Class 9: Candy Mini-Project

Aadhya Tripathi (PID: A17878439)

Table of contents

Background

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

Data Import

The data comes as a CSV file from FiveThirtyEight.

```
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?

There are 85 different candy types.

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

There are 38 fruity candy types.

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

My favorite candy is "Milky Way" with a winpercent of 73.099556.

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

The winpercent for "Kit Kat" is 76.7686.

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

The winpercent for "Tootsie Roll Snack Bars" is 49.653503.

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

```
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	

The winpercent variable is on a different scale in comparison to the other columns.

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

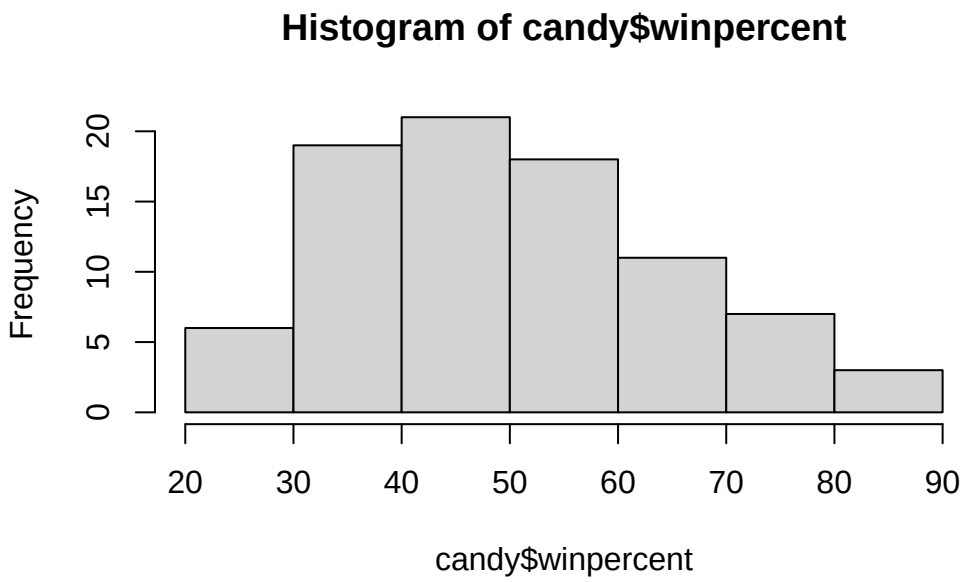
It is a true/false for whether the candy type is chocolate or not.

Exploratory analysis

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

Using base R:

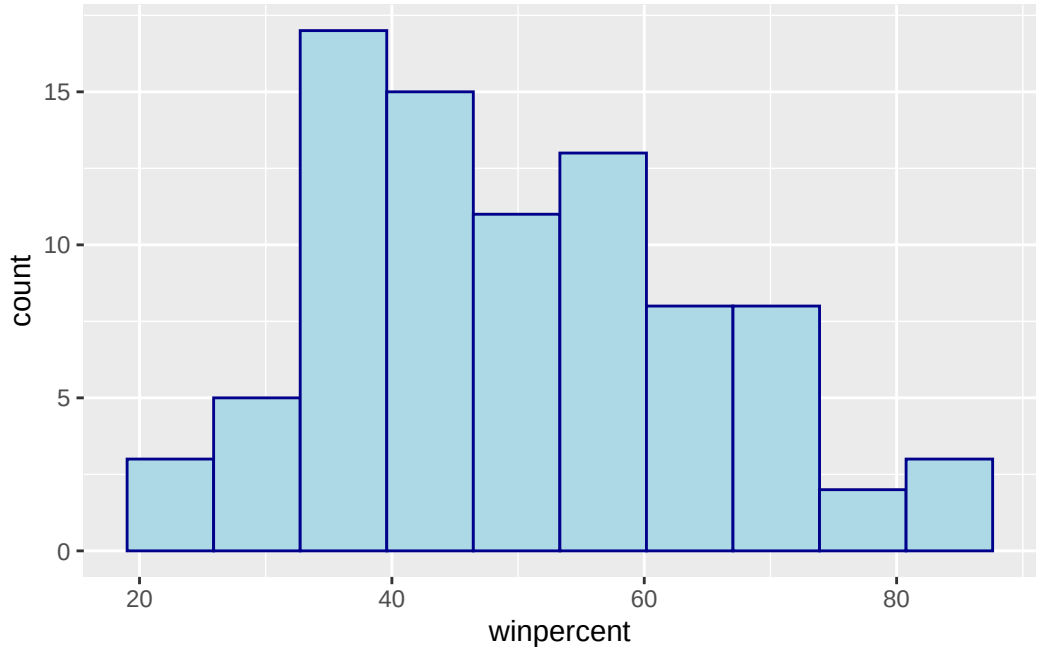
```
hist(candy$winpercent)
```



Using ggplot:

```
library(ggplot2)
```

```
ggplot(candy) +
  aes(winpercent) +
  geom_histogram(bins = 10, fill = "lightblue", col = "darkblue")
```



Q9. Is the distribution of winpercent values symmetrical?

