

# Class 10: Haloween mini project

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## Table of contents

Principal Component Analysis . . . . . 14

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 come from the 538 website and is available as a CSV file:

```
candy_file <- read.csv("candy-data.txt")
```

```
candy = read.csv("candy-data.txt", row.names=1)
head(candy)
```

	chocolate	fruity	caramel	peanut	yalmond	nougat	crisped	rice	wafers
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			

```
flextable::flextable(head(candy,10))
```

chocolate	fruity	caramel	peanut	almond	nougat	crisped	rice	wafer	hard	bar	pluribus	s
1	0	1	0	0	0	1	0	0	1	1	0	0
1	0	0	0	0	1	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	0	0	1	0	0
1	0	1	1	1	1	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0	0	0	0	0	0	0

The functions dim(), nrow(), table() and sum() may be useful for answering the first 2 questions.

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

```
nrow(candy)
```

```
[1] 85
```

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

```
library(tidyverse)
```

```
-- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
v dplyr     1.1.4     v readr      2.1.5
v forcats   1.0.1     v stringr    1.5.2
v ggplot2   4.0.0     v tibble     3.3.0
v lubridate 1.9.4     v tidyr     1.3.1
v purrr     1.1.0
-- Conflicts ----- tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()   masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becom
```

```
candy |>  
ncol()
```

[1] 12

```
library(tidyverse)  
  
candy %>%  
nrow()
```

[1] 85

Count how many candy are fruity?

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

[1] 38

My favorite winpercent

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

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

[1] 50.34755

```
library(dplyr)  
  
candy |>  
filter(rownames(candy)=="Almond Joy") |>  
select(winpercent)
```

```
      winpercent  
Almond Joy    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
```

##Quick overview of the dataset

```
skimr::skim(candy)
```

Table 2: 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	
peanutyalmond	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	

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
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 is on a 0-100 scale the rest are 0-1 scale.

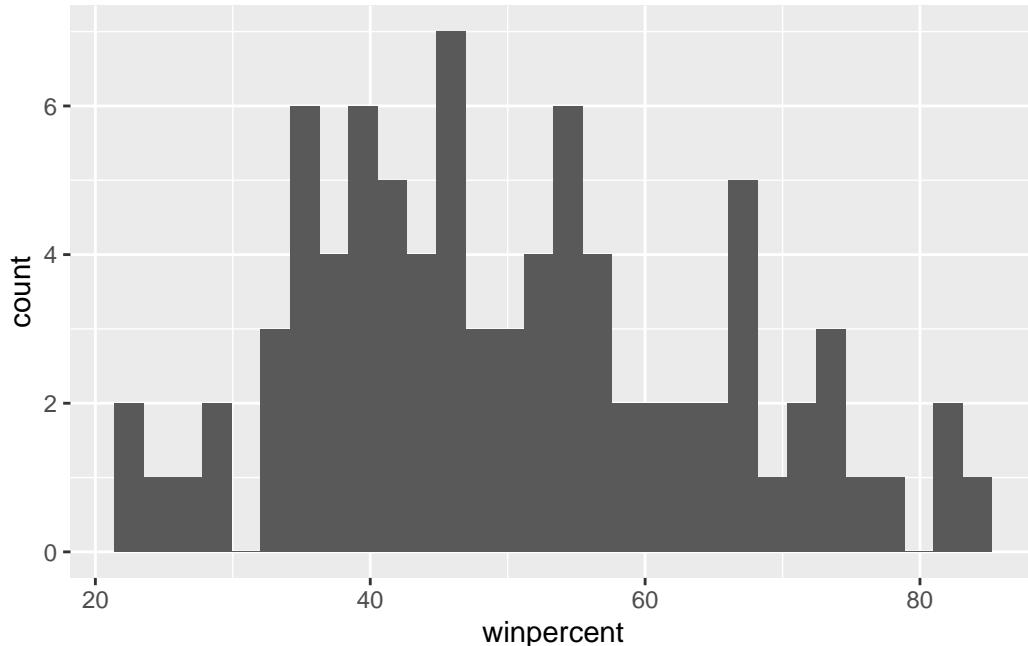
Q7. What do you think a zero and one represent for the candy\$chocolate column?

