# Class09 - Candy Mini-Project

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### Background

In today's mini-project, we will analyze candy data with the exploratory graphics, basic statistics, correlation analysis, and principal component analysis methods we have been learning thus far.

### Data Import

The data comes as a CSV file from 538.

```
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
```

## What is in the dataset?

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

```
nrow(candy)
```

```
[1] 85
```

There are 85 rows in this dataset.

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

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

```
[1] 38
```

There are 38 fruity candy types in this dataset

### What is your favorite candy?

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

My favorite candy in this dataset is `"Caramel Apple Pops"`. Let's see what its win percent is:

```
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
```

```
winpercent <- function(data, candytype) {
  data |>
    filter(row.names(candy) == candytype) |>
    select(winpercent)
}

winpercent(candy, "Caramel Apple Pops")
```

```
                  winpercent
Caramel Apple Pops   34.51768
```

The win percentage is 34.5%.

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

```
winpercent(candy, "Kit Kat")
```

```
        winpercent
Kit Kat    76.7686
```

The win percentage is 76.8%.

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

```
winpercent(candy, "Tootsie Roll Snack Bars")
```

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

### Using the `skimr::skim()` function

`skim()` from the **skimr** package can give a quick overview of a dataset

```
library("skimr")
```

```
Warning: package 'skimr' was built under R version 4.4.3
```

```
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 | |

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|
| nougat | 0 | 1 | 0.08 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | |
| crispedrice-wafer | 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?

The `winpercent` column looks the most different because it is what looks like a curve while the others are either binary or uniform distributions.

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

The zero represents that a candy does not contain chocolate while a 1 represents that the candy does have chocolate.

## Exploratory analysis

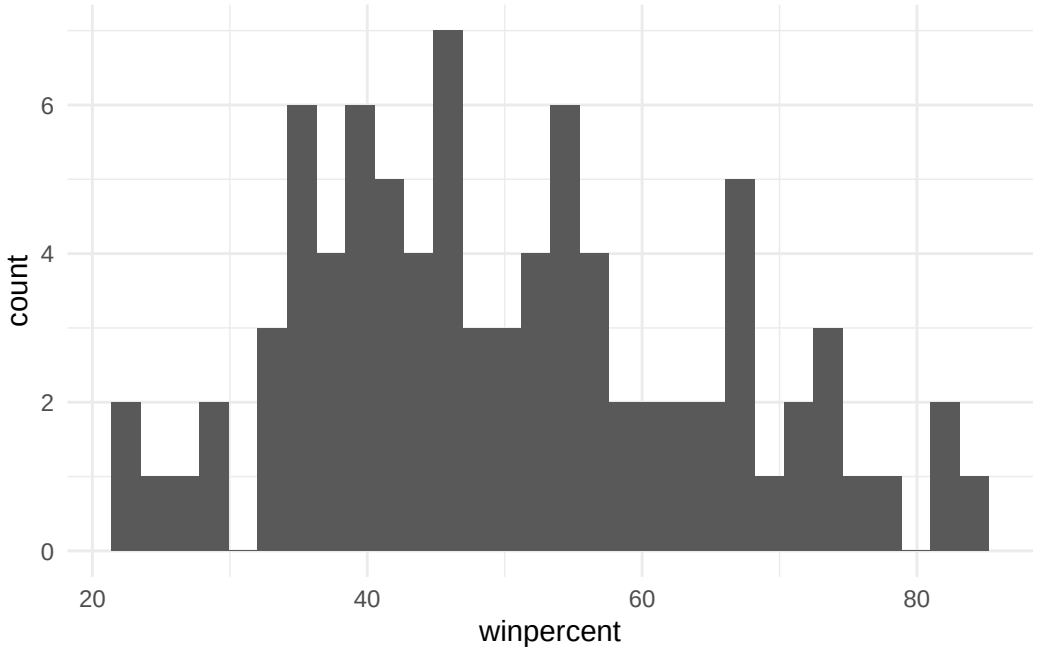
Q8. Plot a histogram of winpercent values using both base R an ggplot2.

