Class 10: Halloween mini project

Joseph Girgiss (PID: A17388247)

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As it is nearly Halloween and the half way point in the quarter let's do a mini project to help us figure out the best candy!

Our data comes from the 538 website and is available as a CSV file:

Data Import

```r
candy_file <- "candy-data.csv"
candy = read.csv(candy_file, 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?

```r
nrow(candy)
```

```
[1] 85
```

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

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

```
[1] 38
```

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

```
[1] 81.64291
```

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

My favorite candy in the dataset is Milky Way.

```r
candy["Milky Way", ]$winpercent
```

```
[1] 73.09956
```

> 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"?

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

```
[1] 49.6535
```

Quick overview of the dataset

```r
library(skimr)
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?

Yes, winpercent looks to be on a different scale since its values between 0-100 when all others are between 0 and 1.

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

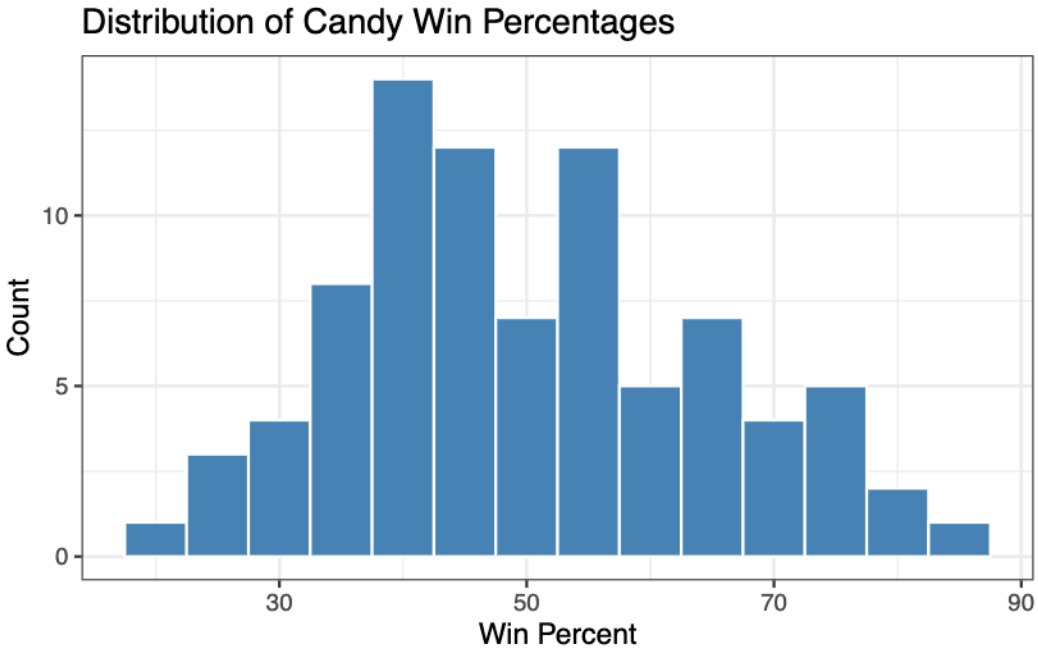
```r
candy$chocolate
```

```
 [1] 1 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 0 0 0 1 1 0 1 1 1
[39] 1 1 1 0 1 1 0 0 0 1 0 0 0 1 1 1 1 0 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 0 1 1
[77] 1 1 0 1 0 0 0 0 1
```

1 = the candy is a chocolate, 0 = the candy is not a chocolate.