That the candy does not contain chocolate

Q8. Plot a histogram of winpercent values

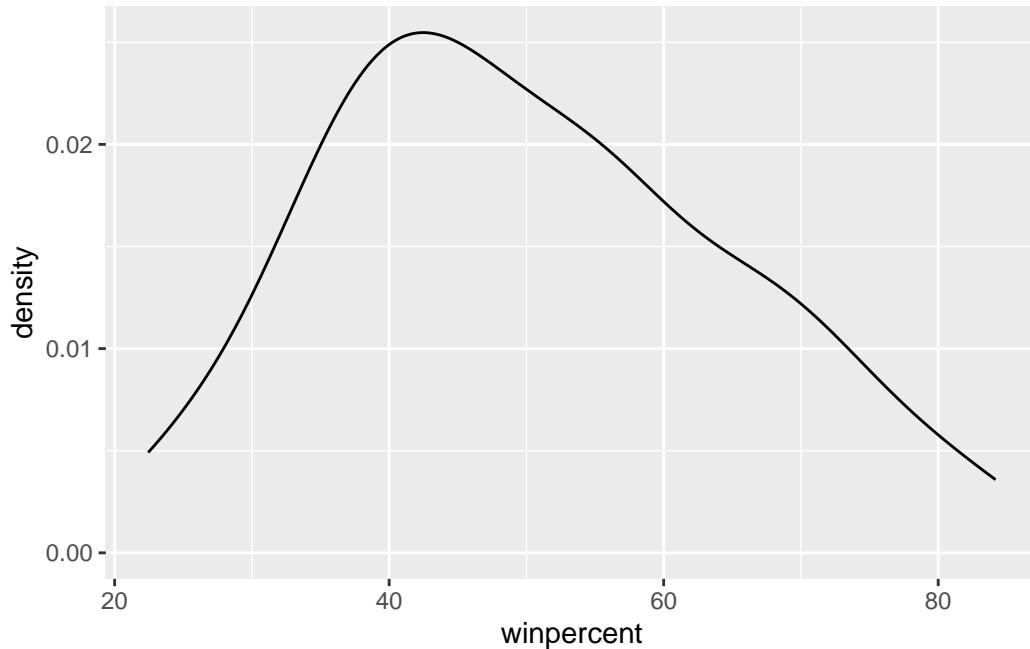
```
ggplot(candy, aes(x=winpercent)) +
  geom_histogram()
```

`stat\_bin()` using `bins = 30`. Pick better value `binwidth`.



Q9. Is the distribution of winpercent values symmetrical?

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



The peak is before 50 and thus is not symmetrical.

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

The center of distribution is below 50 since the median is at 47.83% win percent.

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

#4-6. Do the same for fruity candy
#7. Compare mean winpercents of chocolate vs fruity
#8. Pick the highest as winner

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

```

[1] 60.92153

```
mean(candy[candy$chocolate==1,]$winpercent)
```

[1] 60.92153

```

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

```

[1] 44.11974

```
candy |>
  filter(chocolate==1) |>
  select(winpercent)
```

	winpercent
100 Grand	66.97173
3 Musketeers	67.60294
Almond Joy	50.34755
Baby Ruth	56.91455
Charleston Chew	38.97504
Hershey's Kisses	55.37545
Hershey's Krackel	62.28448
Hershey's Milk Chocolate	56.49050

Hershey's Special Dark	59.23612
Junior Mints	57.21925
Kit Kat	76.76860
Peanut butter M&M's	71.46505
M&M's	66.57458
Milk Duds	55.06407
Milky Way	73.09956
Milky Way Midnight	60.80070
Milky Way Simply Caramel	64.35334
Mounds	47.82975
Mr Good Bar	54.52645
Nestle Butterfinger	70.73564
Nestle Crunch	66.47068
Peanut M&Ms	69.48379
Reese's Miniatures	81.86626
Reese's Peanut Butter cup	84.18029
Reese's pieces	73.43499
Reese's stuffed with pieces	72.88790
Rolo	65.71629
Sixlets	34.72200
Nestle Smarties	37.88719
Snickers	76.67378
Snickers Crisper	59.52925
Tootsie Pop	48.98265
Tootsie Roll Juniors	43.06890
Tootsie Roll Midgies	45.73675
Tootsie Roll Snack Bars	49.65350
Twix	81.64291
Whoppers	49.52411

Q12. Is this difference statistically significant?