```
library(ggplot2)
```

```
Warning: package 'ggplot2' was built under R version 4.4.3
```

```
ggplot(candy) +
  aes(x = winpercent) +
  geom_histogram() +
  theme_minimal()
```

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




Q9. Is the distribution of winpercent values symmetrical?

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

```
[1] 50.31676
```

```
median(candy$winpercent)
```

```
[1] 47.82975
```

No, the distribution is skewed right because the median is less than the mean

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

The center is below 50%

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

Steps: 1. Find all chocolate candy in the dataset 2. Extract their `winpercent` values 3. Calculate the mean of these values 4. Repeat for fruity candy in the dataset

```
choc_candy <- candy[candy$chocolate == 1, ]
choc_wins <- choc_candy$winpercent
mean_choc_wins <- mean(choc_wins)
mean_choc_wins
```

```
[1] 60.92153
```

```
fruity_candy <- candy[candy$fruity == 1, ]
fruity_wins <- fruity_candy$winpercent
mean_fruity_wins <- mean(fruity_wins)
mean_fruity_wins
```

```
[1] 44.11974
```

Q12. Is this difference statistically significant?

```
t.test(choc_wins, fruity_wins)
```

```
    Welch Two Sample t-test

data:  choc_wins and fruity_wins
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
```

Yes, it is statistically significant with a Welch Two Sample t-test.

## Overall candy rankings

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

