Halloween Candy Mini-Project

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Today we will take a wee step back to some data we can taste, and explore the correlation structure and principal components of some Halloween candy.

1. Data Import

```
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
```

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

```
nrow(candy)
```

```
[1] 85
```

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

```
table(candy$fruity)
```

```
 0  1
47 38
```

38

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

```
candy["Almond Joy",]$winpercent
```

```
[1] 50.34755
```

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

```
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
```

2. Explanatory Analysis

We can use the **skimr** package to get a quick overview of a given data set. This can be useful for the first time you encounter a new data set.

```
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 last column `candy$winpercent` is on a different scale to all others.

```
apply(candy, 2, sd)
```

```
     chocolate          fruity         caramel   peanutyalmondy 
     0.4987379       0.5001400       0.3731162       0.3731162 
        nougat crispedricewafer            hard             bar 
     0.2765332       0.2765332       0.3834825       0.4338609 
```

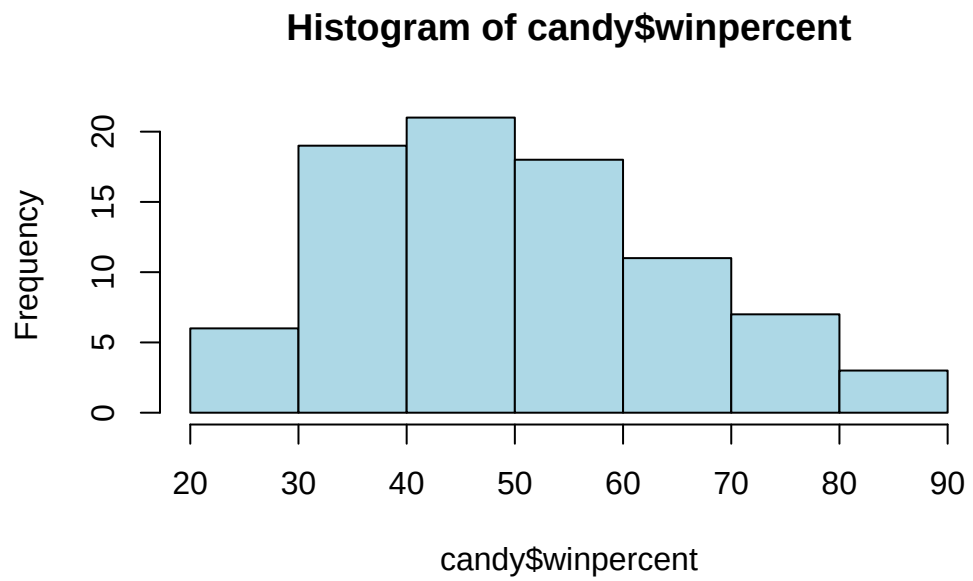
```
    pluribus      sugarpercent      pricepercent        winpercent
   0.5026540         0.2827779         0.2857396        14.7143574
```

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

It represents whether the candy contains chocolate (1 = TRUE) or if it does not (0 = FALSE).

Q8. Plot a histogram of winpercent values

```
hist(candy$winpercent, col = "lightblue")
```



Q9. Is the distribution of winpercent values symmetrical?

No

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

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

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

Median is below 50%.

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

```
choc.inds <- candy$chocolate ==1
choc.candy <- candy[choc.inds,]
choc.win <- choc.candy$winpercent
mean(choc.win)
```

```
[1] 60.92153
```

```
fruit.inds <- candy$fruity ==1
fruit.candy <- candy[fruit.inds,]
fruit.win <- fruit.candy$winpercent
mean(fruit.win)
```

```
[1] 44.11974
```

Q12. Is this difference statistically significant?