```
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 is significant as p-value < 0.05.

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

```

ord.ind <- order(candy$winpercent)
head( candy[ord.ind,], 5 )

```

	chocolate	fruity	caramel	peanuty	almondy	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	
	crispedrice	wafer	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						

```

candy %>% arrange(ascending=winpercent) %>% head(5)

```

	chocolate	fruity	caramel	peanuty	almondy	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	
	crispedrice	wafer	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?

```
candy %>% arrange(descending=candy$winpercent) %>% tail(5)
```

	chocolate	fruity	caramel	peanuty	almondy	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
	crispedrice	wafers	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				

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

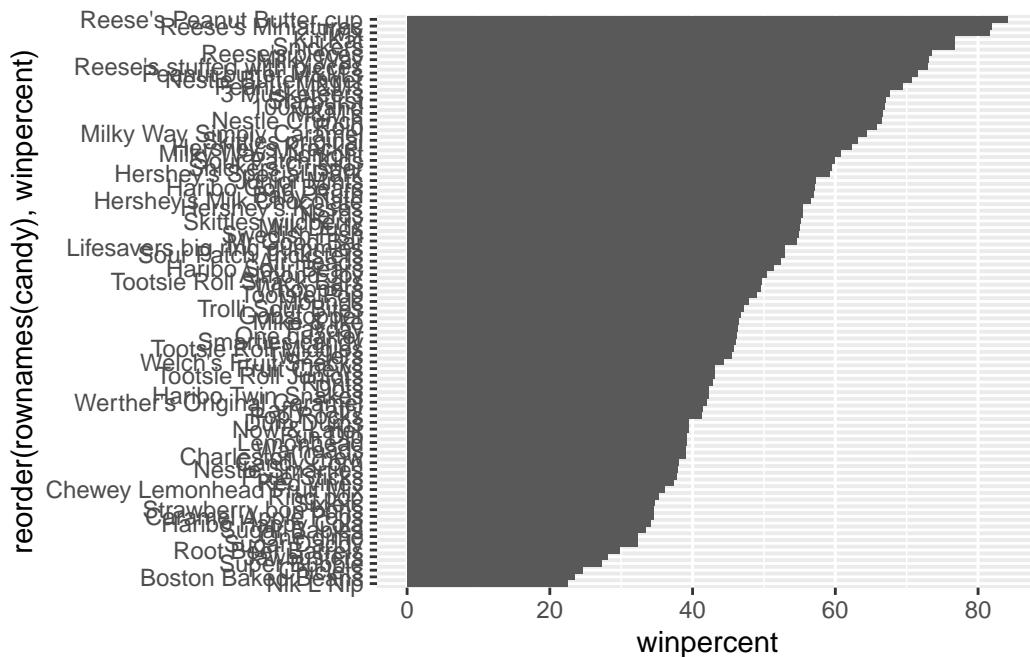
	chocolate	fruity	caramel	peanuty	almondy	nougat
Reese's Peanut Butter cup	1	0	0		1	0
Reese's Miniatures	1	0	0		1	0
Twix	1	0	1		0	0

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.