No, there is a skew to the right.

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

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

```
[1] 50.31676
```

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

```
[1] 47.82975
```

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

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

The mean is slightly above 50%. However, the median is below 50%. Based on the median, the center is determined to be below 50%.

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

Steps to solve this problem: 1. Find all chocolate candy in the dataset 2. Find winpercent of these 3. Calculate mean winpercent 4. Repeat 1-3 for fruity candy 5. Compare chocolate mean and fruity mean

```
choc_win <- candy$winpercent[as.logical(candy$chocolate)]
fruity_win <- candy$winpercent[as.logical(candy$fruity)]

print(mean(choc_win))
```

```
[1] 60.92153
```

```
print(mean(fruity_win))
```

```
[1] 44.11974
```

```
mean(choc_win) > mean(fruity_win)
```

```
[1] TRUE
```

Based on their mean values, chocolate candy is ranked higher than fruit candy.

Q12. Is this difference statistically significant?

```
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
```

Based on the extremely low p-value, we can reject the null hypothesis and the difference is statistically significant.

Overall Candy Rankings

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

Use dplyr to rearrange the data by winpercent.

```
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 |>
  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 5 least liked candy types in this dataset are “Nik L Nip”, “Boston Baked Beans”, “Chiclets”, “Super Bubble”, and “Jawbusters”.

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

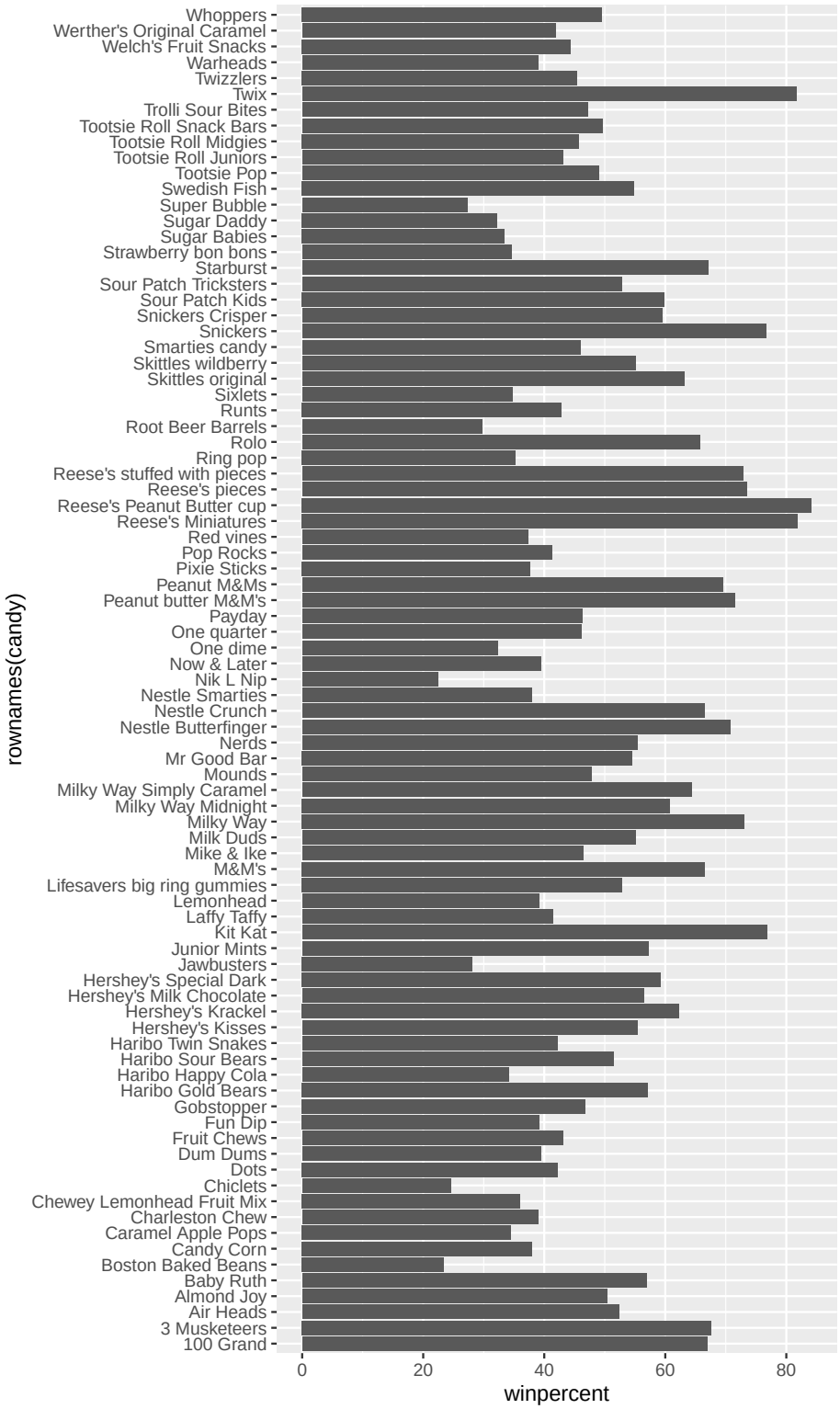
```
candy |>
  arrange(desc(winpercent)) |>
    head(5)
```

