# Class 9: Halloween Candy

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Today we will examine data from 538 on common Halloween candy. In particular we will use ggplot, dplyr, and PCA to make sense of this multivariate dataset.

### Importing Candy Data

```
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
```

Answer: 85

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

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

```
[1] 38
```

Answer: 38

### What is your favorite candy?

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

```
candy["Nerds", ]$winpercent
```

```
[1] 55.35405
```

Answer: Nerds is my favorite candy, and its winpercent is 55.35%.

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

```
candy["Kit Kat", ]$winpercent
```

```
[1] 76.7686
```

Answer: Kit Kat's win percent is 76.7%.

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

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

```
[1] 49.6535
```

Answer: The win percent of Tootsie Roll Snack Bars is 49.6%.

How many chocolate candy are in the dataset?

```
sum(candy$chocolate)
```

```
[1] 37
```

Answer: 37

To get a quick overview of a new datset the `skimr` package can be useful:

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 | |

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 | |

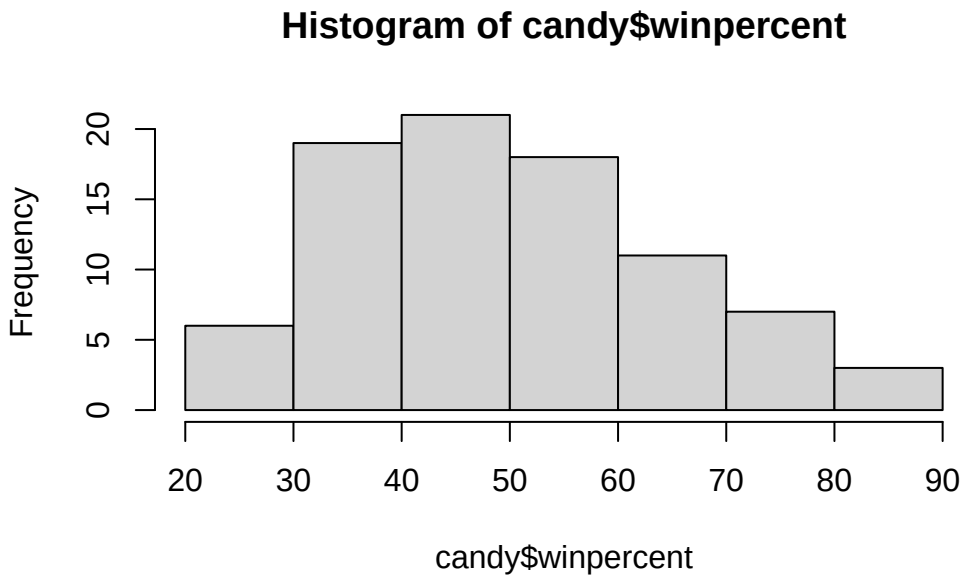
Answer: The `winpercent` column is different than the rest. It has much higher values. It looks like `winpercent` column is on a different scale than the others (0-100% rather than 0-1). I will need to scale this dataset before analysis like PCA.

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

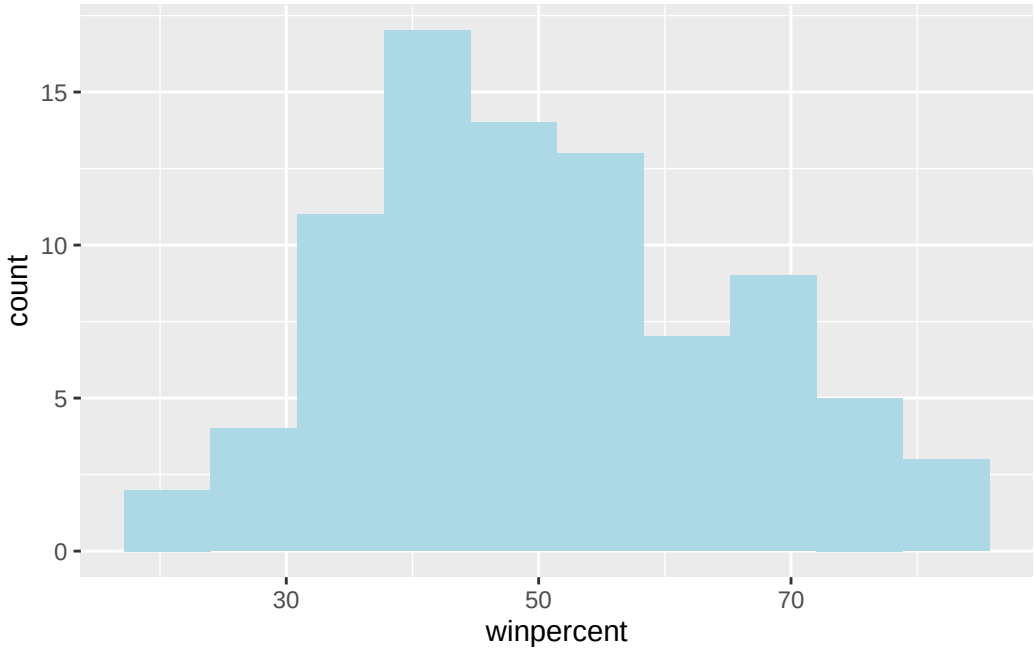
Answer: The zero's represent that the candy does not have chocolate, one's means it does have chocolate. For example, starburst would have a zero.

Q8. Plot a histogram of winpercent values

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



```
library(ggplot2)

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




Q9. Is the distribution of winpercent values symmetrical?

No, the distribution is not symmetrical it skews to the left.

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 
```

Below, since the median is below.

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

-step 1: find all “chocolate” candy

```
choc.inds<-candy$chocolate == 1
```

-step 2: find their “winpercent” values

```
choc.win<-candy[choc.inds, ]$winpercent
```

-step 3: summarize these values

```
mean(choc.win)
```

```
[1] 60.92153
```

-step 4: find all “fruity” candy

```
fruity.inds<-candy$fruity == 1
```

-step 5: find their winpercent values

```
fruity.win<-candy[fruity.inds, ]$winpercent
```

-step 6: summarize these values

```
mean(fruity.win)
```

```
[1] 44.11974
```

-step 7: compare the two summary values

Answer: The chocolate is higher ranked because the mean is higher (60.9) compared to fruity (44.1).