```
ans <- t.test(choc.win, fruit.win)
```

Yes with a P-value of 2.8713778×10^{-8} meaning the differences in average win percents are statistically significant.

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

There are two related functions that can help here. One is the classic `sort()` and `order()`

```
x <- c(5,10,1,4)
sort(x)
```

```
[1]  1  4  5 10
```

```
order(x)
```

```
[1] 3 4 1 2
```

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

```
tail(candy[inds,], 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
```

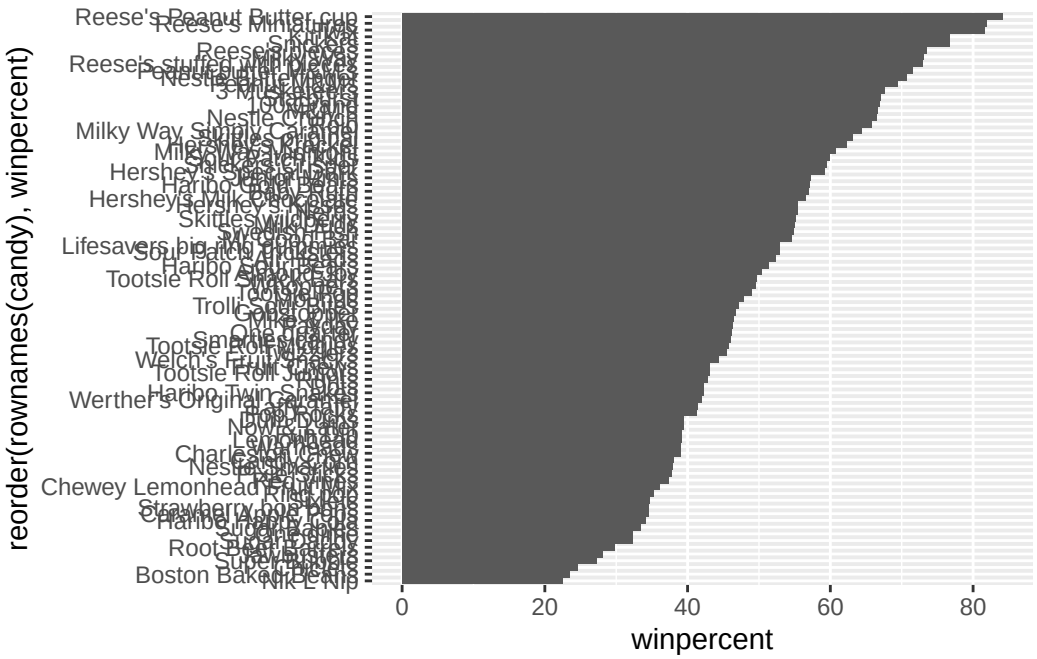
```
inds <- order(candy$winpercent, decreasing=T)
head( candy[inds,], 5)
```

```
                        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
                        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
                        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
```

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

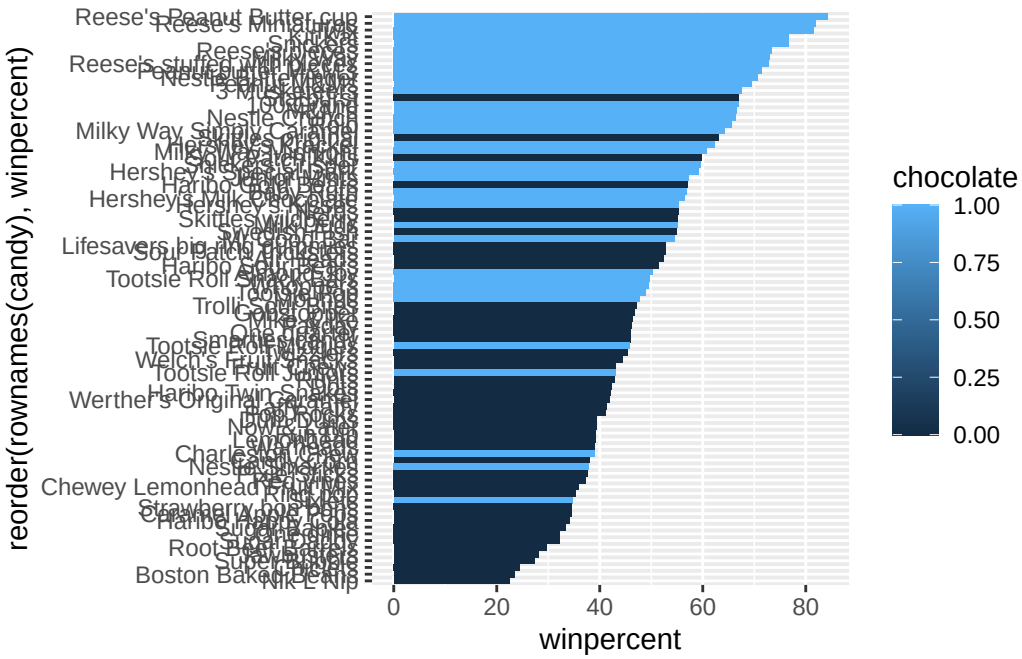
Make a bar plot with ggplot and order it by winpercent values