```
                         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
```

The 5 all time favorite candy types in this dataset are “Reese’s Peanut Butter cup”, “Reese’s Miniatures”, “Twix”, “Kit Kat”, and “Snickers”.

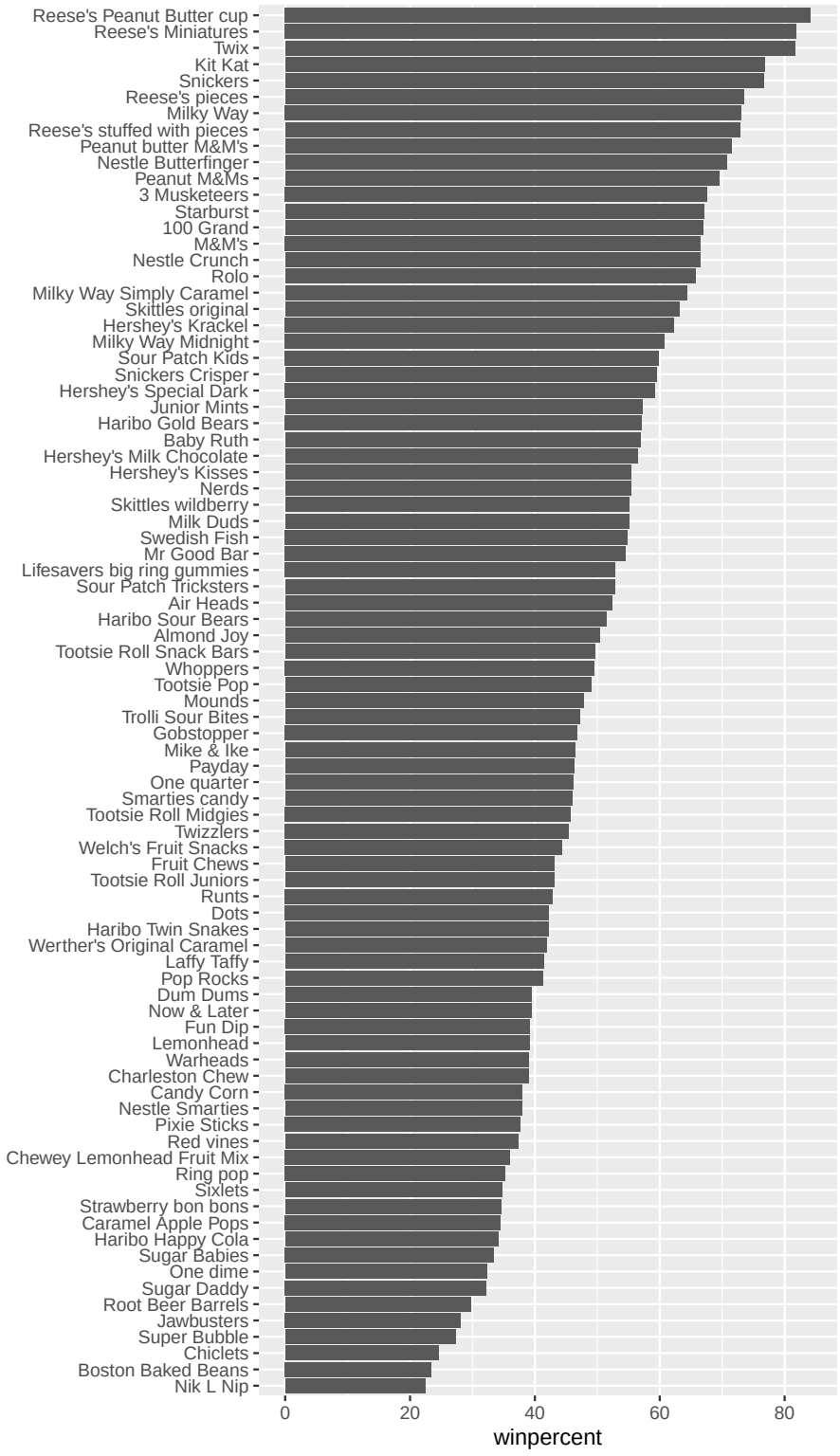
Q15. Make a first barplot of candy ranking based on winpercent values.

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