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
```

Answer: The p-value is very low (2.871e-08) meaning this difference is statistically significant.

```
candy$winpercent
```

```
 [1] 66.97173 67.60294 32.26109 46.11650 52.34146 50.34755 56.91455 23.41782
 [9] 38.01096 34.51768 38.97504 36.01763 24.52499 42.27208 39.46056 43.08892
[17] 39.18550 46.78335 57.11974 34.15896 51.41243 42.17877 55.37545 62.28448
[25] 56.49050 59.23612 28.12744 57.21925 76.76860 41.38956 39.14106 52.91139
[33] 71.46505 66.57458 46.41172 55.06407 73.09956 60.80070 64.35334 47.82975
[41] 54.52645 55.35405 70.73564 66.47068 22.44534 39.44680 46.29660 69.48379
[49] 37.72234 41.26551 37.34852 81.86626 84.18029 73.43499 72.88790 35.29076
[57] 65.71629 29.70369 42.84914 34.72200 63.08514 55.10370 37.88719 45.99583
[65] 76.67378 59.52925 59.86400 52.82595 67.03763 34.57899 33.43755 32.23100
[73] 27.30386 54.86111 48.98265 43.06890 45.73675 49.65350 47.17323 81.64291
[81] 45.46628 39.01190 44.37552 41.90431 49.52411
```

## Overall Candy Rankings

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

```
#not that useful- it just sorts values
sort(candy$winpercent)
```

```
 [1] 22.44534 23.41782 24.52499 27.30386 28.12744 29.70369 32.23100 32.26109
 [9] 33.43755 34.15896 34.51768 34.57899 34.72200 35.29076 36.01763 37.34852
[17] 37.72234 37.88719 38.01096 38.97504 39.01190 39.14106 39.18550 39.44680
[25] 39.46056 41.26551 41.38956 41.90431 42.17877 42.27208 42.84914 43.06890
```

```
[33] 43.08892 44.37552 45.46628 45.73675 45.99583 46.11650 46.29660 46.41172
[41] 46.78335 47.17323 47.82975 48.98265 49.52411 49.65350 50.34755 51.41243
[49] 52.34146 52.82595 52.91139 54.52645 54.86111 55.06407 55.10370 55.35405
[57] 55.37545 56.49050 56.91455 57.11974 57.21925 59.23612 59.52925 59.86400
[65] 60.80070 62.28448 63.08514 64.35334 65.71629 66.47068 66.57458 66.97173
[73] 67.03763 67.60294 69.48379 70.73564 71.46505 72.88790 73.09956 73.43499
[81] 76.67378 76.76860 81.64291 81.86626 84.18029
```

```
x<-c(10,1,100)
sort(x)
```

```
[1]   1  10 100
```

```
x[ order(x)]
```

```
[1]   1  10 100
```

The `order()` function tells us how to arange the elments of the inpuut to make them sorted- i.e. how to order them

we can determine the order of win percent to make them sorted and use that order to arrange the whole dataset.

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

```
                  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
Root Beer Barrels         0      0       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
Root Beer Barrels                0    1   0        1        0.732        0.069
                  winpercent
```

```
Nik L Nip            22.44534
Boston Baked Beans   23.41782
Chiclets             24.52499
Super Bubble         27.30386
Jawbusters           28.12744
Root Beer Barrels    29.70369
```

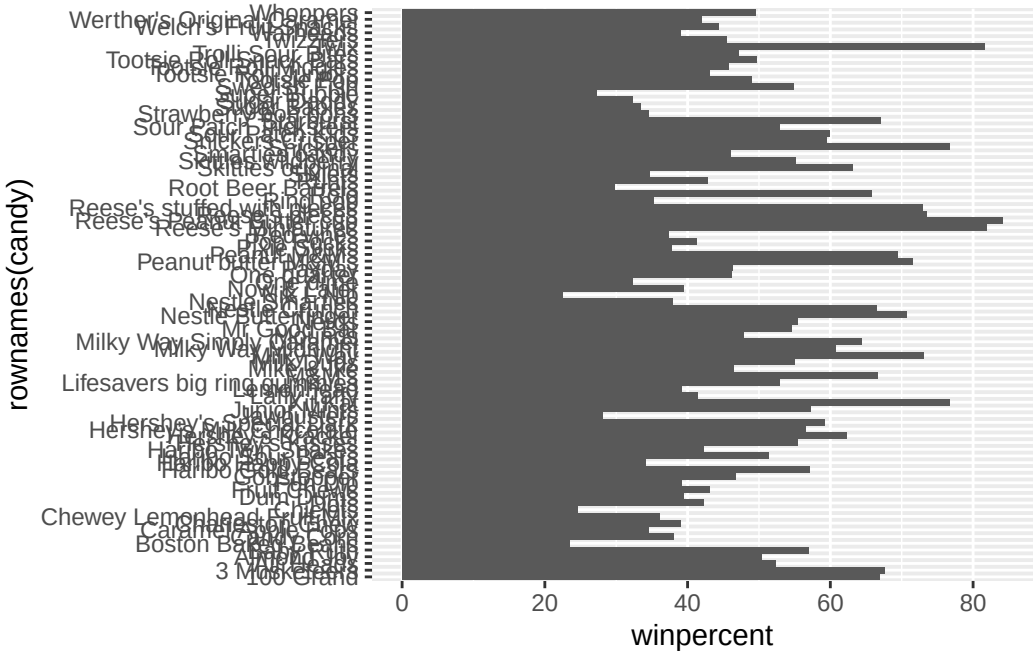
Q14. What are the top 5 all time favorite candy types out of this set?

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

