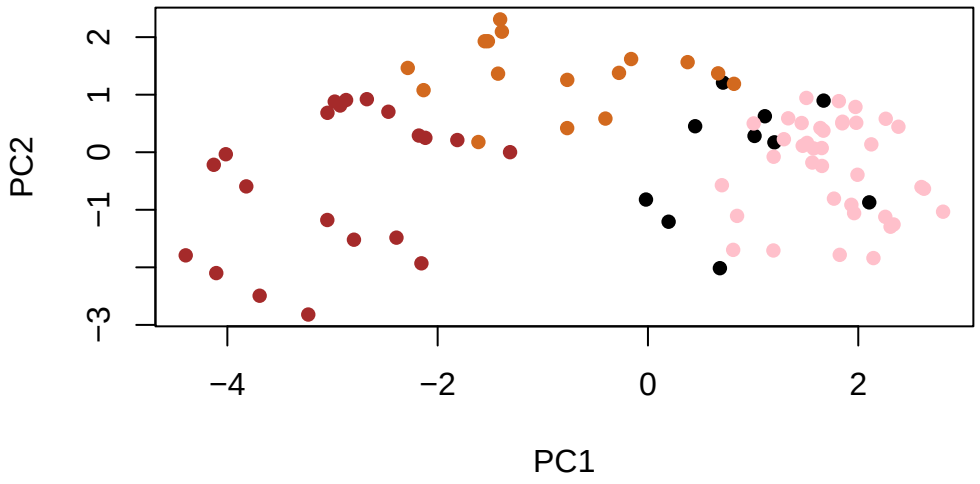
```
candy.pca <- prcomp(candy, scale = T)
summary(candy.pca)
```

```
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
```

Plot with "Base R"

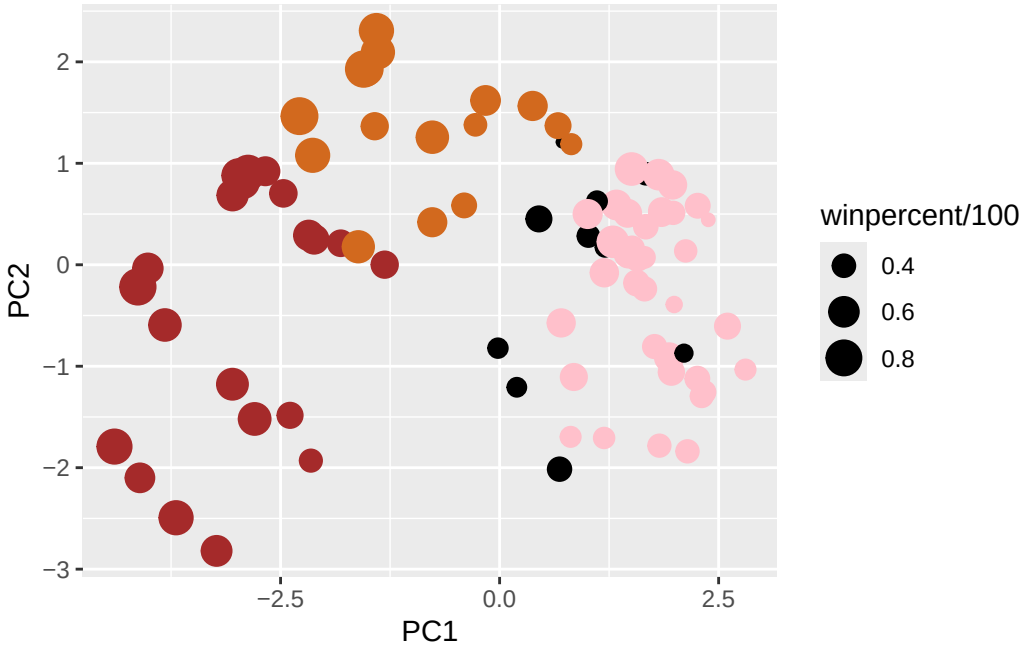
```
plot(candy.pca$x[,1:2], col=my_cols, pch = 16)
```