rownames(candy)
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.

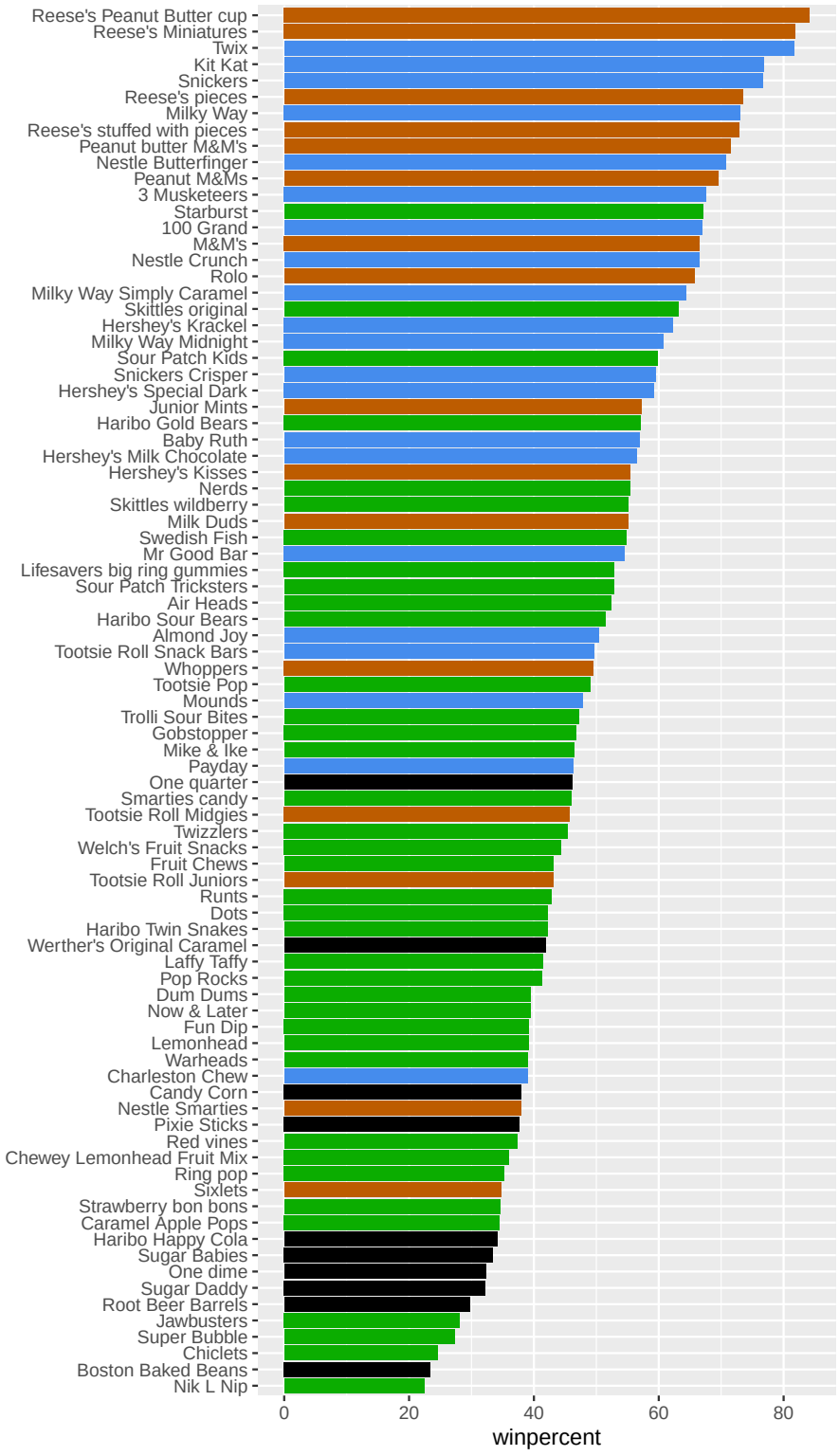
```
ggplot(candy) +
  aes(winpercent, reorder(rownames(candy),winpercent)) +
  geom_col() +
  ylab("")
```


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

Color the bars based on candy type. Brown is for chocolate, blue for bar candies, and green for fruity candies.