```
                         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
Reese's pieces                    1      0       0              1      0
                         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
Reese's pieces                           0    0   0        1        0.406
                         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 pieces                   0.651   73.43499
```

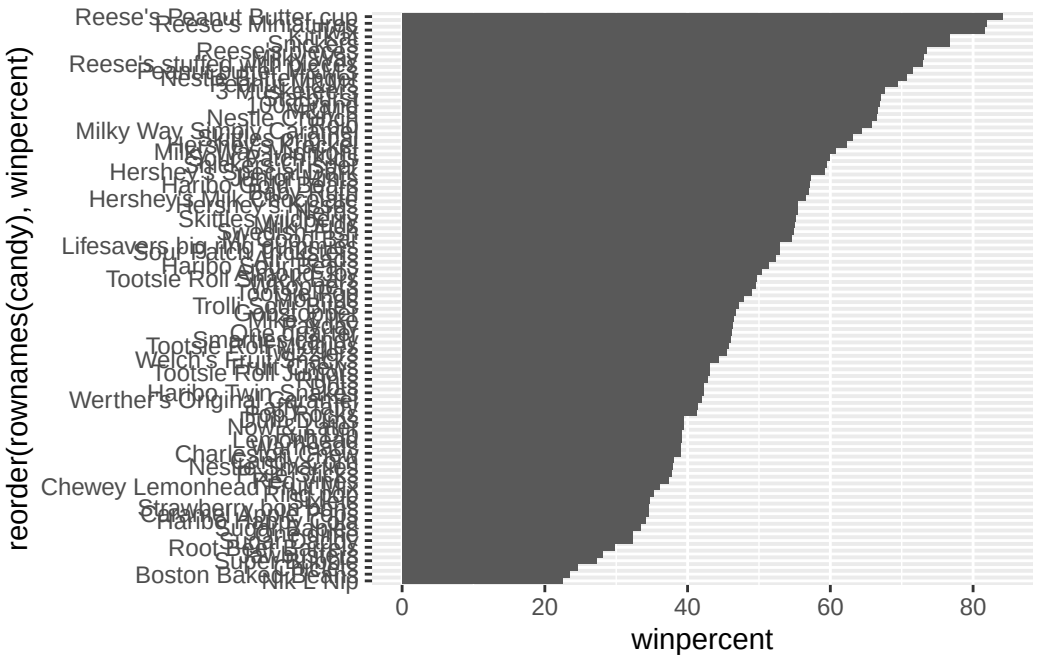
Q15. Make a first barplot of candy ranking based on winpercent values.

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

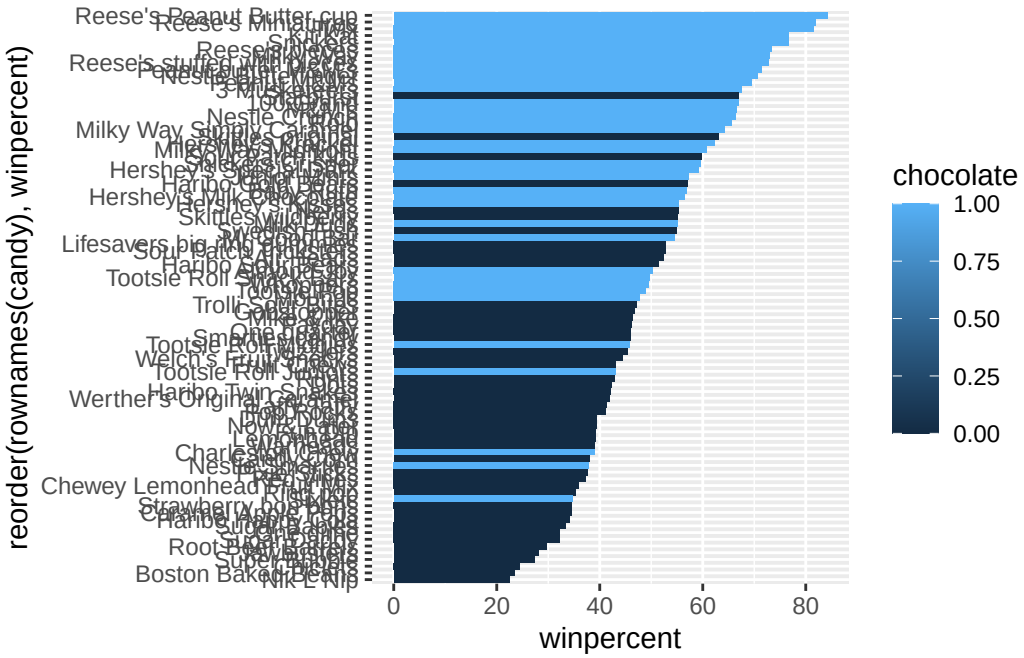



Let's rearrange >Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent?

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




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

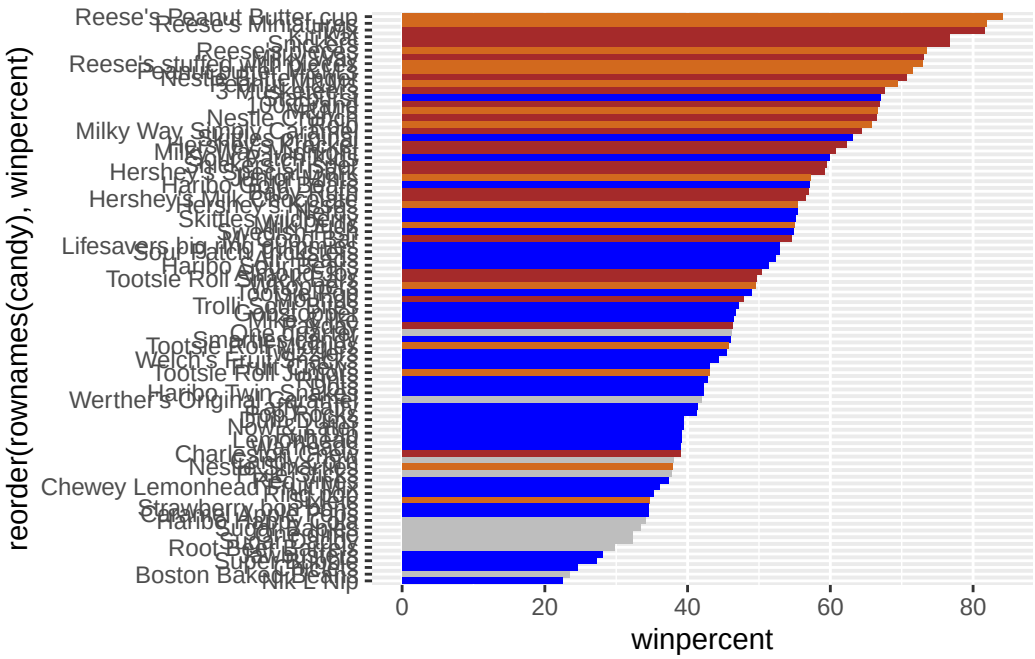


We Need to make our own seperate color vector where we can spell out what candy is colored a particular color.