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

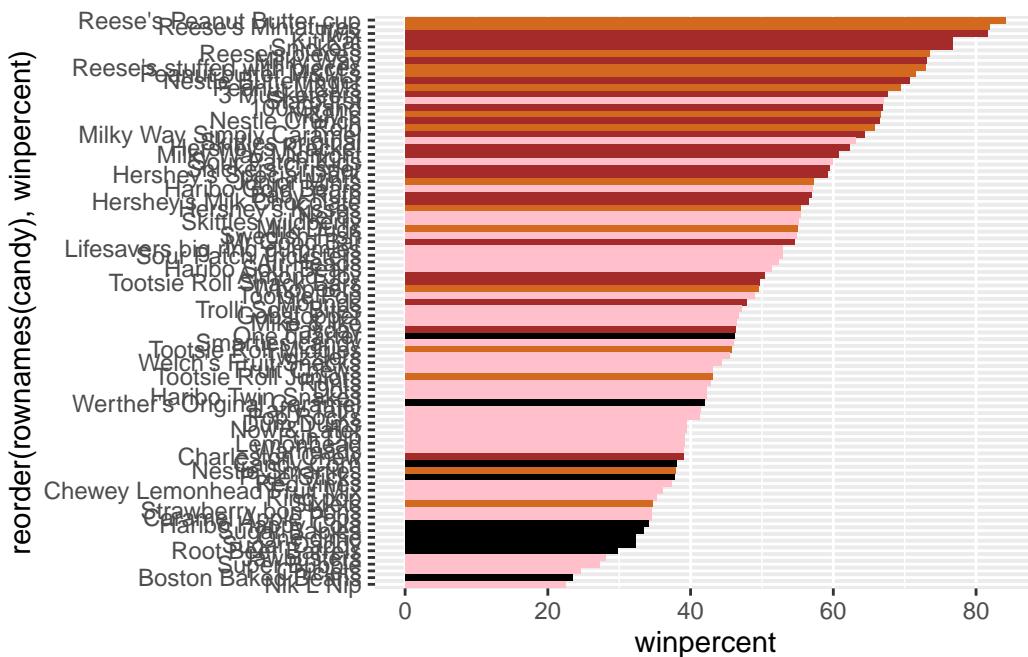
```
ggplot(candy) +
  aes(x=winpercent,
      y=reorder(rownames(candy), winpercent)) +
  geom_col()
```



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"
```

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



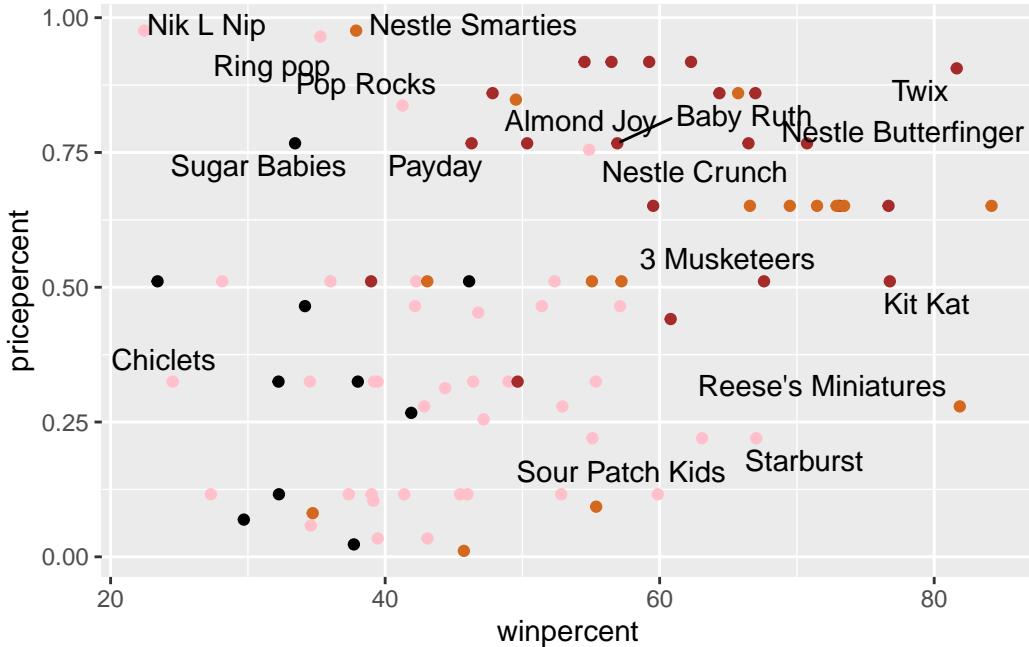
##Winpercent and Pricepercent

A plot with both variables/columns winpercent and pricepercent

```
library(ggrepel)

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

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



Q17. What is the worst ranked chocolate candy?