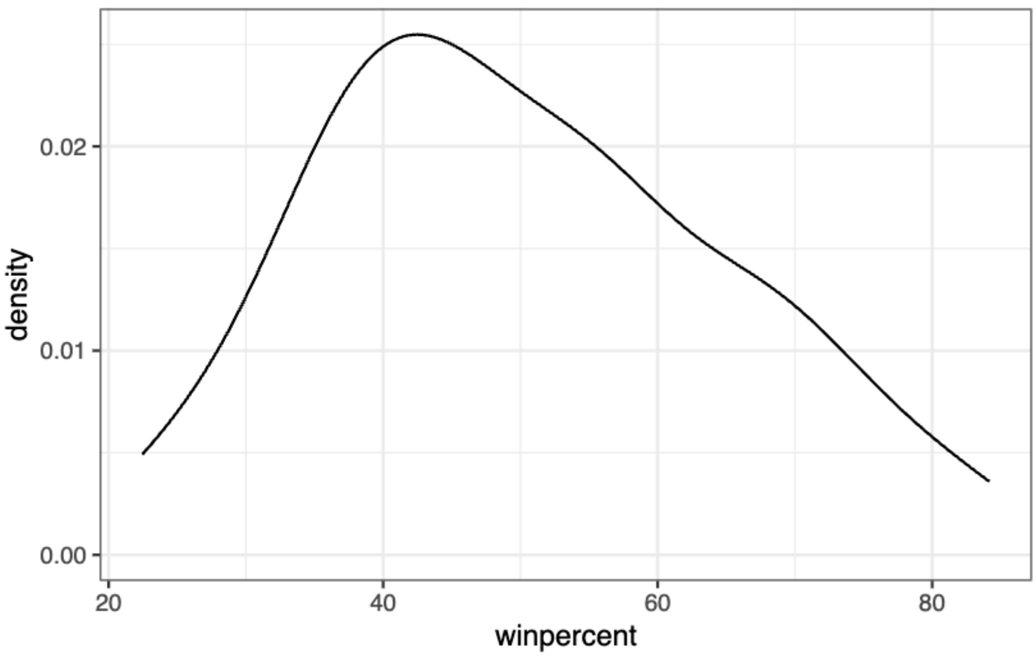
Q8. Plot a histogram of winpercent values

```r
library(ggplot2)

ggplot(candy, aes(winpercent)) +
  geom_histogram(binwidth = 5, fill = "steelblue", color = "white") +
  labs(title = "Distribution of Candy Win Percentages",
       x = "Win Percent", y = "Count") +
  theme_bw()
```



Q9. Is the distribution of winpercent values symmetrical?

```r
ggplot(candy, aes(winpercent)) +
  geom_density() +
  theme_bw()
```



The distribution of winpercent values is asymmetrical.

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

```
mean(candy$winpercent)
```

```
[1] 50.31676
```

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

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

Center: mean = 50.31676 > 50%, median = 47.83 < 50% (indicating a right skew).

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

```
# 1. Find all chocolate candy in the dataset
# 2. Find their winpercent values
# 3. Calculate the mean of these values
# 4. Repeat for fruity candy.
# 5. Compare mean winpercents of chocolate vs fruity
```

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

```
[1] 60.92153
```

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

```
[1] 44.11974
```

```r
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
```

```r
candy %>%
  summarize(
    mean_choc = mean(winpercent[chocolate == 1]),
    mean_fruit = mean(winpercent[fruity == 1])
  )
```

```
  mean_choc mean_fruit
1  60.92153   44.11974
```

On average the chocolate candy is higher than fruity candy.

Q12. Is this difference statistically significant?

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

```

	Welch Two Sample t-test

data:  choc.win and fruit.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 difference between chocolate and fruity candy is statistically significant because the p-value is very small (p-value = 2.871e-08).

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

```r
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
```

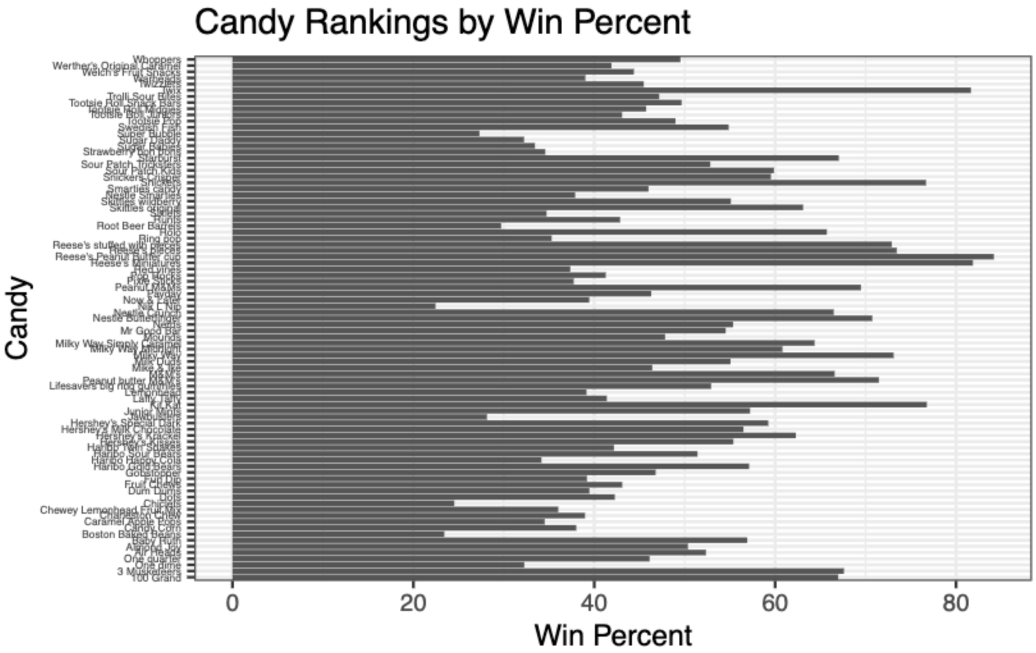
Q14. What are the top 5 all time favorite candy types out of this set?