```
mycols<- rep("gray",nrow(candy))
mycols [candy$chocolate ==1] <-"chocolate"
mycols [candy$bar ==1] <-"brown"
mycols [candy$fruity ==1] <-"blue"
mycols
```

```
 [1] "brown"     "brown"     "gray"      "gray"      "blue"      "brown"
 [7] "brown"     "gray"      "gray"      "blue"      "brown"     "blue"
[13] "blue"      "blue"      "blue"      "blue"      "blue"      "blue"
[19] "blue"      "gray"      "blue"      "blue"      "chocolate" "brown"
[25] "brown"     "brown"     "blue"      "chocolate" "brown"     "blue"
[31] "blue"      "blue"      "chocolate" "chocolate" "blue"      "chocolate"
[37] "brown"     "brown"     "brown"     "brown"     "brown"     "blue"
[43] "brown"     "brown"     "blue"      "blue"      "brown"     "chocolate"
[49] "gray"      "blue"      "blue"      "chocolate" "chocolate" "chocolate"
[55] "chocolate" "blue"      "chocolate" "gray"      "blue"      "chocolate"
[61] "blue"      "blue"      "chocolate" "blue"      "brown"     "brown"
[67] "blue"      "blue"      "blue"      "blue"      "gray"      "gray"
[73] "blue"      "blue"      "blue"      "chocolate" "chocolate" "brown"
[79] "blue"      "brown"     "blue"      "blue"      "blue"      "gray"
[85] "chocolate"
```

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




Q17. What is the worst ranked chocolate candy?

Based on the figure the worst ranked chocoalte candy is Sixlets.

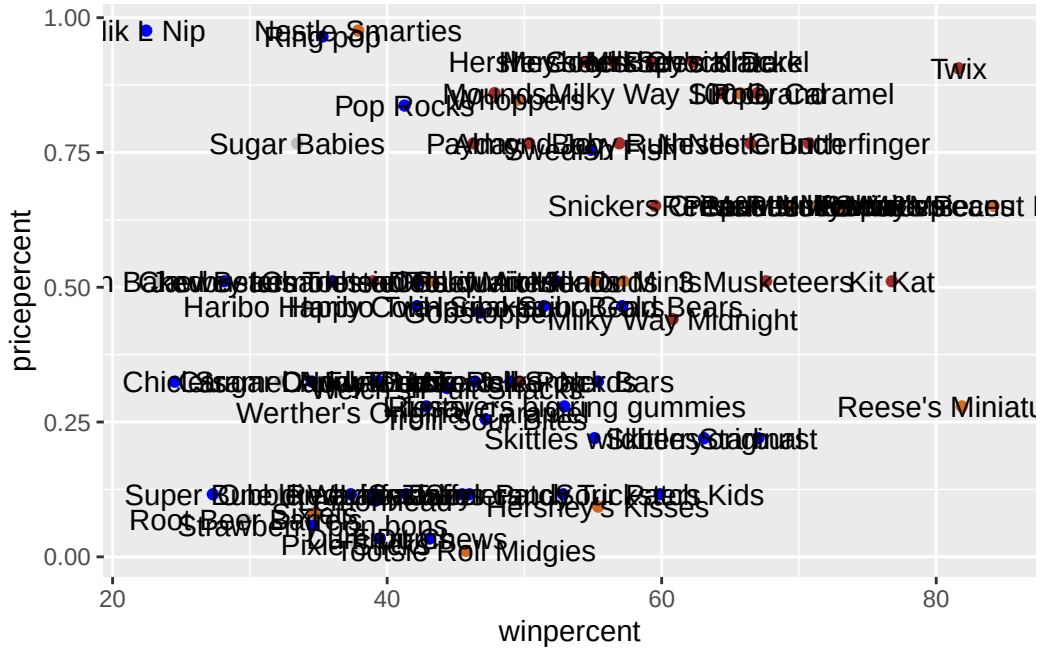
Q18. What is the best ranked fruity candy?

Based on the figure the best ranked fruity candy is Starburst.

### Taking a look at Price percent

Make a plot of winpercent (x-axis) vs price percent (y-axis)

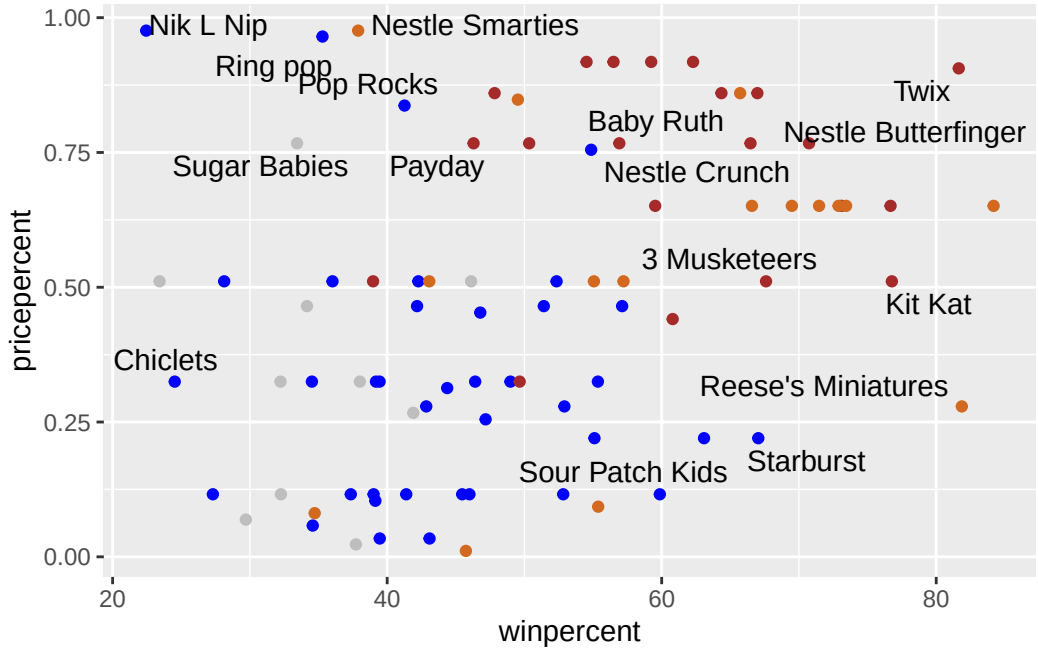
```
library(ggrepel)

ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=mycols) +
  geom_text()
```




To avoid overlap of the text labels we can use the add on package

```
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(max.overlaps=6)
```

```
Warning: ggrepel: 69 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```




```
ord <- order(candy$pricepercent, decreasing = TRUE)
head( candy[ord,c(11,12)], n=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
```

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?

Answer: The candy that ranked the highest in terms of winpercent foe the least money was Reese's Miniatures.

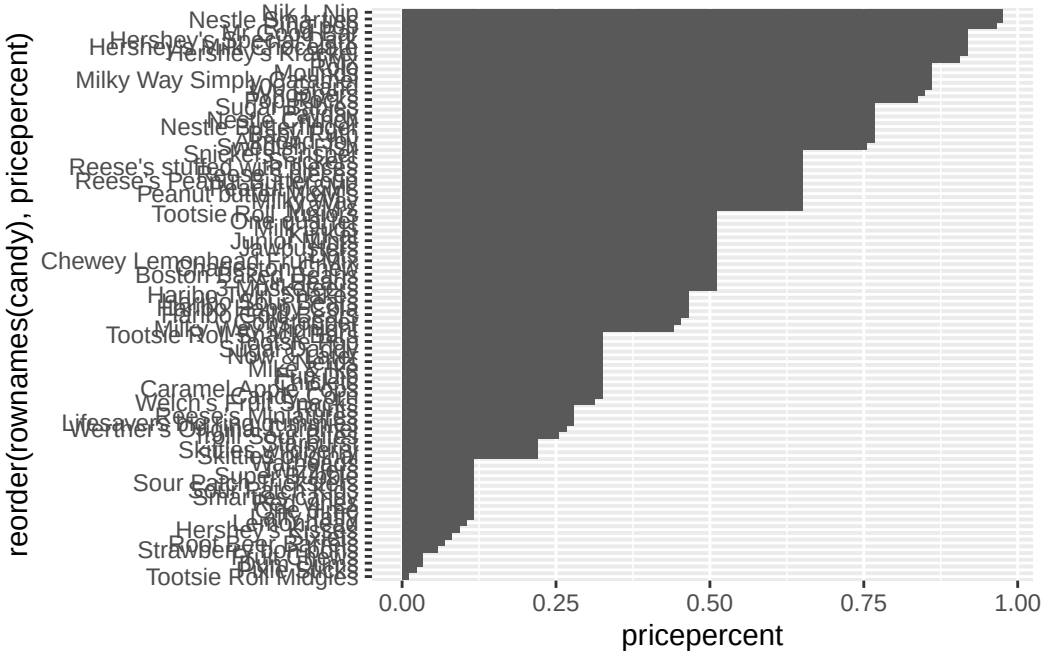
Q20. What are the top 5 most expensive candy types in the dataset and of these which is the least popular?

Answer: Nik L Nip's, Ring Pop, Nestle smarties, Ring Pop, and Hershey's Krackel.

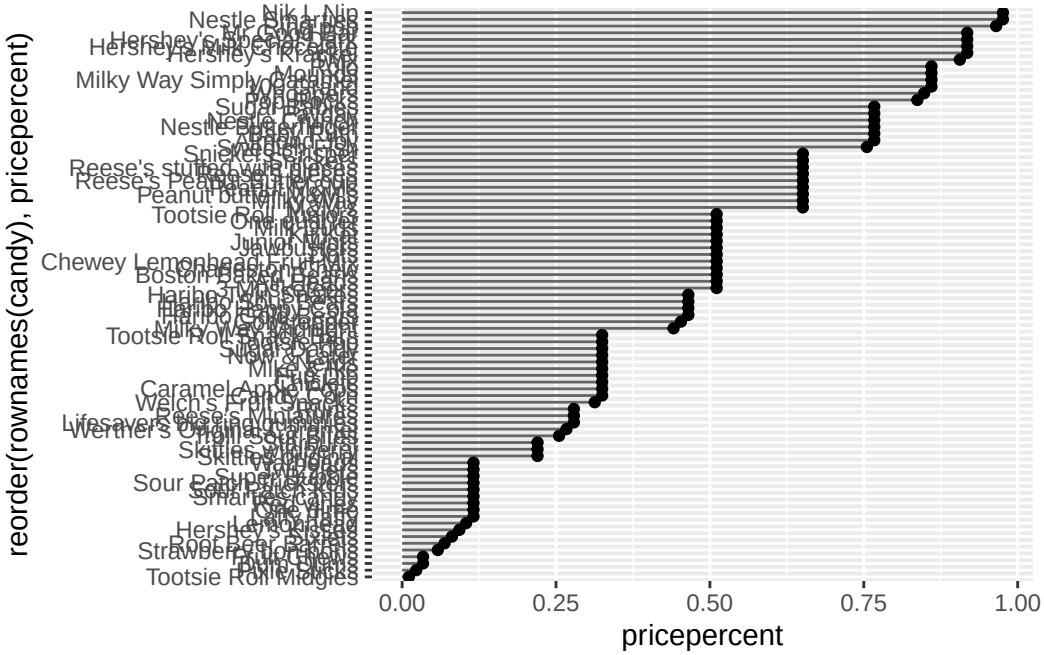
The candy that is the most expensive and least popular is Nik L Nip's. v