```
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
```

The five least liked candies are Nik L Nip, Chiclets, Super Bubble, and Jawbusters

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

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

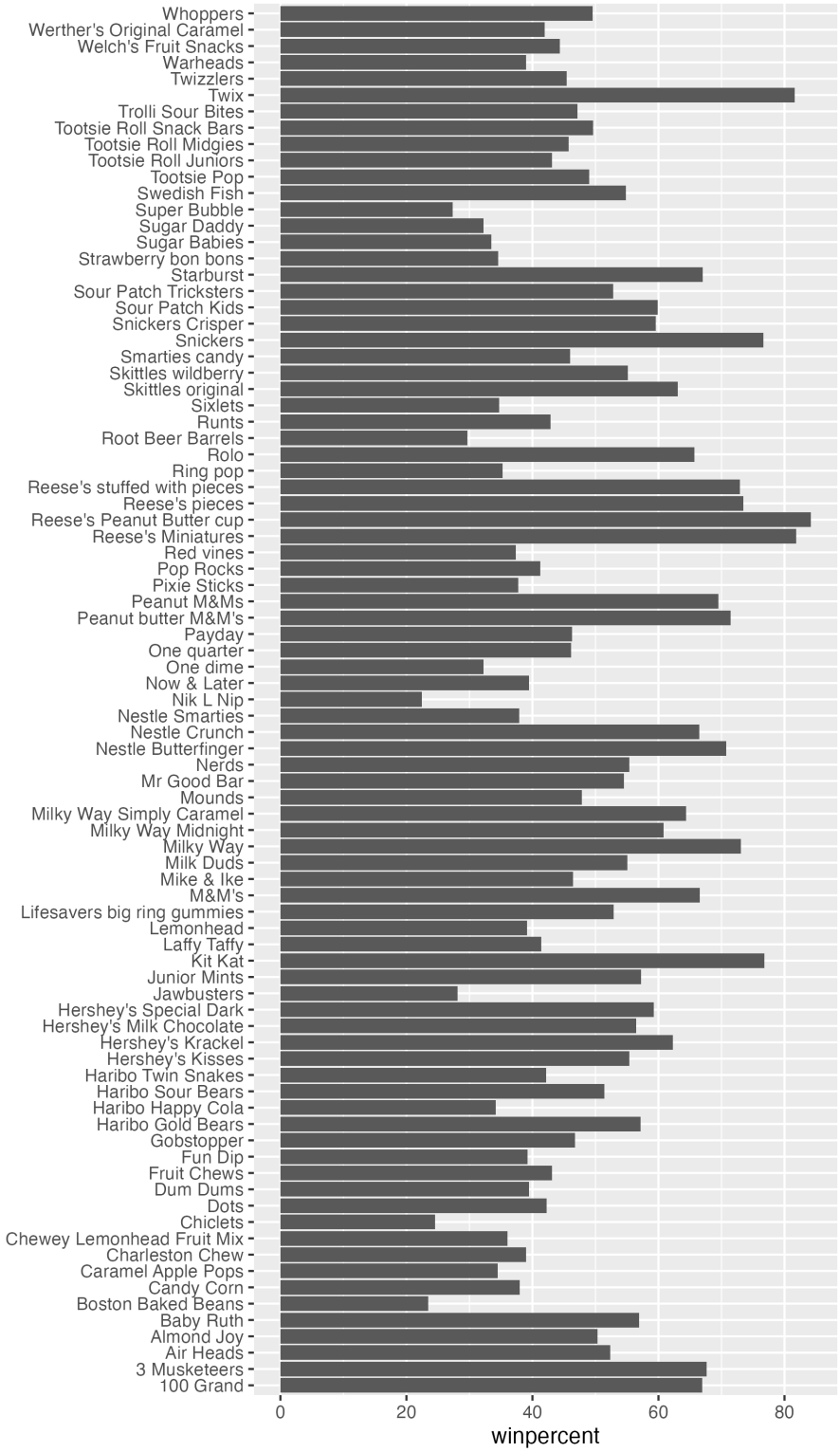
```
                        chocolate fruity caramel peanutyalmondy nougat
Reese's Peanut Butter cup         1      0       0              1      0
Reese's Miniatures                1      0       0              1      0
Twix                              1      0       1              0      0
Kit Kat                           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
```

I prefer the `dplyr` version because it is easier to read.

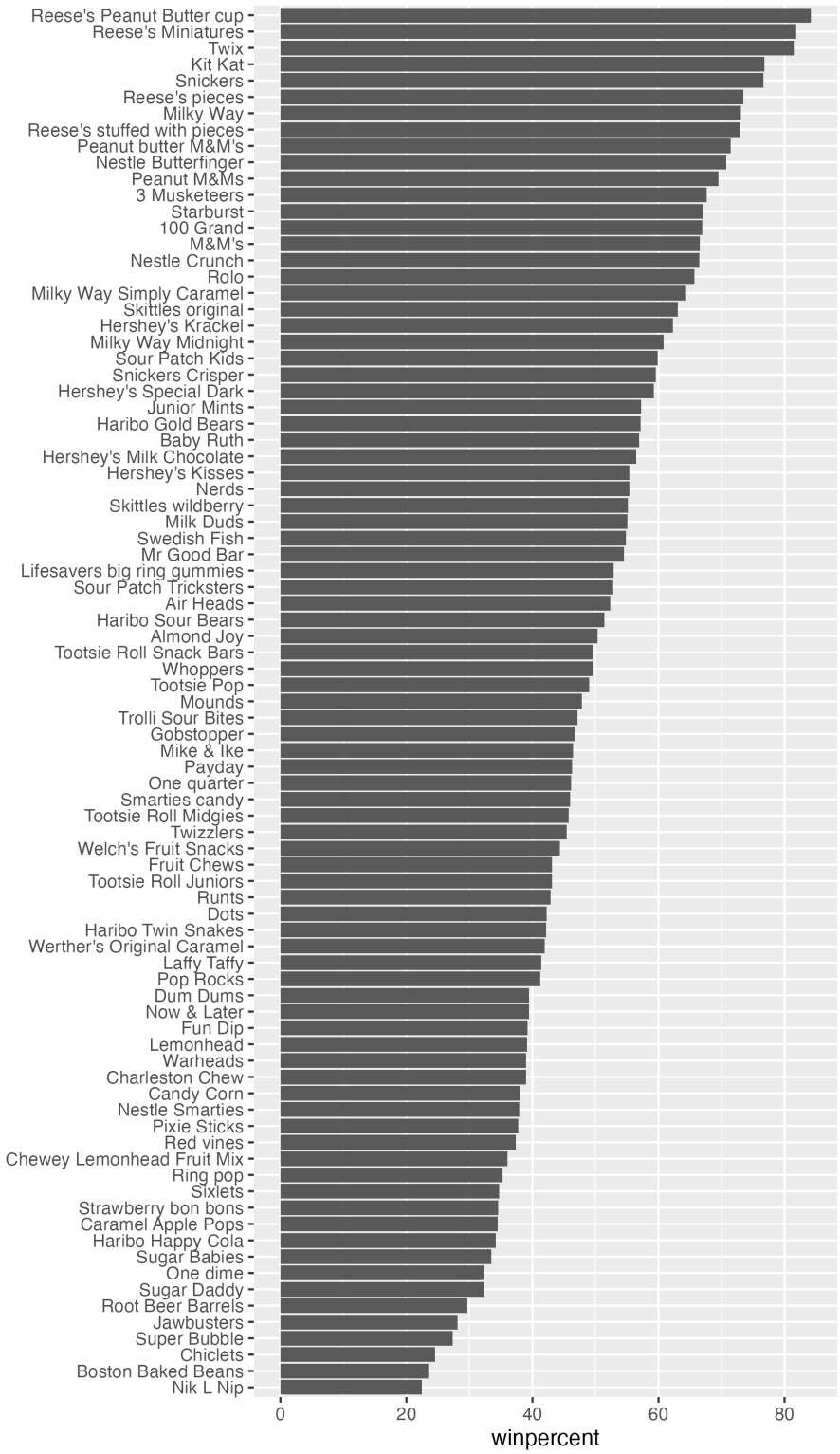
Q15. Make a first barplot of candy ranking based on winpercent values.