```r
candy %>%
  arrange(desc(winpercent)) %>%
  head(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.

```r
library(ggplot2)
candy$CandyName <- factor(rownames(candy), levels = rownames(candy))


ggplot(candy) +
  aes(x = winpercent, y = CandyName) +
  geom_col() +
  theme_bw() +
  labs(x = "Win Percent", y = "Candy", title = "Candy Rankings by Win Percent") +
  theme(
    axis.text.y = element_text(size = 4)
  )
```

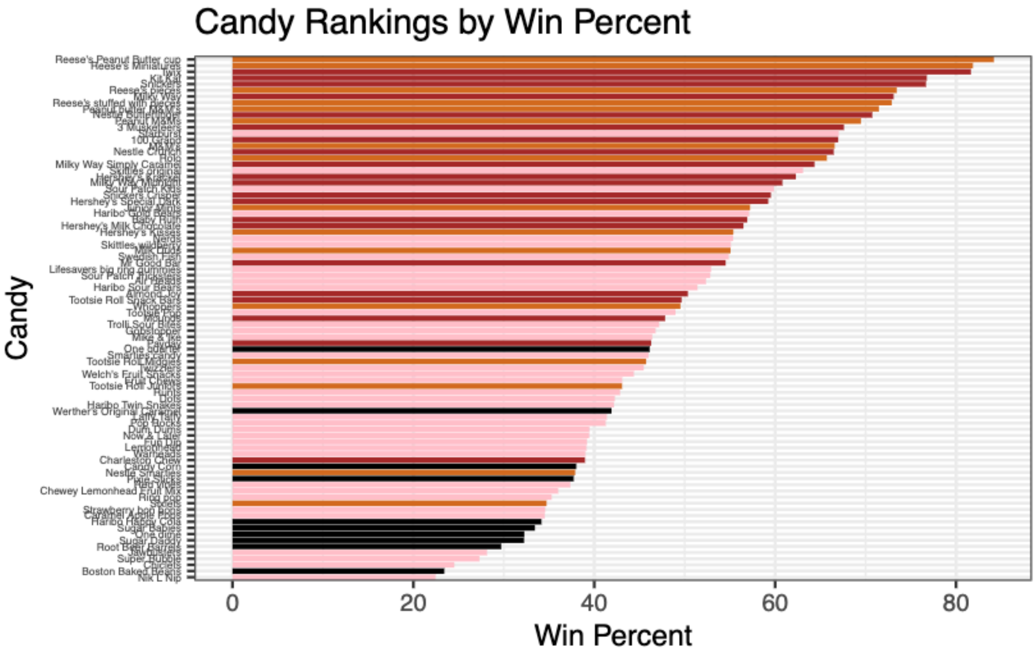


> Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent?

Let's also add some color based on the type of candy.

```
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"
```

```
candy$CandyName <- factor(rownames(candy), levels = rownames(candy)[order(candy$winpercent)]]
ggplot(candy) +
  aes(x = winpercent, y = CandyName) +
  geom_col(fill=my_cols) +
  theme_bw() +
  labs(x = "Win Percent", y = "Candy", title = "Candy Rankings by Win Percent") +
  theme(
    axis.text.y = element_text(size = 4)
  )
```



Q17. What is the worst ranked chocolate candy?

```
candy %>%
  filter(chocolate == 1) %>%
  arrange(winpercent) %>%
  head(1)
```

```
        chocolate fruity caramel peanutyalmondy nougat crispedricewafer hard
Sixlets         1      0       0              0      0                0    0
        bar pluribus sugarpercent pricepercent winpercent CandyName
Sixlets   0        1         0.22        0.081     34.722   Sixlets
```

Sixlets are the worst ranked chocolate candy.

Q18. What is the best ranked fruity candy?

```
candy %>%
  filter(fruity == 1) %>%
  arrange(desc(winpercent)) %>%
  head(1)
```

```
          chocolate fruity caramel peanutyalmondy nougat crispedricewafer hard
Starburst         0      1       0              0      0                0    0
          bar pluribus sugarpercent pricepercent winpercent CandyName
Starburst   0        1        0.151         0.22   67.03763 Starburst
```