Q21. Make a barplot again with geom_col() this time using pricepercent and then improve this step by step, first ordering the x-axis by value and finally making a so called "dot chat" or "lollipop" chart by swapping geom_col() for geom_point() + geom_segment().

```
ggplot(candy) +
  aes(pricepercent, reorder(rownames(candy), pricepercent)) +
  geom_segment(aes(yend = reorder(rownames(candy), pricepercent),
                   xend = 0), col="gray40") +
    geom_col()
```




```
ggplot(candy) +
  aes(pricepercent, reorder(rownames(candy), pricepercent)) +
  geom_segment(aes(yend = reorder(rownames(candy), pricepercent),
                   xend = 0), col="gray40") +
    geom_point()
```



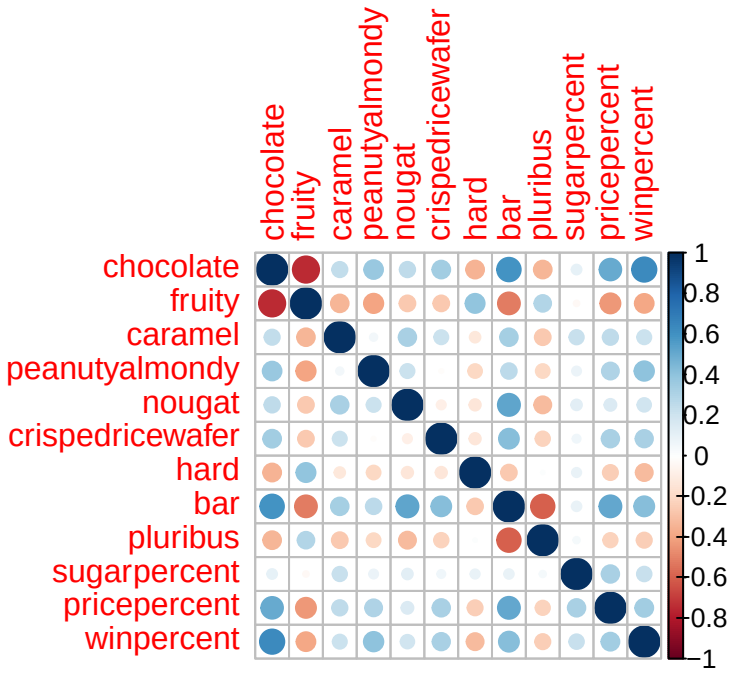

## Exploring the correlation structure

First we will use correlation and view the results with 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)?

Answer: Chocolate and Fruity are anti correlated.

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

Chocolate and winpercent are the most positively correlated.

## Principal Component Analysis

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

```
summary(pca)
```

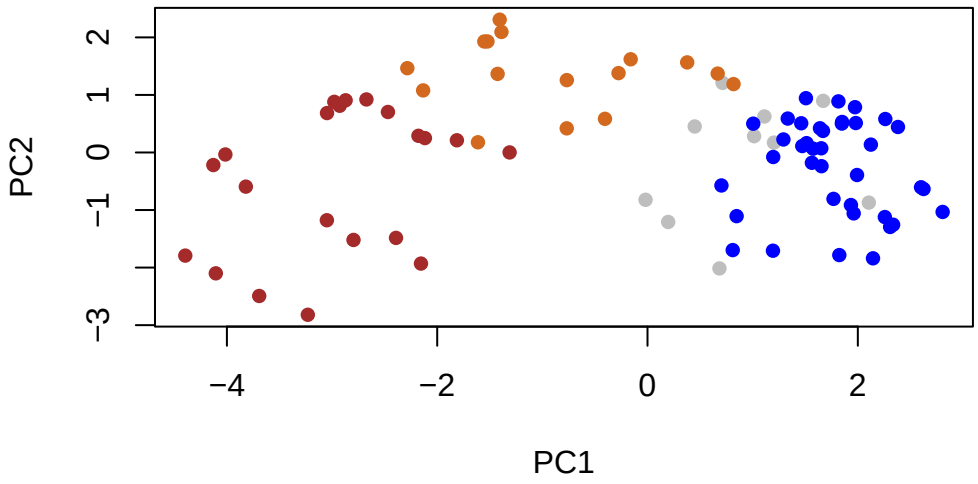
```
Importance of components:
                          PC1    PC2    PC3     PC4    PC5     PC6     PC7
Standard deviation     2.0788 1.1378 1.1092 1.07533 0.9518 0.81923 0.81530
Proportion of Variance 0.3601 0.1079 0.1025 0.09636 0.0755 0.05593 0.05539
Cumulative Proportion  0.3601 0.4680 0.5705 0.66688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

```
attributes(pca)
```

```
$names
[1] "sdev"     "rotation" "center"   "scale"    "x"