```
library(ggplot2)
ggplot(candy)+
  aes(winpercent, reorder(rownames(candy),winpercent)) +
  geom_col()
```



Let's add some color now.

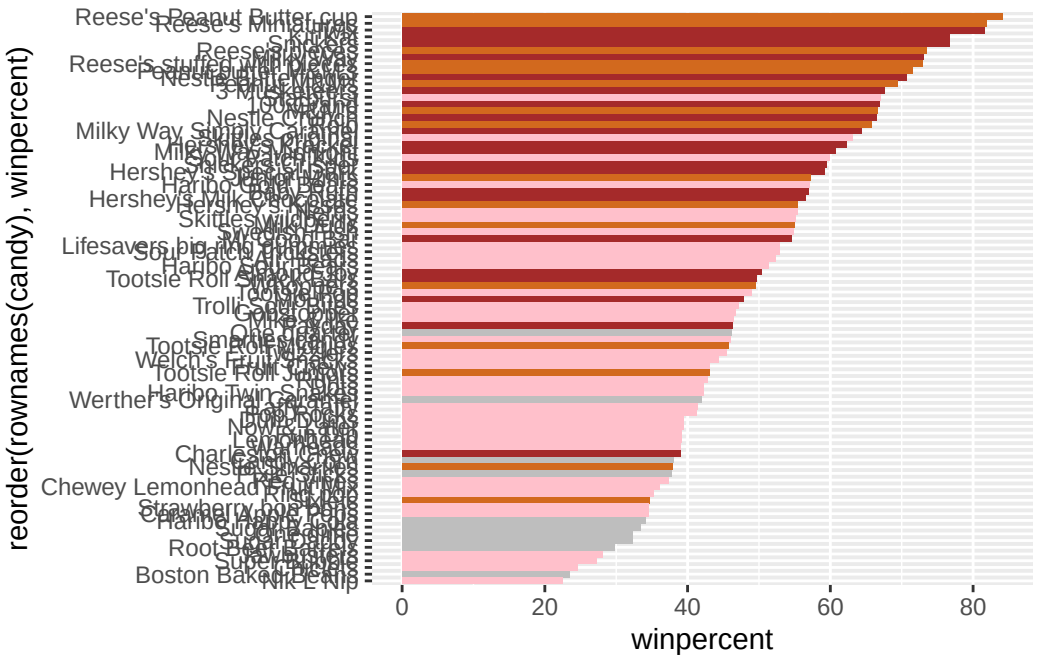
```
library(ggplot2)
ggplot(candy)+
  aes(x=winpercent, y=reorder(rownames(candy),winpercent), fill = chocolate) +
  geom_col()
```



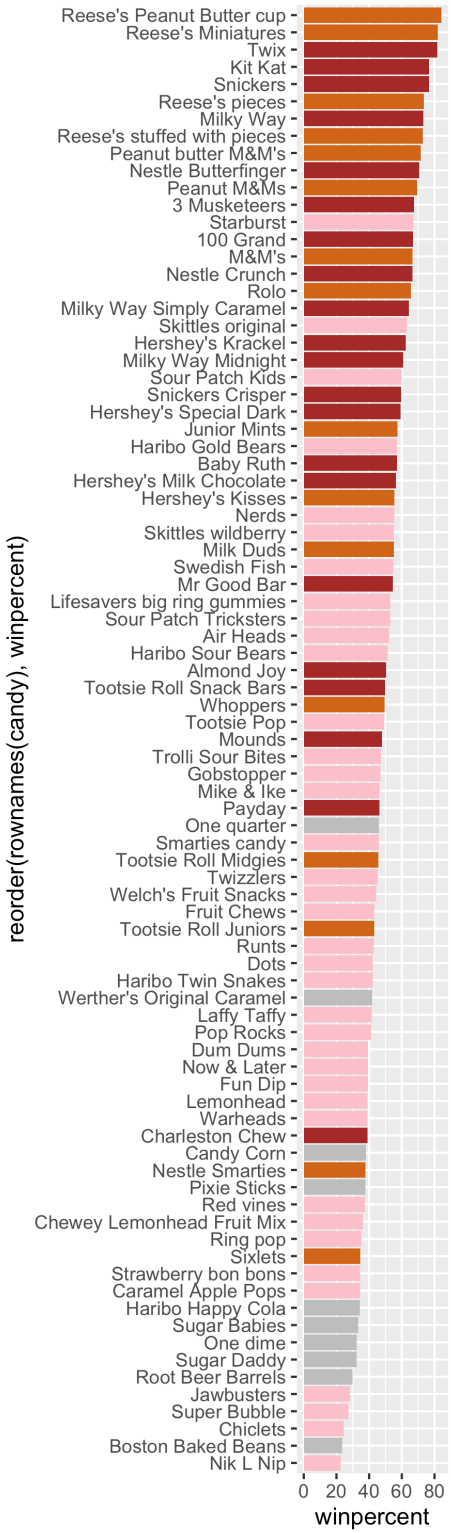
Here we want a custom color vector to color each bar the way we want - with `chocolate` and `fruity` candy together with whether it is a bar or not.