```
plot1 <- ggplot(candy) +
  aes(winpercent, rownames(candy)) +
  geom_col() +
  ylab("")

ggsave("barplot1.png", plot = plot1, height = 10, width = 6)
```


Whoppers
Werther's Original Caramel
Welch's Fruit Snacks
Warheads
Twizzlers
Twix
Trolli Sour Bites
Tootsie Roll Snack Bars
Tootsie Roll Midgies
Tootsie Roll Juniors
Tootsie Pop
Swedish Fish
Super Bubble
Sugar Daddy
Sugar Babies
Strawberry bon bons
Starburst
Sour Patch Tricksters
Sour Patch Kids
Snickers Crisper
Snickers
Smarties candy
Skittles wildberry
Skittles original
Sixlets
Runts
Root Beer Barrels
Rolo
Ring pop
Reese's stuffed with pieces
Reese's pieces
Reese's Peanut Butter cup
Reese's Miniatures
Red vines
Pop Rocks
Pixie Sticks
Peanut M&Ms
Peanut butter M&M's
Payday
One quarter
One dime
Now & Later
Nik L Nip
Nestle Smarties
Nestle Crunch
Nestle Butterfinger
Nerds
Mr Good Bar
Mounds
Milky Way Simply Caramel
Milky Way Midnight
Milky Way
Milk Duds
Mike & Ike
M&M's
Lifesavers big ring gummies
Lemonhead
Laffy Taffy
Kit Kat
Junior Mints
Jawbusters
Hershey's Special Dark
Hershey's Milk Chocolate
Hershey's Krackel
Hershey's Kisses
Haribo Twin Snakes
Haribo Sour Bears
Haribo Happy Cola
Haribo Gold Bears
Gobstopper
Fun Dip
Fruit Chews
Dum Dums
Dots
Chiclets
Chewey Lemonhead Fruit Mix
Charleston Chew
Caramel Apple Pops
Candy Corn
Boston Baked Beans
Baby Ruth
Almond Joy
Air Heads
3 Musketeers
100 Grand
0
20
40
60
80
winpercent

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

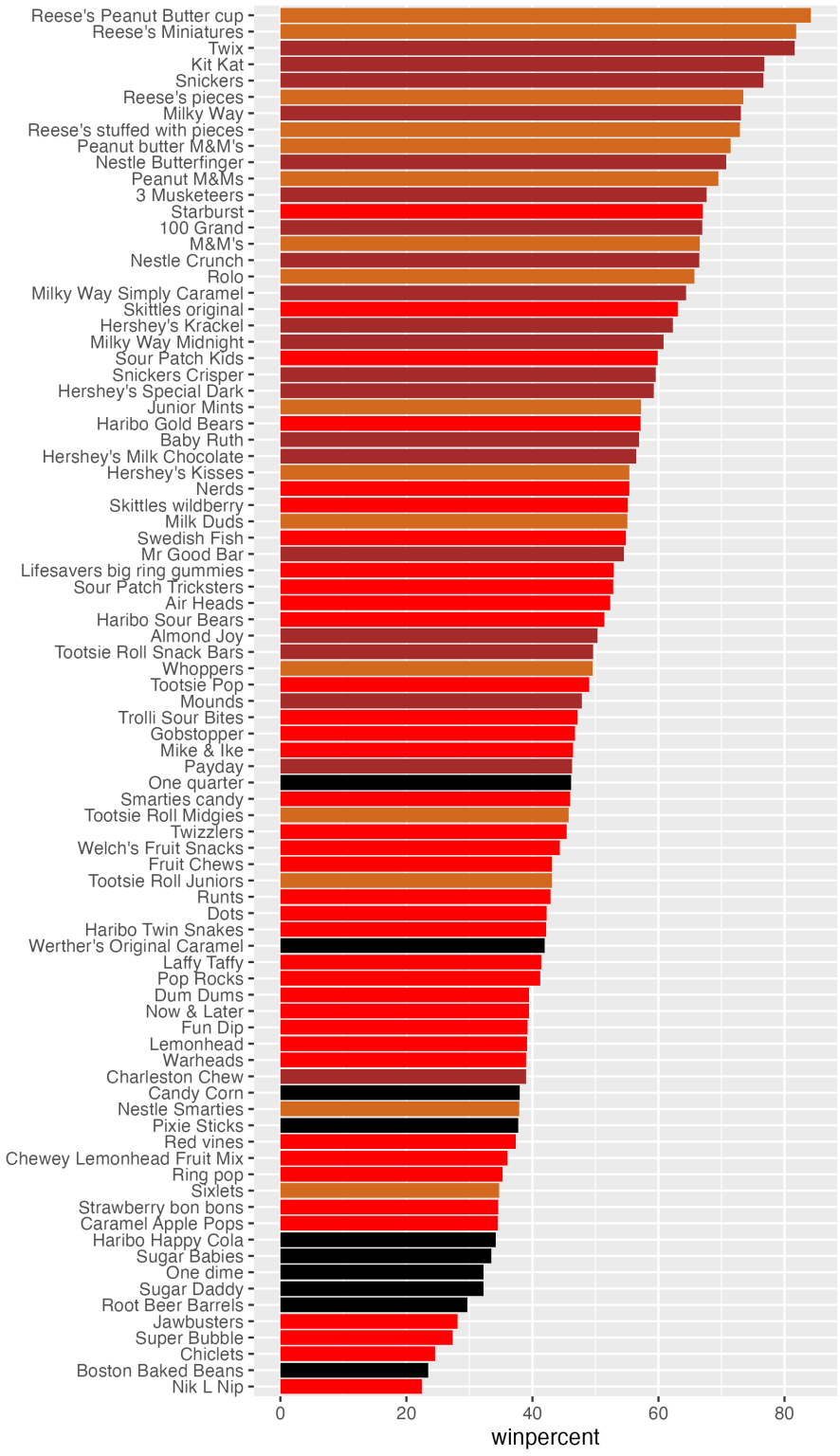
```
plot2 <- ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent)) +
  geom_col() +
  ylab("")