```
my_cols=rep("black", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "#BD5C00"
my_cols[as.logical(candy$bar)] = "#458CED"
my_cols[as.logical(candy$fruity)] = "#0BAD00"
```

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


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.

Taking a look at pricepercent

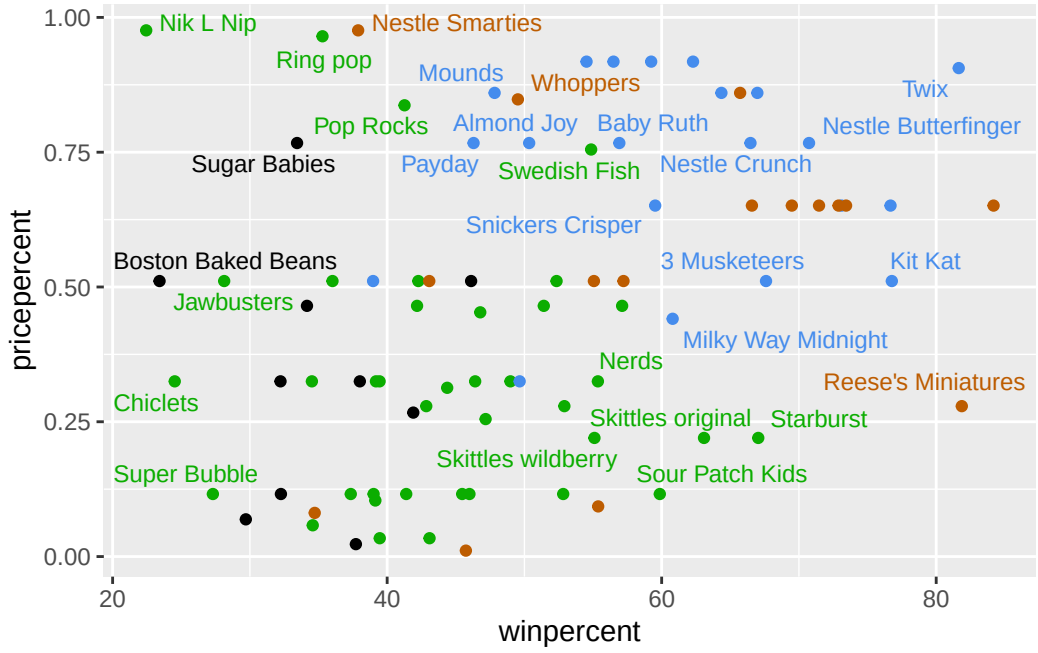
Use ggrepel to make overalpping data point labels easier to read.