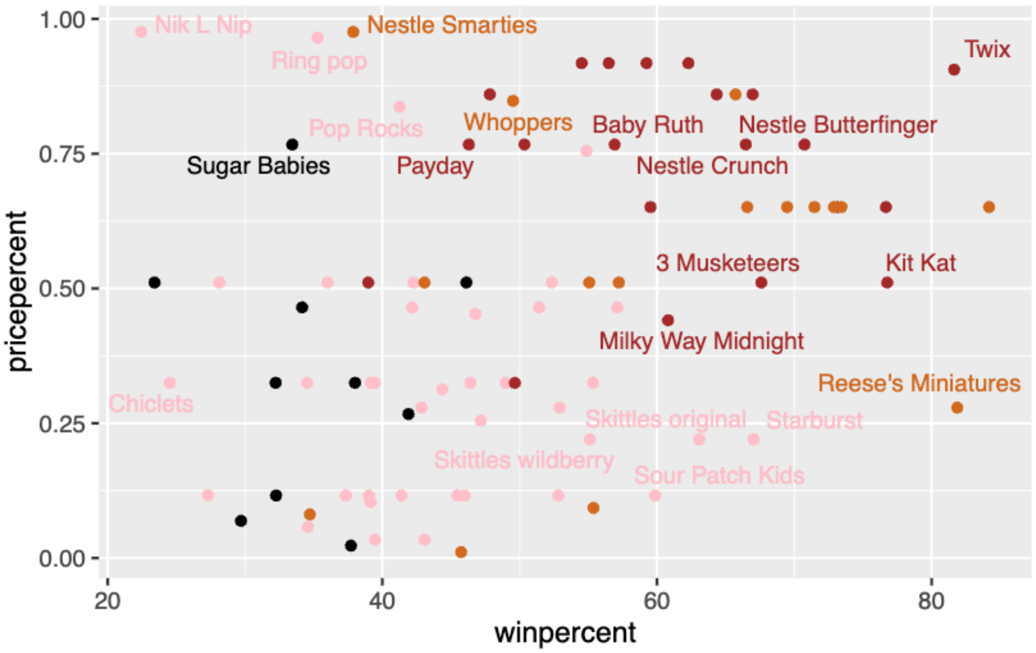
Starburst is the best ranked fruity candy.

Winpercent and Pricepercent

A plot with both variable/columns winpercent and pricepercent

```
library(ggrepel)

# How about a plot of price vs win
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols, size=3.3, max.overlaps = 5)
```

```
Warning: ggrepel: 65 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?

```
library(dplyr)
candy %>%
  mutate(Value = winpercent / (pricepercent + 1e-6)) %>%
  arrange(desc(Value)) %>%
  head(1)
```

```
                     chocolate fruity caramel peanutyalmondy nougat
Tootsie Roll Midgies         1      0       0              0      0
                     crispedricewafer hard bar pluribus sugarpercent
Tootsie Roll Midgies                0    0   0        1        0.174
                     pricepercent winpercent            CandyName    Value
Tootsie Roll Midgies        0.011   45.73675 Tootsie Roll Midgies 4157.508
```

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

```
top5_expensive <- candy %>%
  arrange(desc(pricepercent)) %>%   # sort by price descending
  slice(1:5) %>%                    # take top 5
  select(pricepercent, winpercent)  # show relevant columns

top5_expensive
```

```
                         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
```

```
least_popular <- top5_expensive %>%
  slice_min(winpercent)   # candy with lowest winpercent

least_popular
```

```
          pricepercent winpercent
Nik L Nip        0.976   22.44534
```

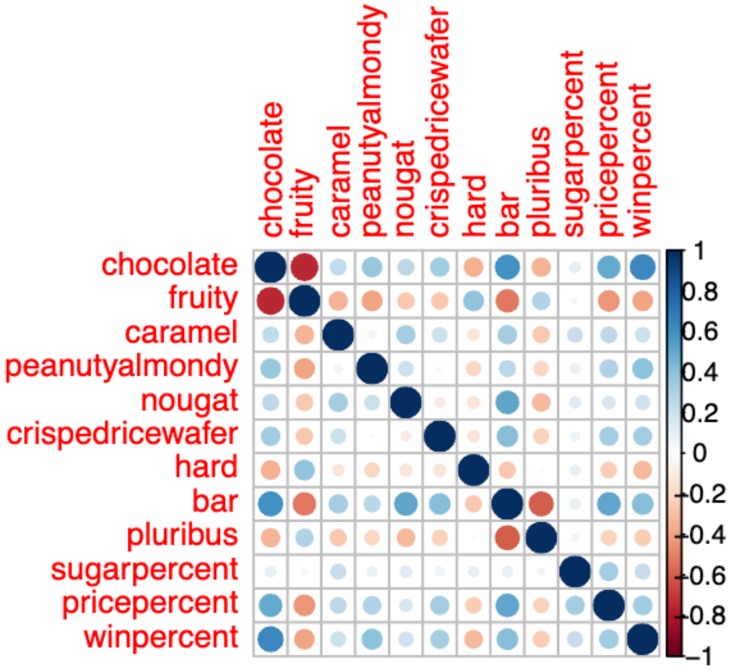
Exploring the correlation structure

Now that we've explored the dataset a little, we'll see how the variables interact with one another. We'll use correlation and view the results with the corrplot package to plot a correlation matrix.