The worst ranked chocolate candy is sixlet.

Q18. What is the best ranked fruity candy?

The best ranked fruity candy is starburst.

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?

The top 5 most expensive candy types are fruity, fruity, chocolate, chocolate bar, and chocolate bar. The least popular one here is the fruity candy "Nik L Nip".

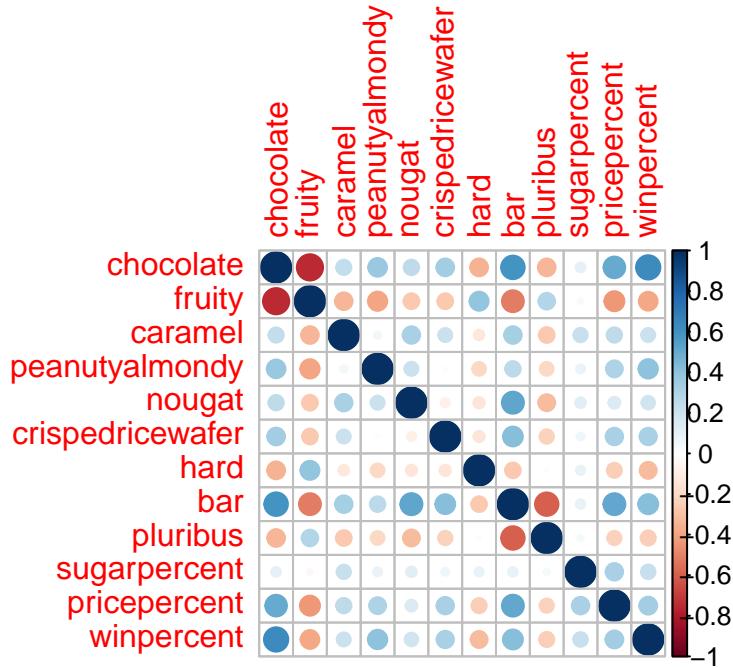
#Exploring the correlation structure

Now that we've explored the dataset a little we'll see how the variables interact with each other. ... the corrplot package to plot a correlation matrix.

```
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 are strongly anti-correlated.

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

Chocolate and winpercent are the most positively correlated.

## Principal Component Analysis

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

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

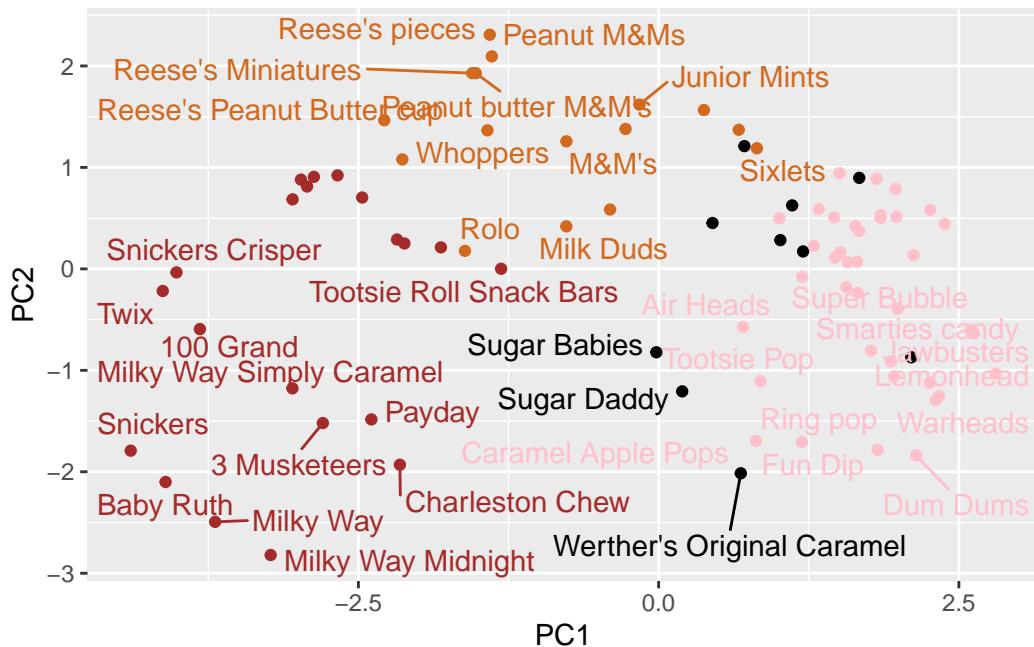
Importance of components:

	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		