ggsave("barplot2.png", plot = plot2,  height = 10, width = 6)
```


Reese's Peanut Butter cup
Reese's Miniatures
Twix
Kit Kat
Snickers
Reese's pieces
Milky Way
Reese's stuffed with pieces
Peanut butter M&M's
Nestle Butterfinger
Peanut M&Ms
3 Musketeers
Starburst
100 Grand
M&M's
Nestle Crunch
Rolo
Milky Way Simply Caramel
Skittles original
Hershey's Krackel
Milky Way Midnight
Sour Patch Kids
Snickers Crisper
Hershey's Special Dark
Junior Mints
Haribo Gold Bears
Baby Ruth
Hershey's Milk Chocolate
Hershey's Kisses
Nerds
Skittles wildberry
Milk Duds
Swedish Fish
Mr Good Bar
Lifesavers big ring gummies
Sour Patch Tricksters
Air Heads
Haribo Sour Bears
Almond Joy
Tootsie Roll Snack Bars
Whoppers
Tootsie Pop
Mounds
Trolli Sour Bites
Gobstopper
Mike & Ike
Payday
One quarter
Smarties candy
Tootsie Roll Midgies
Twizzlers
Welch's Fruit Snacks
Fruit Chews
Tootsie Roll Juniors
Runts
Dots
Haribo Twin Snakes
Werther's Original Caramel
Laffy Taffy
Pop Rocks
Dum Dums
Now & Later
Fun Dip
Lemonhead
Warheads
Charleston Chew
Candy Corn
Nestle Smarties
Pixie Sticks
Red vines
Chewey Lemonhead Fruit Mix
Ring pop
Sixlets
Strawberry bon bons
Caramel Apple Pops
Haribo Happy Cola
Sugar Babies
One dime
Sugar Daddy
Root Beer Barrels
Jawbusters
Super Bubble
Chiclets
Boston Baked Beans
Nik L Nip
0
20
40
60
80
winpercent

### Adding color