```
library(corrplot)
```

```
corrplot 0.95 loaded
```

```
cij <- cor(candy[sapply(candy, is.numeric)])
corrplot(cij)
```



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

```
# Convert the correlation matrix to a data frame for easier filtering
corr_df <- as.data.frame(as.table(cij))
colnames(corr_df) <- c("Variable1", "Variable2", "Correlation")

# Filter out the diagonal (where Variable1 equals Variable2)
off_diagonal_corr <- subset(corr_df, Variable1 != Variable2)
```

```
# Find the row with the minimum correlation value
most_anti_correlated <- off_diagonal_corr[which.min(off_diagonal_corr$Correlation), ]

# Print the result
print("Most Anti-Correlated Pair:")
```

```
[1] "Most Anti-Correlated Pair:"
```

```
print(most_anti_correlated)
```

```
  Variable1 Variable2 Correlation
2    fruity chocolate  -0.7417211
```

Fruity and Chocolate are most anti-correlated.

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

```
# Find the row with the maximum correlation value
most_positively_correlated <- off_diagonal_corr[which.max(off_diagonal_corr$Correlation), ]

# Print the result
print("Most Positively Correlated Pair:")
```

```
[1] "Most Positively Correlated Pair:"
```

```
print(most_positively_correlated)
```

```
    Variable1 Variable2 Correlation
12 winpercent chocolate   0.6365167
```

Winpercent and chocolate are the most potively correlated pair.

Principal component analysis

The function to use is called `prcomp()` with an optional `scale=T/F` argument.

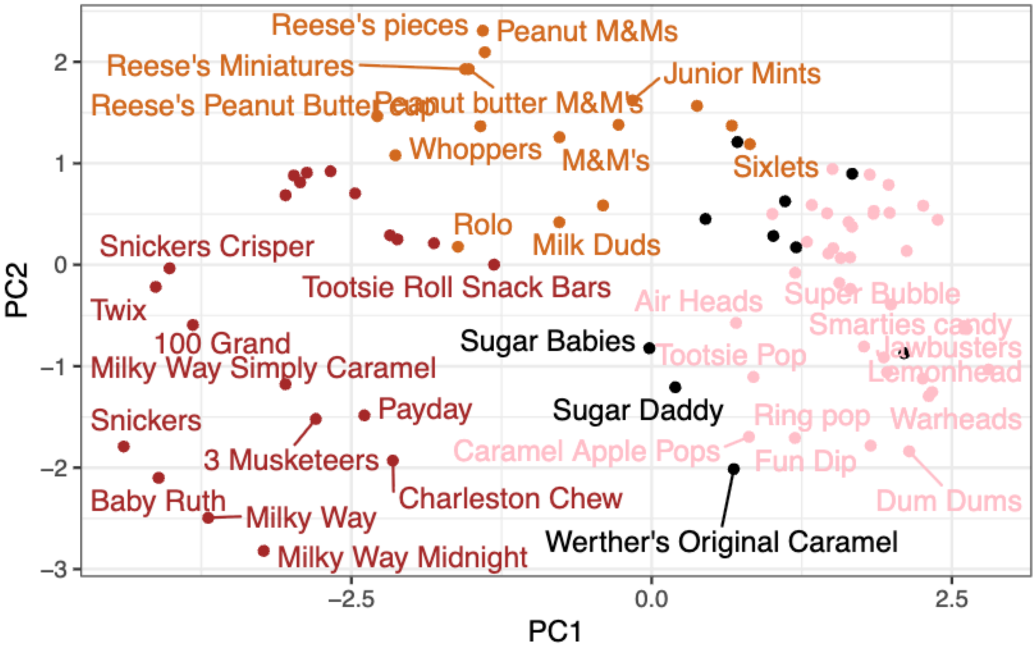
```
candy_numeric <- candy[sapply(candy, is.numeric)]
pca <- prcomp(candy_numeric, scale=TRUE)
summary(pca)
```

```
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
```

Our main PCA result figure

```
ggplot(pca$x) +
  aes(PC1, PC2) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols,label=rownames(candy)) +
  theme_bw()
```