Our main PCA result figure

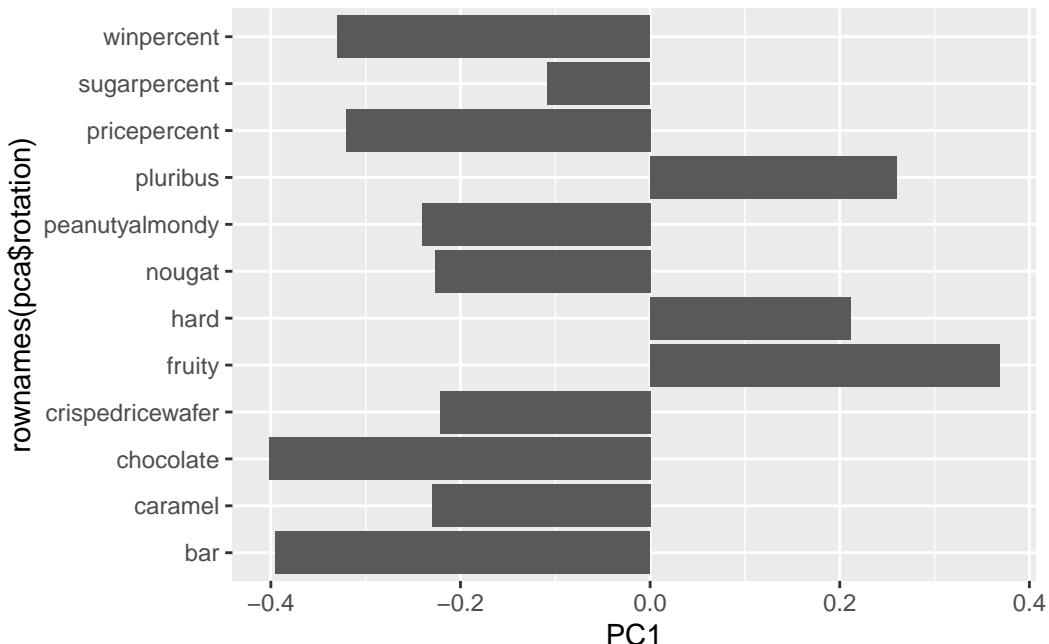
```
ggplot(pca$x) +
  aes(PC1, PC2, label=rownames(pca$x)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols)
```

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 variables to the new PCs

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



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 strongly picked up by PC1 in the positive direction which makes sense since many fruity candy tend to be hard and contain a higher amount of them per package.

Interactive plots that can be zoomed on and “brushed” over can be made with the **plotly** package. Its output is interactive and will not render to PDF :-(

```
library(plotly)
```

```
Attaching package: 'plotly'
```

```
The following object is masked from 'package:ggplot2':
```

```
last_plot
```

```
The following object is masked from 'package:stats':
```

```
filter
```

```
The following object is masked from 'package:graphics':
```

```
layout
```

```
#plotly(p)
```