Plot using ggplot

```
candy.data <- cbind(candy, candy.pca$x[,1:3])
```

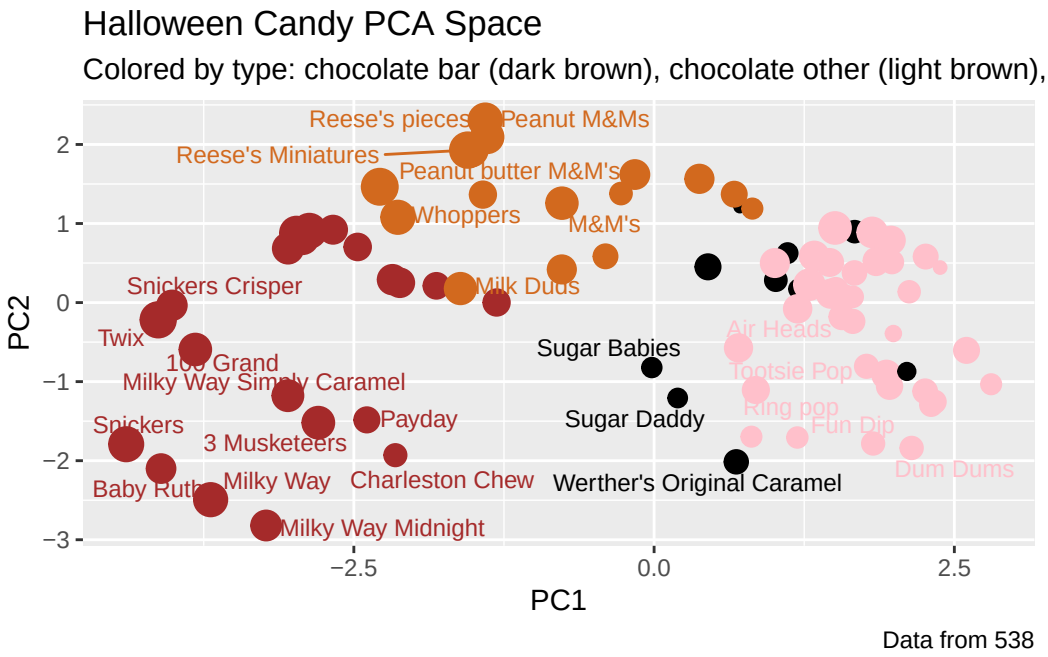
```
candy.pca.plot <- ggplot(candy.data) +
  aes(PC1, PC2,
      size = winpercent/100,
      text = rownames(candy.data),
      label = rownames(candy.data)) +
  geom_point(col = my_cols)
candy.pca.plot
```



Use `ggrepel` to label the plot

```
candy.pca.plot + geom_text_repel(size=3.3, col=my_cols, 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
```

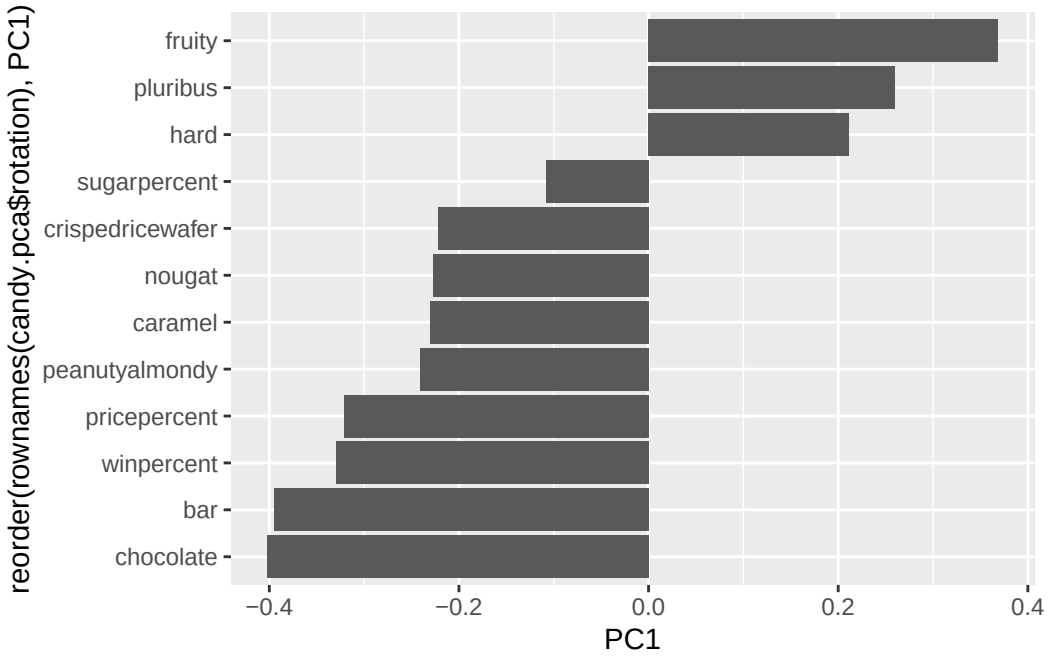


Use `plotly` package to generate an interactive plot, but we will not include this for the PDF format.

```
# library(plotly)
# ggplotly(candy.pca.plot)
```

Let's plot the effects of PC1

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



Q24. Complete the code to generate the loadings plot above. What original variables are picked up strongly by PC1 in the positive direction? Do these make sense to you? Where did you see this relationship highlighted previously?

Fruity, pluribus, and hard candies tend to be strongly and positively supported by PC1. This makes sense because the fruity candies are negatively correlated to chocolate candy, which are on the negative side of PC1. These tend to be different from chocolate, according to both the PCA chart and correlation plot.

Summary

Q25. Based on your exploratory analysis, correlation findings, and PCA results, what combination of characteristics appears to make a "winning" candy? How do these different analyses (visualization, correlation, PCA) support or complement each other in reaching this conclusion?

The most popular type of candy is chocolate. Chocolate candies are more expensive, but more popular. According to the correlation plot, chocolate candies are positively correlated to popularity (win percent) and price. Overall, fruity candies are cheaper, less popular, and negatively correlated with chocolate. The cheapest, popular candy is the fruity Tootsie roll.