```
Warning: ggrepel: 48 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



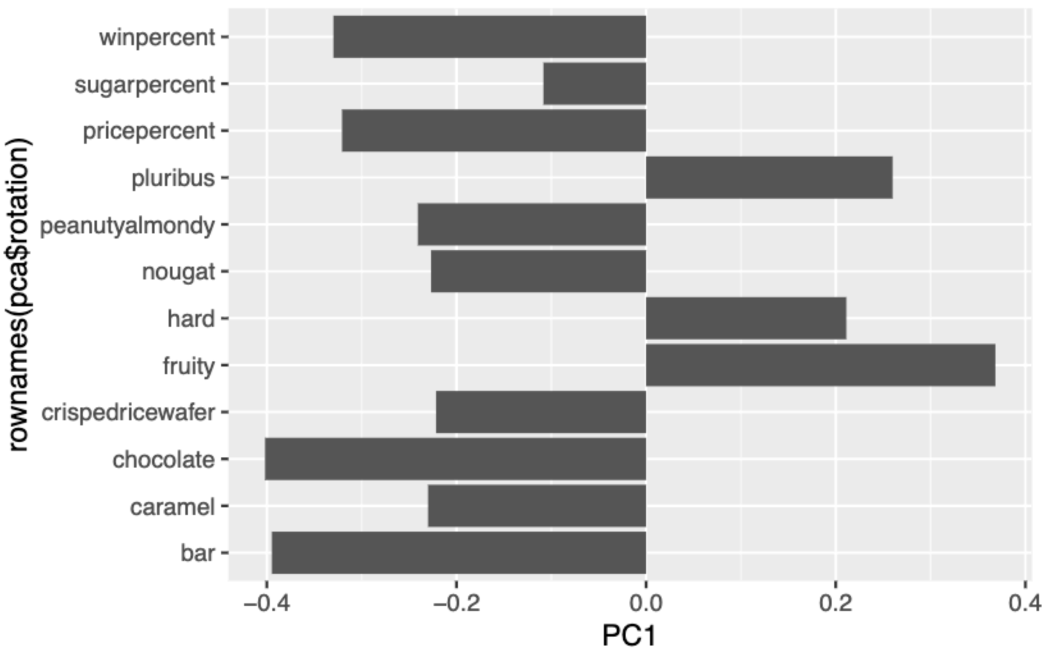
We should also examine the variable "loadings" or contributions of the original variable to the new PCs.

```
pca$rotation
```

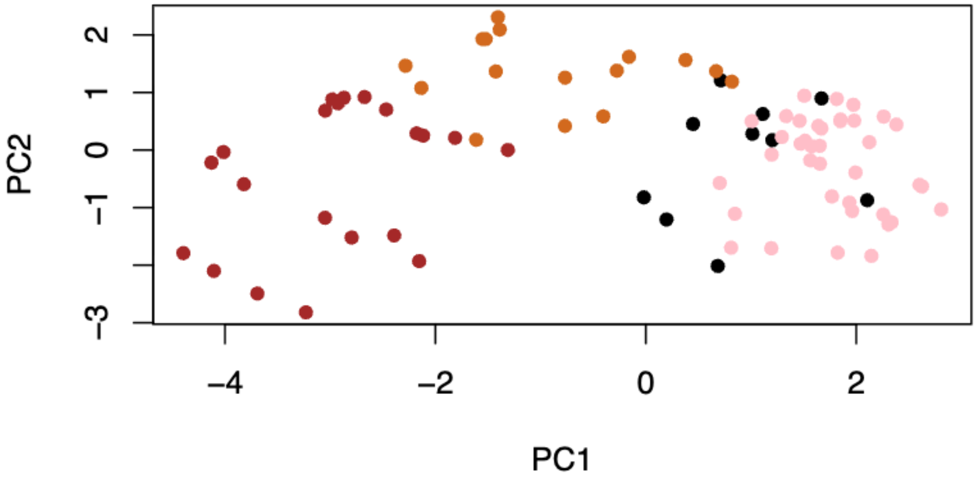
```
                      PC1         PC2         PC3          PC4          PC5
chocolate      -0.4019466  0.21404160  0.01601358 -0.016673032  0.066035846
fruity          0.3683883 -0.18304666 -0.13765612 -0.004479829  0.143535325
caramel        -0.2299709 -0.40349894 -0.13294166 -0.024889542 -0.507301501
peanutyalmondy -0.2407155  0.22446919  0.18272802  0.466784287  0.399930245
nougat         -0.2268102 -0.47016599  0.33970244  0.299581403 -0.188852418
crispedricewafer -0.2215182  0.09719527 -0.36485542 -0.605594730  0.034652316
hard            0.2111587 -0.43262603 -0.20295368 -0.032249660  0.574557816
bar            -0.3947433 -0.22255618  0.10696092 -0.186914549  0.077794806
pluribus        0.2600041  0.36920922 -0.26813772  0.287246604 -0.392796479
sugarpercent   -0.1083088 -0.23647379 -0.65509692  0.433896248  0.007469103
pricepercent   -0.3207361  0.05883628 -0.33048843  0.063557149  0.043358887
winpercent     -0.3298035  0.21115347 -0.13531766  0.117930997  0.168755073
                       PC6         PC7         PC8          PC9         PC10
chocolate      -0.09018950 -0.08360642 -0.49084856 -0.151651568  0.107661356
fruity         -0.04266105  0.46147889  0.39805802 -0.001248306  0.362062502
caramel        -0.40346502 -0.44274741  0.26963447  0.019186442  0.229799010
peanutyalmondy -0.09416259 -0.25710489  0.45771445  0.381068550 -0.145912362
```

```
nougat            0.09012643  0.36663902 -0.18793955  0.385278987  0.011323453
crispedricewafer -0.09007640  0.13077042  0.13567736  0.511634999 -0.264810144
hard             -0.12767365 -0.31933477 -0.38881683  0.258154433  0.220779142
bar               0.25307332  0.24192992 -0.02982691  0.091872886 -0.003232321
pluribus          0.03184932  0.04066352 -0.28652547  0.529954405  0.199303452
sugarpercent      0.02737834  0.14721840 -0.04114076 -0.217685759 -0.488103337
pricepercent      0.62908570 -0.14308215  0.16722078 -0.048991557  0.507716043
winpercent       -0.56947283  0.40260385 -0.02936405 -0.124440117  0.358431235
                        PC11        PC12
chocolate         0.10045278  0.69784924
fruity            0.17494902  0.50624242
caramel           0.13515820  0.07548984
peanutyalmondy    0.11244275  0.12972756
nougat           -0.38954473  0.09223698
crispedricewafer -0.22615618  0.11727369
hard              0.01342330 -0.10430092
bar               0.74956878 -0.22010569
pluribus          0.27971527 -0.06169246
sugarpercent      0.05373286  0.04733985
pricepercent     -0.26396582 -0.06698291
winpercent       -0.11251626 -0.37693153
```