$class
[1] "prcomp"
```

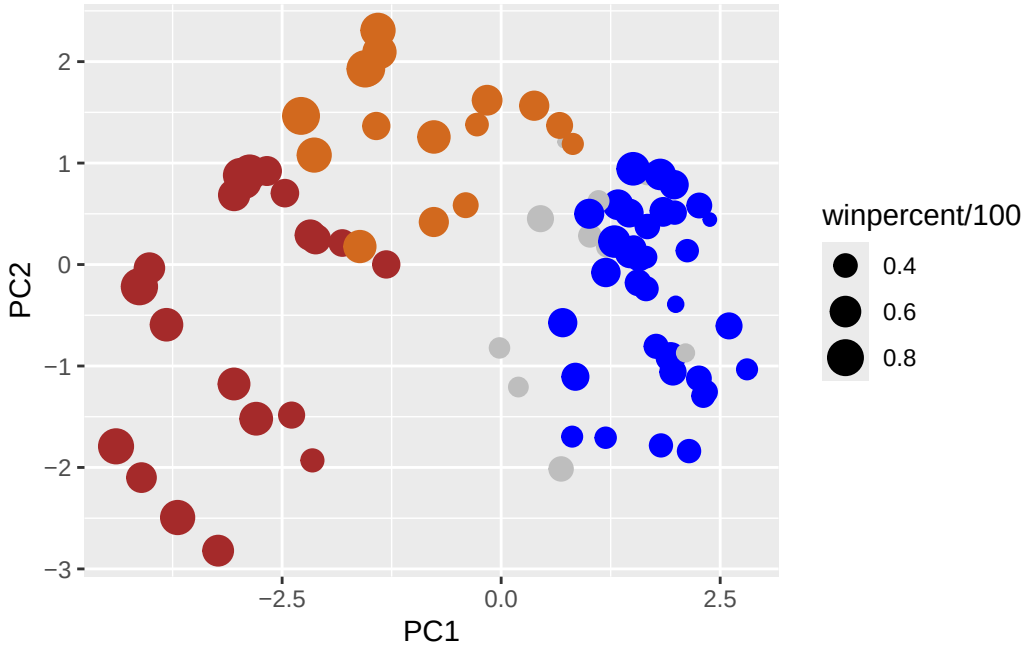
```
plot(pca$x[,1:2], col=mycols, pch=16)
```




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

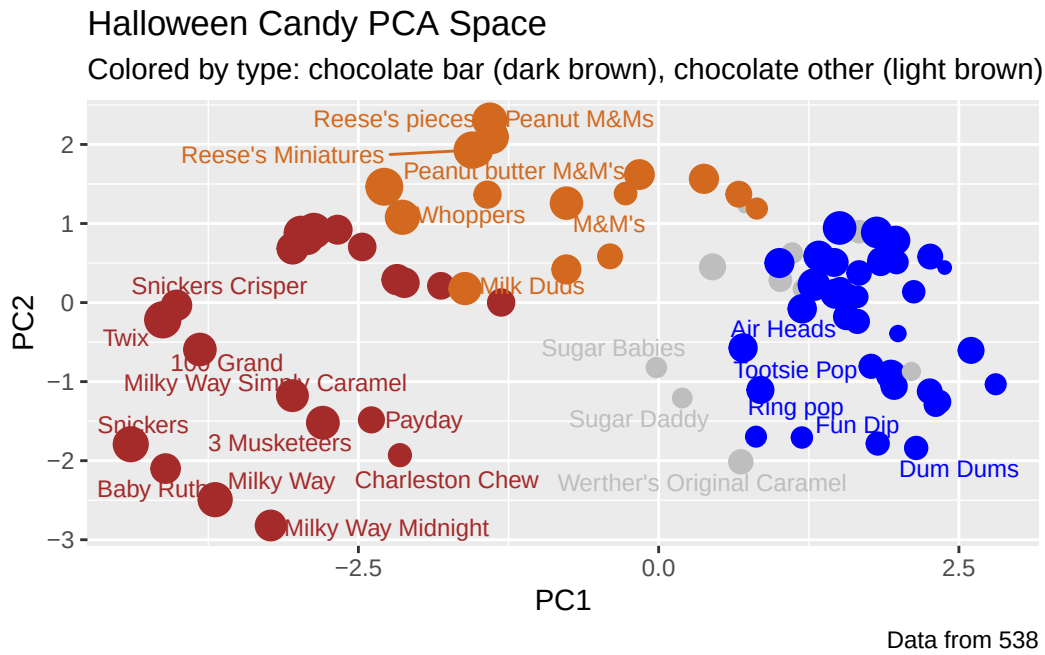
```
p <- ggplot(my_data) +
        aes(x=PC1, y=PC2,
            size=winpercent/100,
            text=rownames(my_data),
            label=rownames(my_data)) +
```

```
        geom_point(col=mycols)

p
```

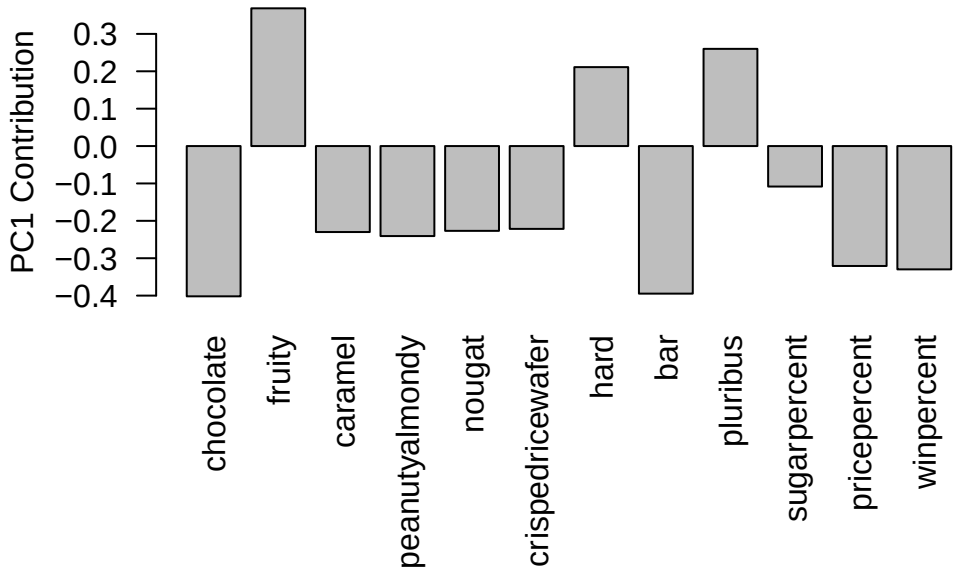



```
library(ggrepel)

p + geom_text_repel(size=3.3, col=mycols, 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
```




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




Let's plot our main results as our PCA "score plot"