```
mycols <- rep("gray", nrow(candy))
mycols[as.logical(candy$chocolate)] <- "chocolate"
mycols[as.logical(candy$fruity)] <- "pink"
mycols[as.logical(candy$bar)] <- "brown"

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




```
ggsave("mybarplot.png", width = 3, height = 10)
```



To insert an image with a preferred size:

Q17. What is the worst ranked chocolate candy?

Charleston Chew

Q18. What is the best ranked fruity candy?

Starbust

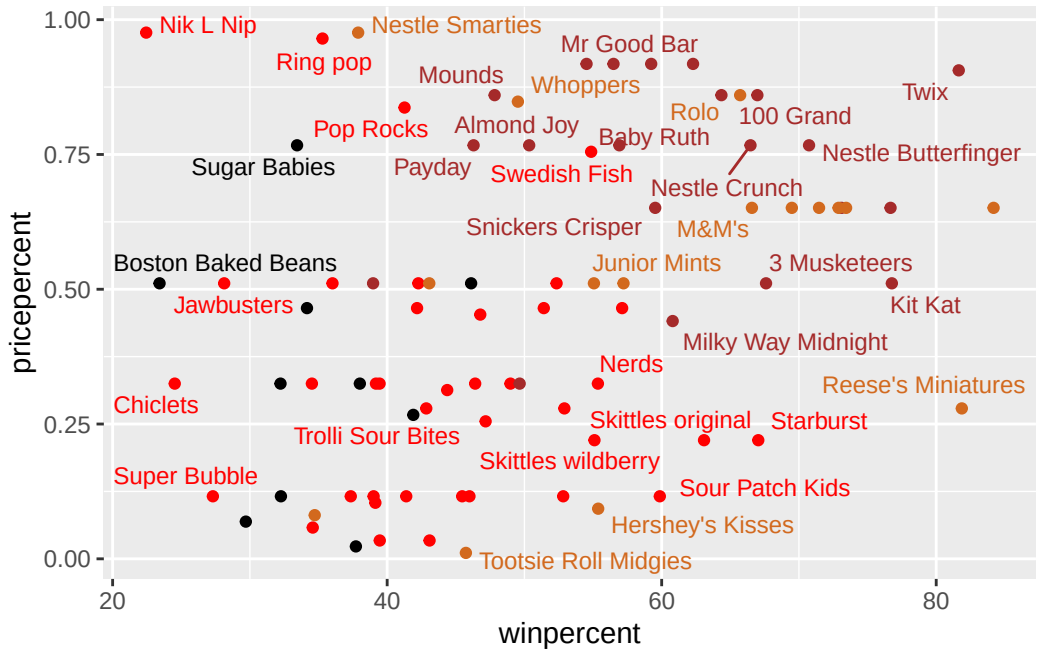
3. Winpercent vs Pricepercent

```
# Pink and gray are too light, lets change to red and black
mycols <- rep("black", nrow(candy))
mycols[as.logical(candy$chocolate)] <- "chocolate"
mycols[as.logical(candy$fruity)] <- "red"
mycols[as.logical(candy$bar)] <- "brown"

library(ggrepel)

# How about a plot of price vs win
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=mycols) +
  geom_text_repel(col=mycols, size=3.3, max.overlaps = 9)
```

```
Warning: ggrepel: 49 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?

Top 5 most expensive candy types:

```
inds <- order(candy$price)
tail(candy[inds,], 5)
```

```
                      chocolate fruity caramel peanutyalmondy nougat
Hershey's Special Dark         1      0       0              0      0
Mr Good Bar                    1      0       0              1      0
Ring pop                       0      1       0              0      0
Nik L Nip                      0      1       0              0      0
Nestle Smarties                1      0       0              0      0
                      crispedricewafer hard bar pluribus sugarpercent
Hershey's Special Dark                0    0   1        0        0.430
Mr Good Bar                           0    0   1        0        0.313
Ring pop                              0    1   0        0        0.732
```

```
Nik L Nip                           0    0   0        1        0.197
Nestle Smarties                     0    0   0        1        0.267
                      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
```

Least popular candy:

```
inds <- order(candy$winpercent)
head(candy[inds,], 1)
```

```
          chocolate fruity caramel peanutyalmondy nougat crispedricewafer hard
Nik L Nip         0      1       0              0      0                 0    0
          bar pluribus sugarpercent pricepercent winpercent
Nik L Nip   0        1        0.197        0.976   22.44534
```

4. Correlation Structure

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

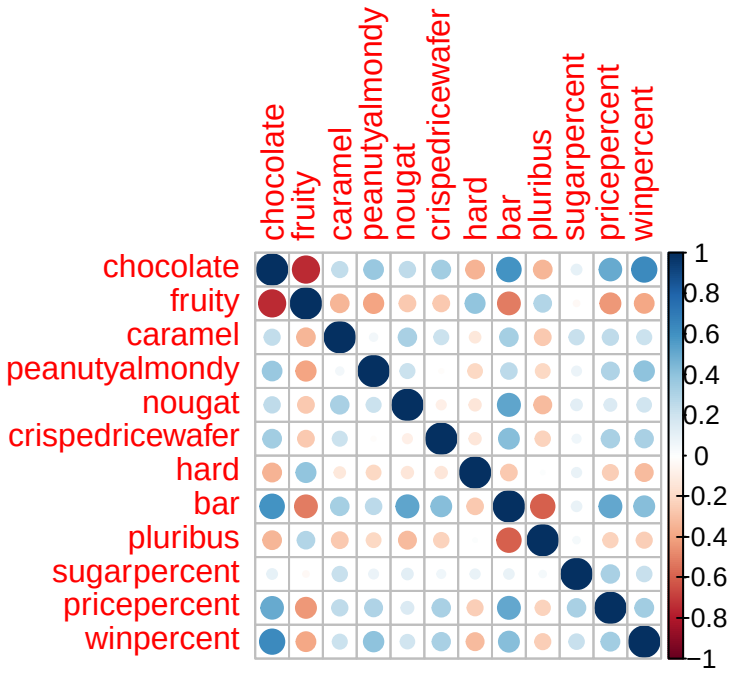
```
                  chocolate      fruity     caramel peanutyalmondy      nougat
chocolate         1.0000000 -0.74172106  0.24987535     0.37782357  0.25489183
fruity           -0.7417211  1.00000000 -0.33548538    -0.39928014 -0.26936712
caramel           0.2498753 -0.33548538  1.00000000     0.05935614  0.32849280
peanutyalmondy    0.3778236 -0.39928014  0.05935614     1.00000000  0.21311310
nougat            0.2548918 -0.26936712  0.32849280     0.21311310  1.00000000
crispedricewafer  0.3412098 -0.26936712  0.21311310    -0.01764631 -0.08974359
hard             -0.3441769  0.39067750 -0.12235513    -0.20555661 -0.13867505
bar               0.5974211 -0.51506558  0.33396002     0.26041960  0.52297636
pluribus         -0.3396752  0.29972522 -0.26958501    -0.20610932 -0.31033884
sugarpercent      0.1041691 -0.03439296  0.22193335     0.08788927  0.12308135
pricepercent      0.5046754 -0.43096853  0.25432709     0.30915323  0.15319643
winpercent        0.6365167 -0.38093814  0.21341630     0.40619220  0.19937530
                 crispedricewafer        hard         bar    pluribus
chocolate              0.34120978 -0.34417691  0.59742114 -0.33967519
```

```
fruity               -0.26936712  0.39067750 -0.51506558  0.29972522
caramel               0.21311310 -0.12235513  0.33396002 -0.26958501