```
library(ggrepel)
```

Make a plot of winpercent vs pricepercent:

```
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols, size=3.3, max.overlaps = 7)
```

```
Warning: ggrepel: 57 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 have a high winpercent while having a relatively low pricepercent.

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

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

```
                        chocolate fruity caramel peanutyalmondy nougat
Nik L Nip                       0      1       0              0      0
Nestle Smarties                 1      0       0              0      0
Ring pop                        0      1       0              0      0
Hershey's Krackel               1      0       0              0      0
Hershey's Milk Chocolate        1      0       0              0      0
                        crispedricewafer hard bar pluribus sugarpercent
Nik L Nip                              0    0   0        1        0.197
Nestle Smarties                        0    0   0        1        0.267
Ring pop                               0    1   0        0        0.732
Hershey's Krackel                      1    0   1        0        0.430
Hershey's Milk Chocolate               0    0   1        0        0.430
                        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
```

The top 5 most expensive candy types are "Nik L Nip", "Nestle Smarties", "Ring pop", "Hershey's Krackel", and "Hershey's Milk Chocolate". The least popular of these is "Nik L Nip".

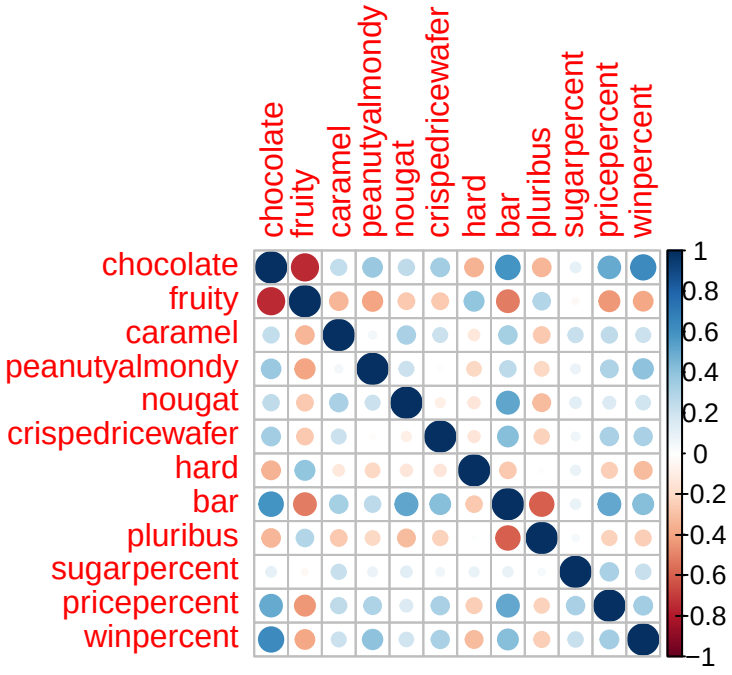
Exploring the correlation structure

Pearson correlation values range from -1 to +1.

```
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)?

Fruity and chocolate

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

Chocolate and winpercent

Principal Component Analysis

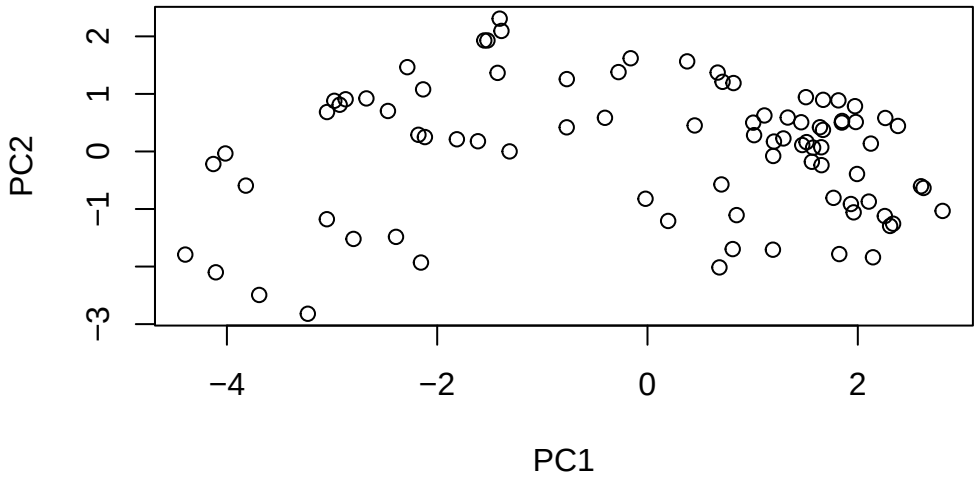
```
pca <- prcomp(candy, scale=TRUE)
summary(pca)
```

```
Importance of components:
                          PC1     PC2     PC3     PC4     PC5     PC6     PC7
```

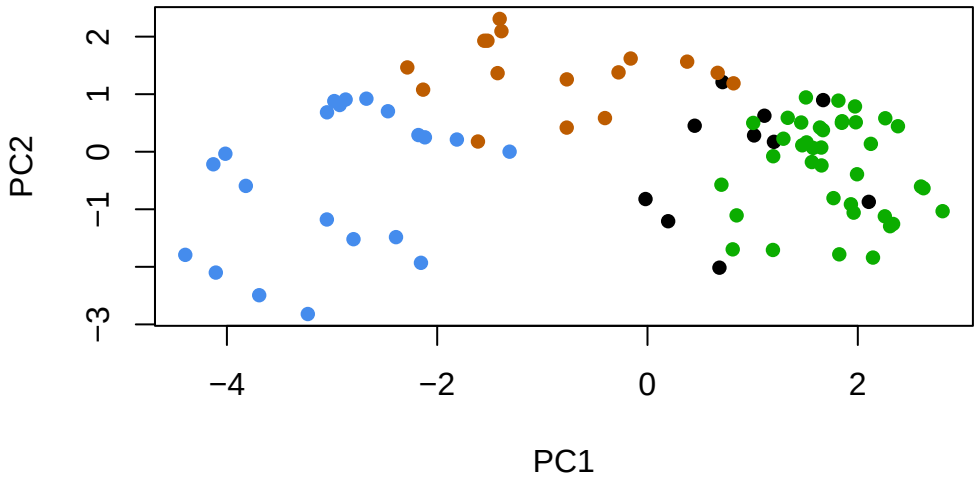
```
Standard deviation     2.0788 1.1378 1.1092 1.07533 0.9518 0.81923 0.81530
Proportion of Variance 0.3601 0.1079 0.1025 0.09636 0.0755 0.05593 0.05539
Cumulative Proportion  0.3601 0.4680 0.5705 0.66688 0.7424 0.79830 0.85369
                           PC8     PC9    PC10    PC11    PC12
Standard 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
```

The main results figure is the PCA score plot:

```
plot(pca$x[,1:2])
```

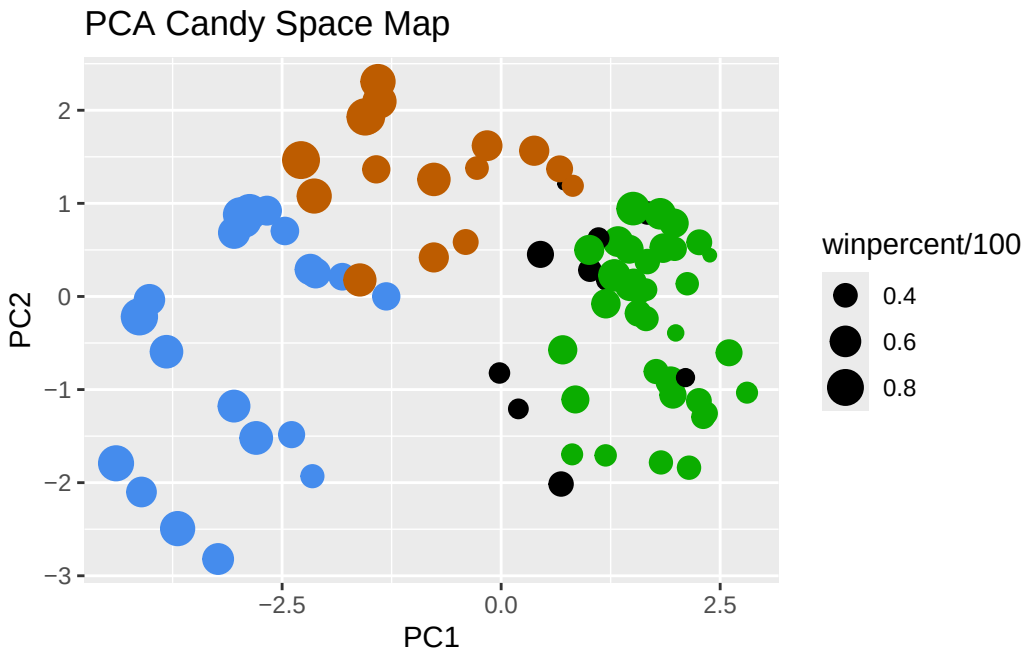


```
plot(pca$x[,1:2], col=my_cols, pch=16)
```



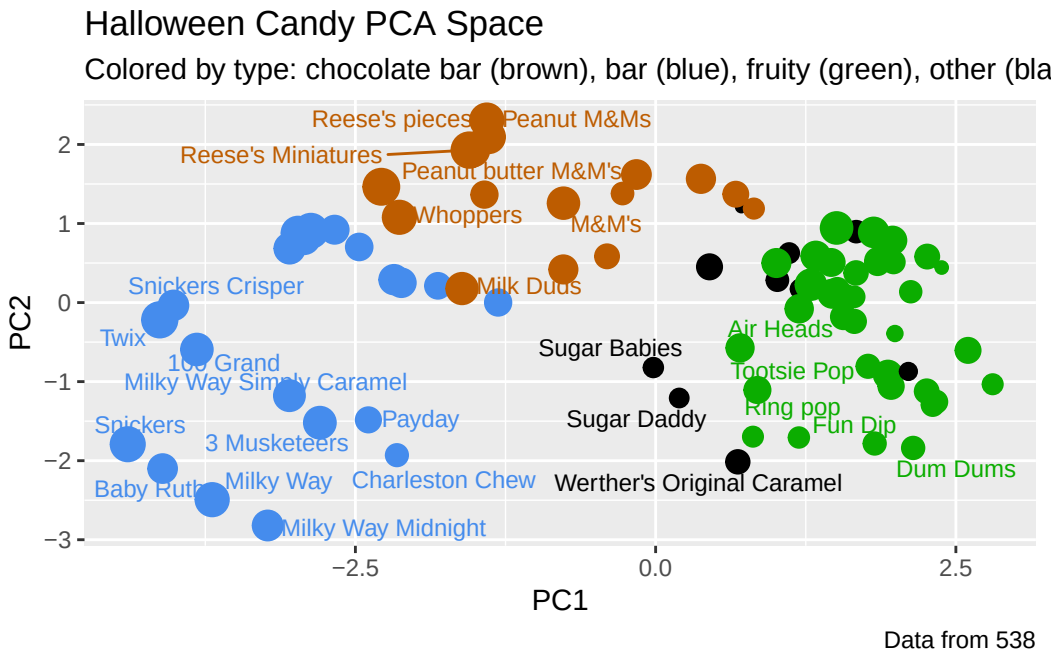