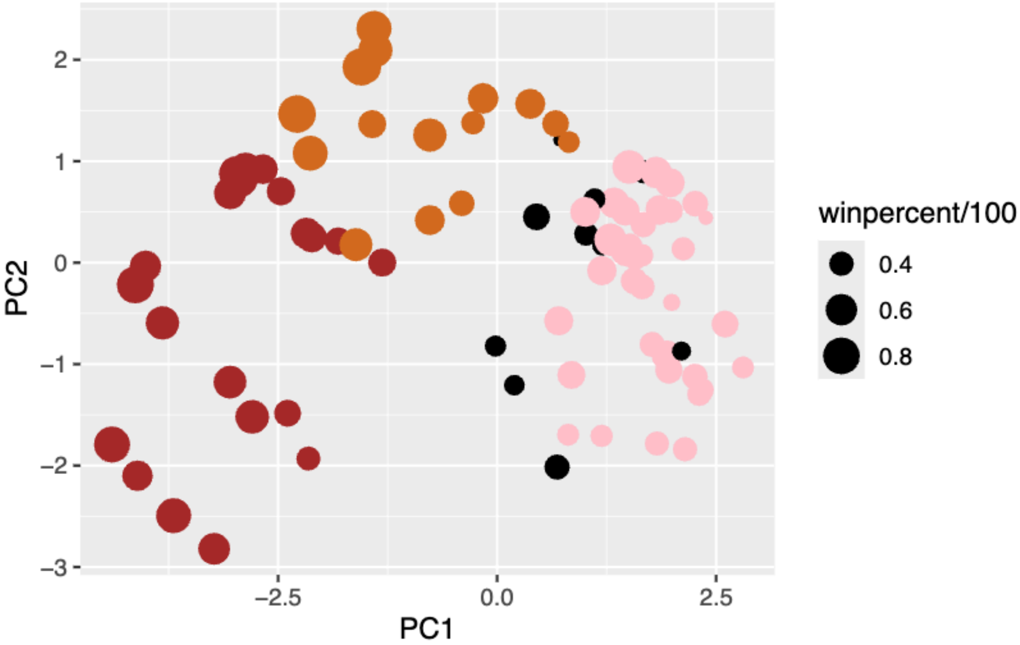
```r
ggplot(pca$rotation) +
  aes(PC1, rownames(pca$rotation)) +
  geom_col()
```