```
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)] <- "red"
```

```
plot3 <- ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent)) +
  geom_col(fill=my_cols) +
  ylab("")

ggsave("barplot3.png", plot = plot3, height = 10, width = 6)
```


Reese's Peanut Butter cup
Reese's Miniatures
Twix
Kit Kat
Snickers
Reese's pieces
Milky Way
Reese's stuffed with pieces
Peanut butter M&M's
Nestle Butterfinger
Peanut M&Ms
3 Musketeers
Starburst
100 Grand
M&M's
Nestle Crunch
Rolo
Milky Way Simply Caramel
Skittles original
Hershey's Krackel
Milky Way Midnight
Sour Patch Kids
Snickers Crisper
Hershey's Special Dark
Junior Mints
Haribo Gold Bears
Baby Ruth
Hershey's Milk Chocolate
Hershey's Kisses
Nerds
Skittles wildberry
Milk Duds
Swedish Fish
Mr Good Bar
Lifesavers big ring gummies
Sour Patch Tricksters
Air Heads
Haribo Sour Bears
Almond Joy
Tootsie Roll Snack Bars
Whoppers
Tootsie Pop
Mounds
Trolli Sour Bites
Gobstopper
Mike & Ike
Payday
One quarter
Smarties candy
Tootsie Roll Midgies
Twizzlers
Welch's Fruit Snacks
Fruit Chews
Tootsie Roll Juniors
Runts
Dots
Haribo Twin Snakes
Werther's Original Caramel
Laffy Taffy
Pop Rocks
Dum Dums
Now & Later
Fun Dip
Lemonhead
Warheads
Charleston Chew
Candy Corn
Nestle Smarties
Pixie Sticks
Red vines
Chewey Lemonhead Fruit Mix
Ring pop
Sixlets
Strawberry bon bons
Caramel Apple Pops
Haribo Happy Cola
Sugar Babies
One dime
Sugar Daddy
Root Beer Barrels
Jawbusters
Super Bubble
Chiclets
Boston Baked Beans
Nik L Nip
0
20
40
60
80
winpercent

Q17. What is the worst ranked chocolate candy?

Sixlets

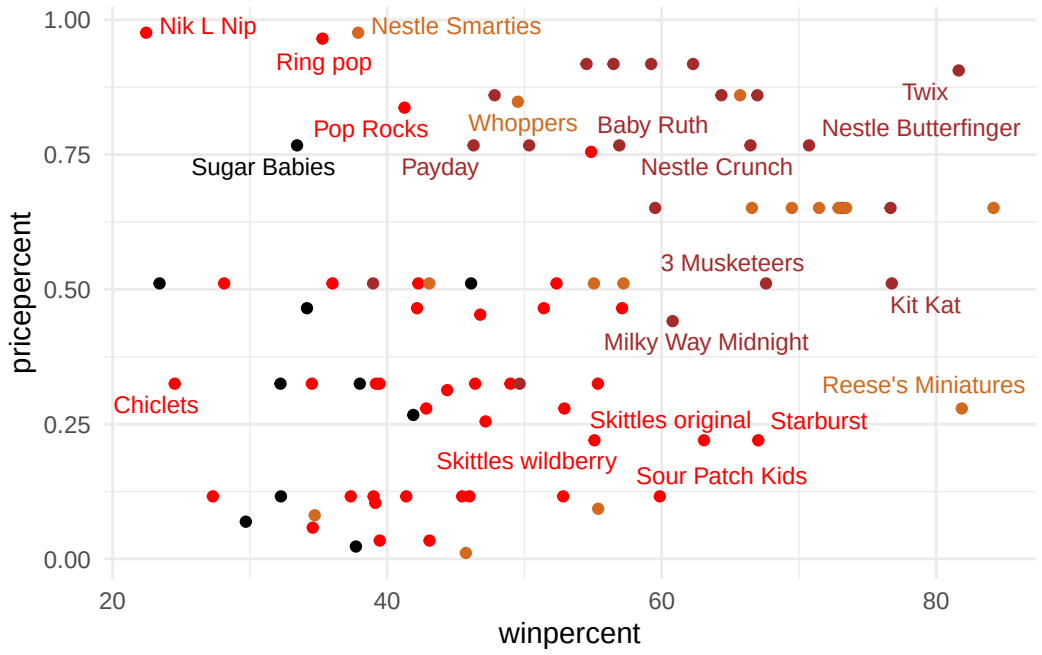
Q18. What is the best ranked fruity candy?

Starburst

## Looking at pricepercent