```
# Make a new data-frame with our PCA results and candy data
my_data <- cbind(candy, pca$x[,1:3])
```

```
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) +
        labs(title="PCA Candy Space Map")

p
```




```
p <- 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 (brown), bar (blue), fruity (green), other (
       caption="Data from 538")

p
```

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



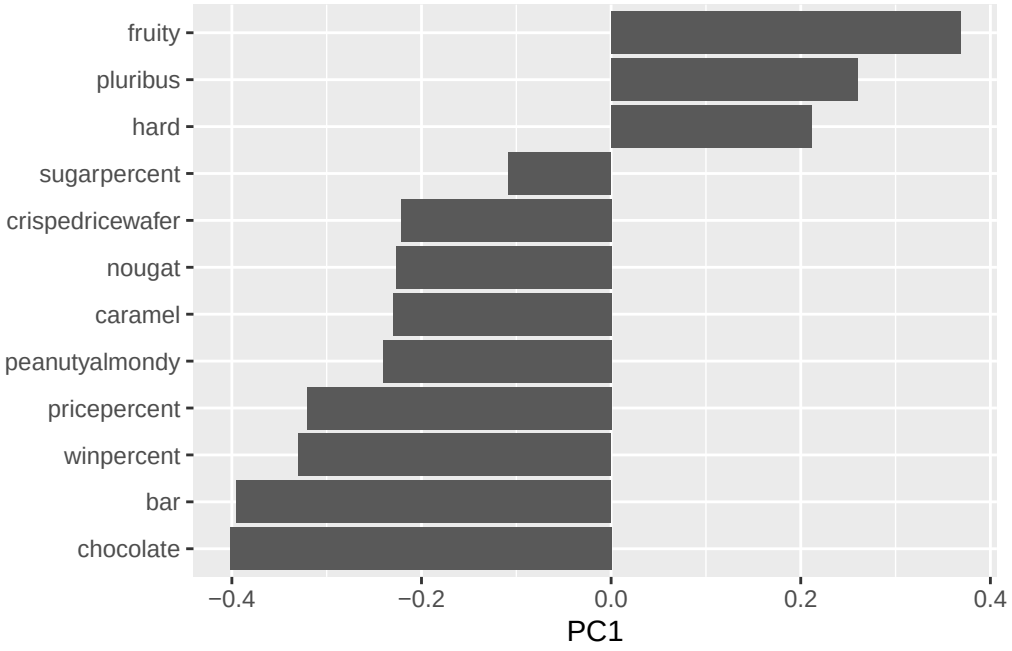
Make an interactive plot with plotly (excluded for PDF render):

```
# library(plotly)
```

```
# ggplotly(p)
```

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?

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



Fruity, pluribus, and hard are in the positive direction. It makes sense for these characteristics to be correlated as many fruity candies come in multiples and may be hard more often than chocolate. This relationship was previously highlighted in the correlation matrix.

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?

Chocolate, bar candy types appear to be the "winning" candy. The correlation matrix shows that winpercent has strongest positive correlation with chocolate, and it has a medium positive correlation with bar as well. The PCA plot supports that chocolate and bar candy are more similar to each other compared to fruity candy, as they are closer together on the PC1 axis than chocolate and fruity. The winpercent ordered barplot visualization shows that that brown and blue, representing chocolate and bar candies, tend to be higher compared to the green fruity candies.