peanutyalmondy       -0.01764631 -0.20555661  0.26041960 -0.20610932
nougat               -0.08974359 -0.13867505  0.52297636 -0.31033884
crispedricewafer      1.00000000 -0.13867505  0.42375093 -0.22469338
hard                 -0.13867505  1.00000000 -0.26516504  0.01453172
bar                   0.42375093 -0.26516504  1.00000000 -0.59340892
pluribus             -0.22469338  0.01453172 -0.59340892  1.00000000
sugarpercent          0.06994969  0.09180975  0.09998516  0.04552282
pricepercent          0.32826539 -0.24436534  0.51840654 -0.22079363
winpercent            0.32467965 -0.31038158  0.42992933 -0.24744787
                  sugarpercent pricepercent winpercent
chocolate           0.10416906    0.5046754  0.6365167
fruity             -0.03439296   -0.4309685 -0.3809381
caramel             0.22193335    0.2543271  0.2134163
peanutyalmondy      0.08788927    0.3091532  0.4061922
nougat              0.12308135    0.1531964  0.1993753
crispedricewafer    0.06994969    0.3282654  0.3246797
hard                0.09180975   -0.2443653 -0.3103816
bar                 0.09998516    0.5184065  0.4299293
pluribus            0.04552282   -0.2207936 -0.2474479
sugarpercent        1.00000000    0.3297064  0.2291507
pricepercent        0.32970639    1.0000000  0.3453254
winpercent          0.22915066    0.3453254  1.0000000
```

```
library(corrplot)
```

```
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 are negatively correlated

```
round(cij["chocolate", "fruity"], 2)
```

```
[1] -0.74
```

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

Chocolate and win percent

```
round(cij["chocolate", "winpercent"], 2)
```

```
[1] 0.64
```

5. Principal Component Analysis (PCA)

We need to be sure to scale our input `candy` data before PCA as we have the `winpercent` column on a different scale to all others in the data set.