```
library(ggrepel)

# How about a plot of win vs price
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) +
  theme_minimal()
```

```
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?

```
best_candy <- candy |>
  select(pricepercent, winpercent) |>
  arrange(desc(winpercent))

head(best_candy, 5)
```

```
                         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 Miniatures is the cheapest of the top 5 winning candies.

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

```
exp_candy <- candy |>
  select(pricepercent, winpercent) |>
  arrange(desc(pricepercent))

head(exp_candy, 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
```

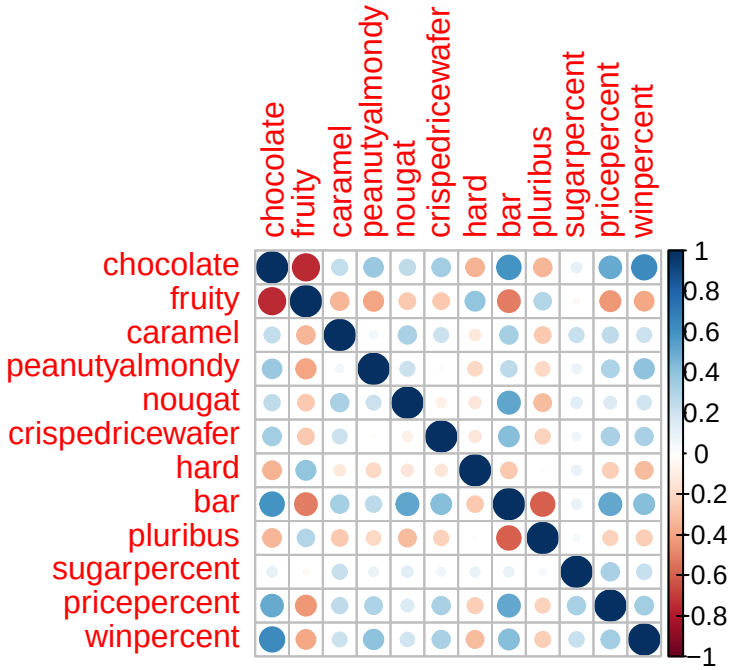
Nik L Nip is least popular of the five most expensive candies.

### Exploring the correlation structure

```
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 anti-correlated.

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

Chocolate and bar are the most positively correlated.

## Principal Component Analysis

Variance of PC axes:

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

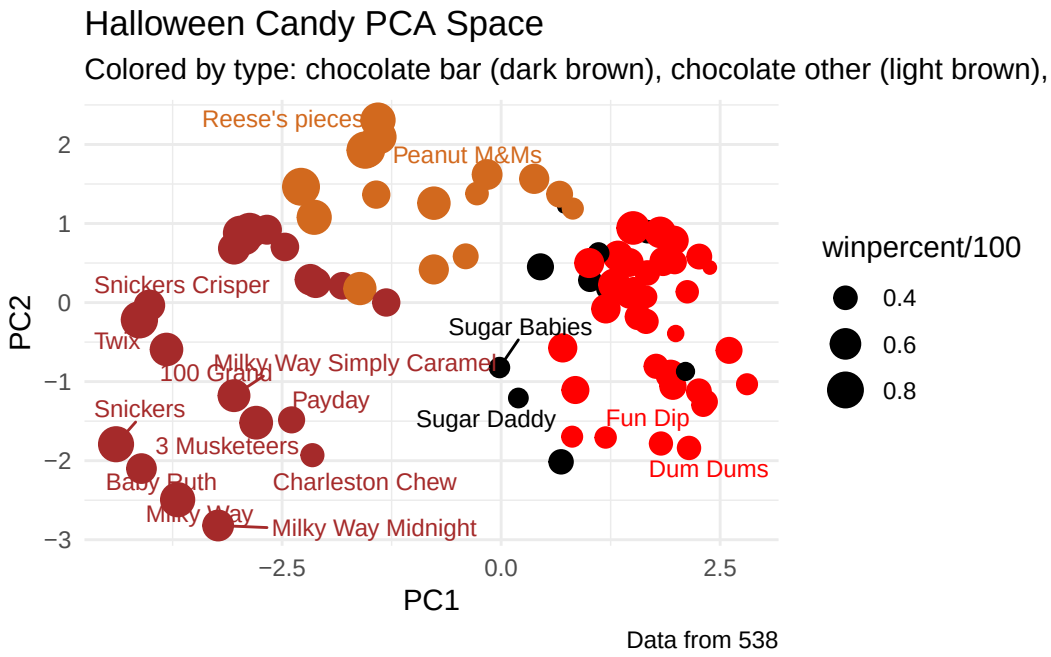
```
Importance of components:
                          PC1    PC2    PC3     PC4    PC5     PC6     PC7
Standard deviation     2.0788 1.1378 1.1092 1.07533 0.9518 0.81923 0.81530
Proportion of Variance 0.3601 0.1079 0.1025 0.09636 0.0755 0.05593 0.05539
Cumulative Proportion  0.3601 0.4680 0.5705 0.66688 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
```