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

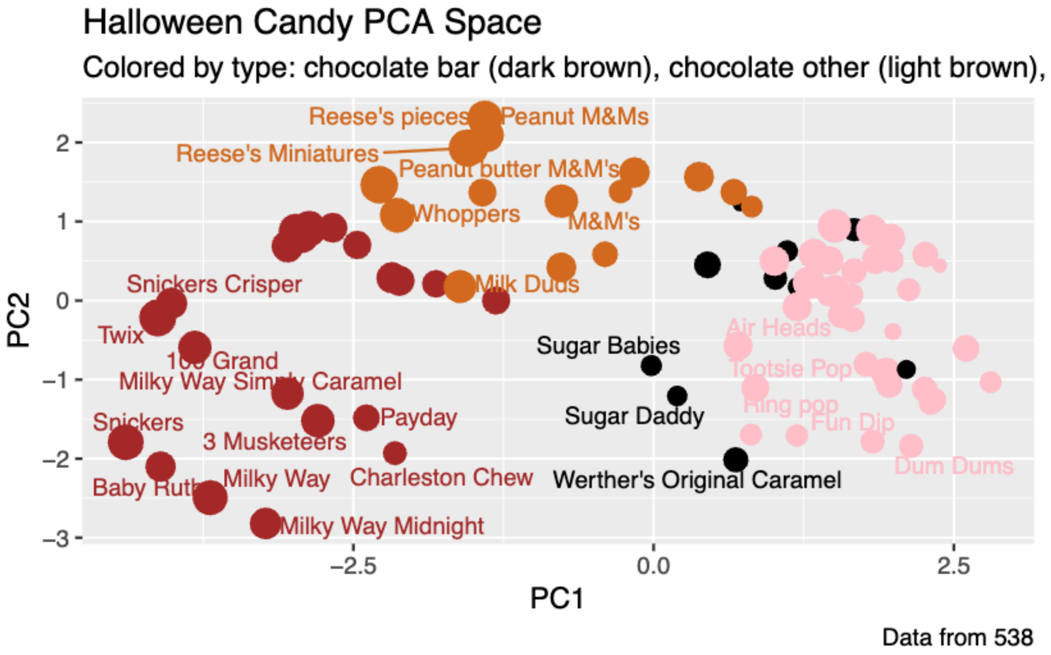


```r
# Make a new data-frame with our PCA results and candy data
my_data <- cbind(candy, pca$x[,1:3])

p <- ggplot(my_data) +
        aes(x=PC1, y=PC2,
            size=winpercent/100,
            text=rownames(my_data),
            label=rownames(my_data)) +
        geom_point(col=my_cols)

p
```



```r
library(ggrepel)

p + 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")
```

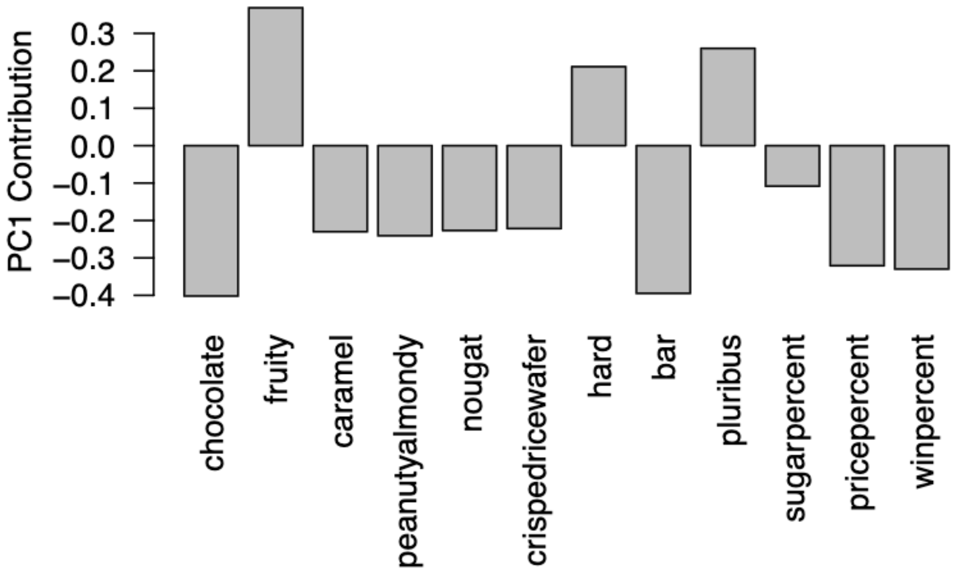
```
Warning: ggrepel: 59 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



Interactive plots that can be zoomed on and "brushed" over can be made with the **plotly** package. It's output is interactive and will not render to PDF.

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

```
par(mar=c(8,4,2,2))
barplot(pca$rotation[,1], las=2, ylab="PC1 Contribution")
```



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

Fruity, hard, and pluribus are picked up strongly by PC1 in the positive direction. This makes sense because PC1 can be considered as a comparison of Chocolate vs fruity. It is logical that the features defining a typical non-chocolate/hard/many-pieces candy (Fruity, Pluribus, Hard) are strongly aligned in the positive direction of PC1, contrasting with the chocolate/bar/high-value (high pricepercent and winpercent) features in the negative direction.