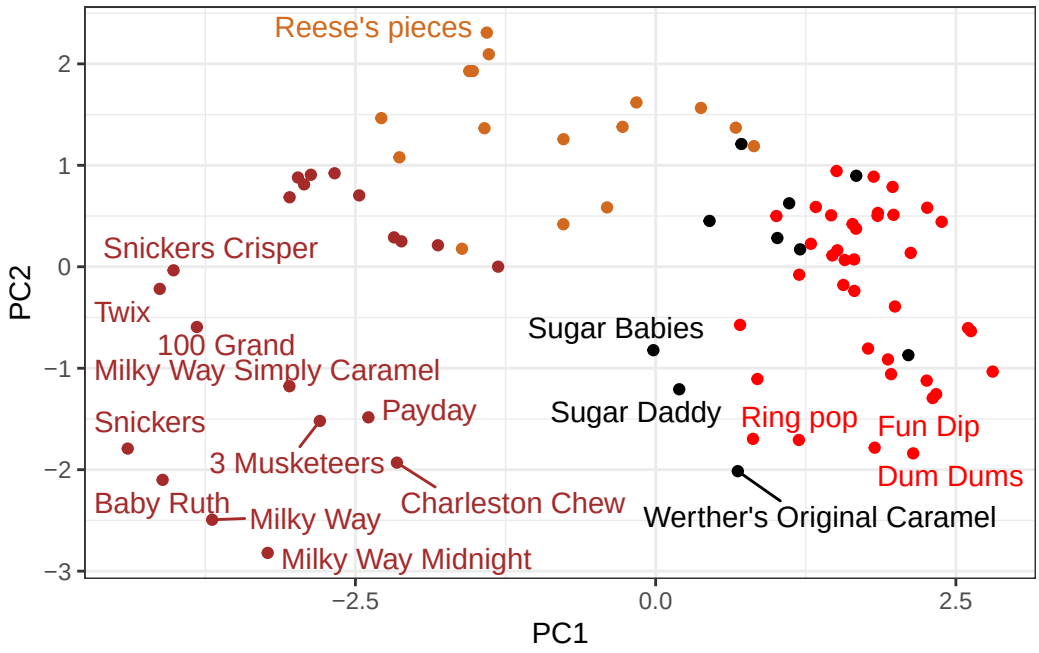
```
pca <- prcomp(candy, scale=TRUE)
summary(pca)
```

```
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
```

First main result figure is my "PCA plot"