Plotting the first two PC axes using `ggplot`:

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

```r
p <- ggplot(candy_data) +
  aes(PC1, PC2,
    size = winpercent/100,
    text = rownames(candy_data),
    label = rownames(candy_data)
    ) +
  geom_point(col = my_cols) +
  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") +
  theme_minimal()

p
```

```
Warning: ggrepel: 68 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```

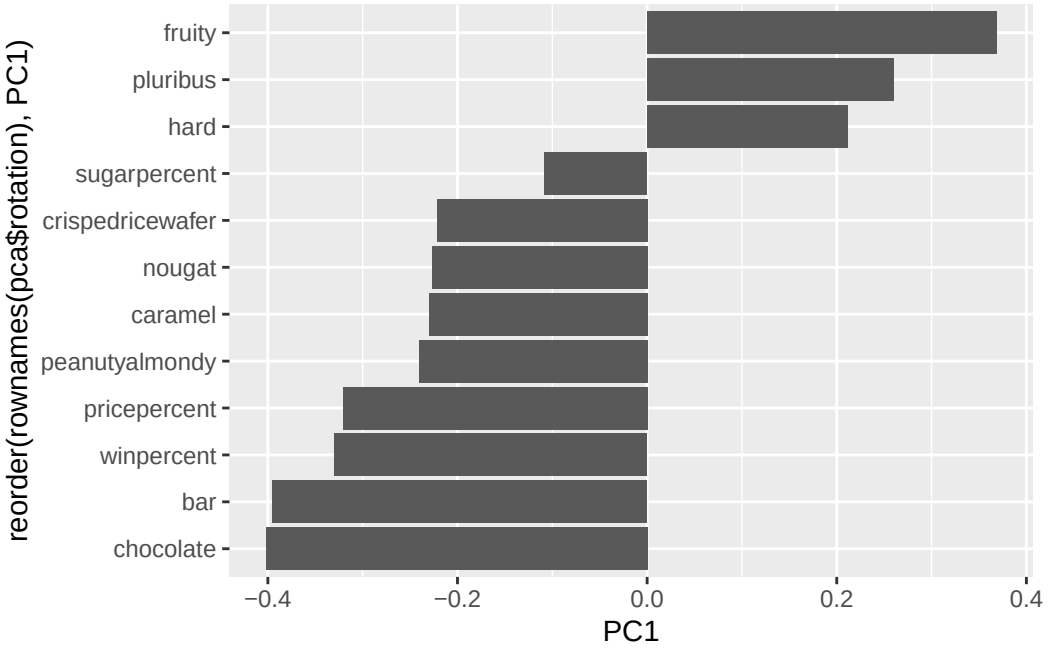



Making an interactive plot:

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

Loading scores plot for PC1:

```
ggplot(pca$rotation) +
  aes(PC1, reorder(rownames(pca$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 and pluribus are. This is the same as the correlation plot where fruity and pluribus were strongly correlated.

## 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?

It looks like chocolates and bars are the best winning candies. This is backed up by the exploratory analysis where the bar plot shows the top winning items are chocolates or bars. This is further backed up by the correlation plot which shows that both chocolate and bars are correlated with winning and bars are correlated with chocolate. The PCA also shows that chocolate, bar, and winning are all strongly associated with the negative direction of PC1. Based on these pieces of evidence, winning candies are usually chocolates and bars.