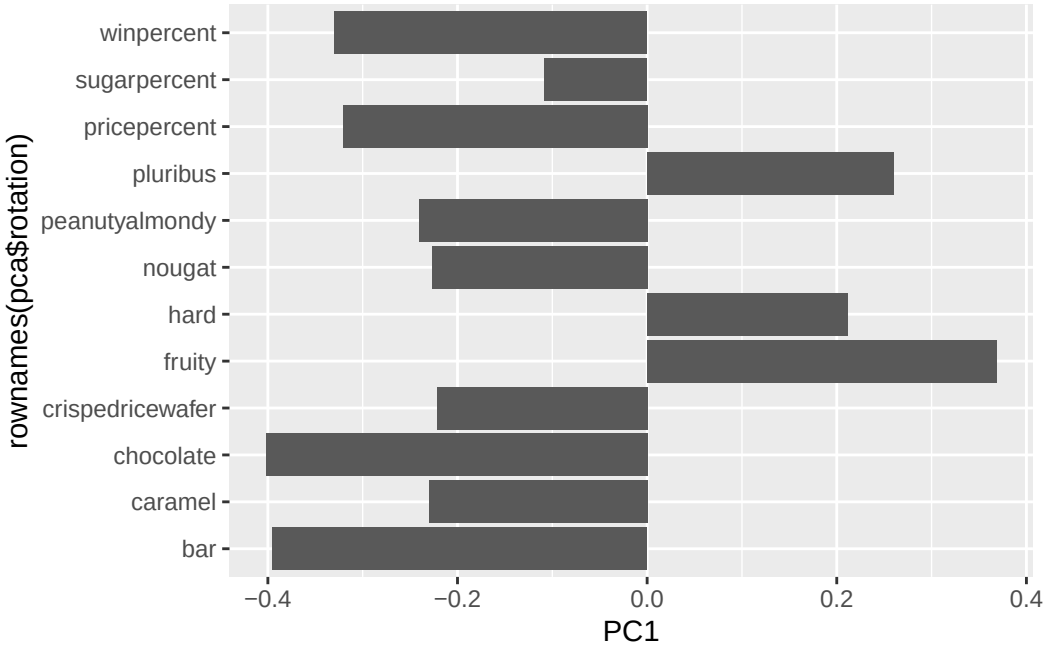
```
ggplot(pca$x) +
  aes(PC1, PC2, label=rownames(pca$x))+
  geom_point(col=mycols)+
  geom_text_repel(max.overlaps=6, col=mycols)+
  theme_bw()
```

```
Warning: ggrepel: 67 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```

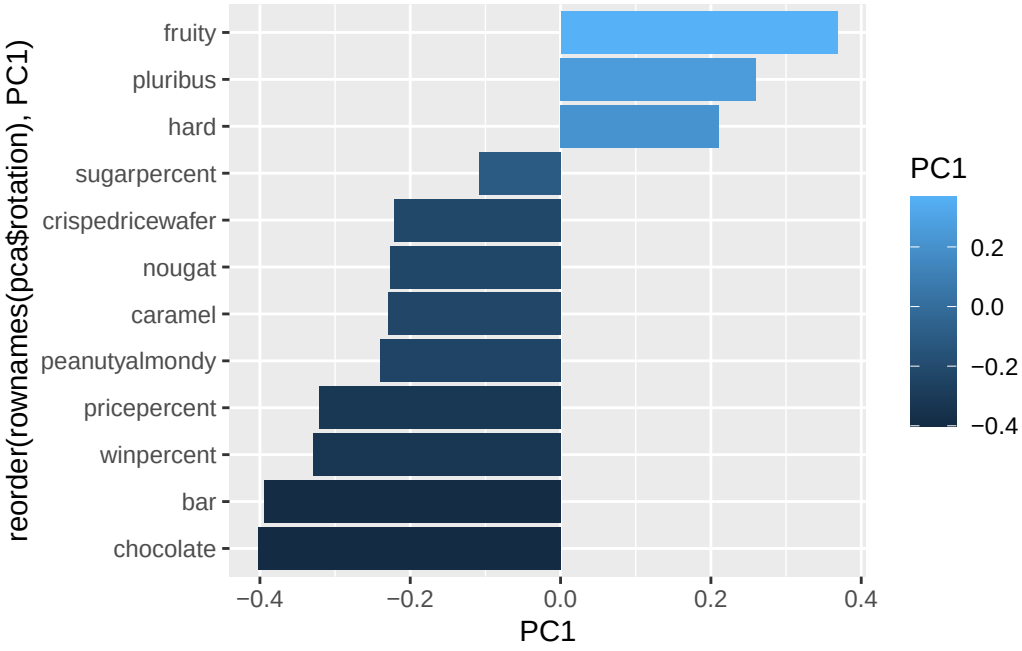


The second main PCA result is in the `pca$rotation` we can plot this to generate a so-called "loadings" plot.

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




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



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

Pluribus, hard, and fruity.