```
pca$x
```

| | PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|---|
| 100 Grand | -3.81986175 | -0.5935787670 | -2.186308676 | -2.37159574 |
| 3 Musketeers | -2.79602364 | -1.5196062111 | 1.412198551 | 0.69943868 |
| One dime | 1.20258363 | 0.1718120657 | 2.060771178 | -1.20067824 |
| One quarter | 0.44865378 | 0.4519735621 | 1.476492844 | -1.00177141 |
| Air Heads | 0.70289922 | -0.5731343263 | -0.929389343 | 0.41245656 |
| Almond Joy | -2.46833834 | 0.7035501120 | 0.858108916 | 0.57249739 |
| Baby Ruth | -4.10531223 | -2.1000967736 | 1.347834706 | 1.85505225 |
| Boston Baked Beans | 0.71385813 | 1.2098216537 | 0.941899950 | 1.10219913 |
| Candy Corn | 1.01357204 | 0.2834319621 | -0.840681586 | 0.83664703 |
| Caramel Apple Pops | 0.81049645 | -1.6960889498 | -0.207020586 | -0.30186567 |
| Charleston Chew | -2.15436587 | -1.9304213037 | 1.675469334 | 0.46999498 |
| Chewey Lemonhead Fruit Mix | 1.65268482 | 0.0726434944 | -0.909617411 | 0.58609915 |
| Chiclets | 2.38180817 | 0.4430926071 | 1.000422079 | -0.59998577 |
| Dots | 1.51249936 | 0.1623958592 | -0.967135199 | 0.63622661 |
| Dum Dums | 2.14430933 | -1.8388386160 | -0.385372660 | -0.14796280 |
| Fruit Chews | 2.26133763 | 0.5818322520 | 0.978626618 | -0.39164187 |
| Fun Dip | 1.82383348 | -1.7828662094 | -0.719415821 | -0.08544003 |
| Gobstopper | 1.96047812 | -1.0584680267 | -1.873874385 | 0.84237208 |
| Haribo Gold Bears | 1.33360746 | 0.5892699921 | -0.431929774 | 0.33530766 |
| Haribo Happy Cola | 1.11167365 | 0.6257697808 | 0.054459647 | 0.16024129 |
| Haribo Sour Bears | 1.46152952 | 0.5073691482 | -0.379443632 | 0.28956535 |
| Haribo Twin Snakes | 1.66849016 | 0.3748646265 | -0.294528131 | 0.21556045 |
| Hershey's Kisses | 0.37722675 | 1.5654519145 | 1.104739528 | -0.30451907 |
| Hershey's Krackel | -3.04788356 | 0.6850792787 | -1.154357778 | -2.79294516 |
| Hershey's Milk Chocolate | -2.11696417 | 0.2504568891 | 0.218316614 | -0.64942872 |
| Hershey's Special Dark | -2.17850376 | 0.2898570052 | 0.193067056 | -0.62742342 |
| Jawbusters | 2.62491587 | -0.6343671618 | 0.114043053 | -0.54172092 |
| Junior Mints | -0.16010610 | 1.6194428347 | 0.442156347 | -0.08935729 |
| Kit Kat | -2.87086546 | 0.9069655335 | -0.545771148 | -2.94691419 |
| Laffy Taffy | 1.65450042 | -0.2379605144 | 1.217408326 | -0.81578254 |
| Lemonhead | 2.33564695 | -1.2553404646 | 1.125823900 | -1.18755633 |
| Lifesavers big ring gummies | 1.19528766 | -0.0783610246 | 0.814040659 | -0.61506538 |
| Peanut butter M&M's | -1.52223814 | 1.9291395890 | -0.815897653 | 2.27060871 |
| M&M's | -0.76747561 | 1.2573539136 | -1.260658369 | 0.98037043 |
| Mike & Ike | 1.57487290 | 0.0664259746 | -1.114406454 | 0.84284942 |
| Milk Duds | -0.76836937 | 0.4192793946 | -0.137573021 | -0.01222490 |
| Milky Way | -3.69272218 | -2.4933313173 | 0.843423990 | 0.70792542 |
| Milky Way Midnight | -3.23036513 | -2.8201031327 | 0.902884388 | 0.75904764 |
| Milky Way Simply Caramel | -3.04936226 | -1.1774777304 | -1.382617058 | 0.15488883 |

| | | | | |
|---|---|---|---|---|
| Mounds | -1.81292795 | 0.2120726312 | 0.636094539 | -0.91126847 |
| Mr Good Bar | -2.67327849 | 0.9217207344 | 0.997161433 | 0.40634715 |
| Nerds | 1.93426895 | -0.9133307225 | -1.670281710 | 0.79359684 |
| Nestle Butterfinger | -2.97855081 | 0.8798835368 | 0.348599786 | 0.94918411 |
| Nestle Crunch | -2.92740488 | 0.8119013154 | -0.747159803 | -2.97250665 |
| Nik L Nip | 1.63985272 | 0.4210217322 | -0.083217936 | -0.24015596 |
| Now & Later | 1.98070982 | 0.5117150919 | 0.460099768 | -0.21340533 |
| Payday | -2.39180556 | -1.4839637512 | 2.091687409 | 1.65680787 |
| Peanut M&Ms | -1.38897069 | 2.0947188031 | -0.260214925 | 1.89874716 |
| Pixie Sticks | 1.67042227 | 0.8969792365 | 1.394703254 | -0.48031281 |
| Pop Rocks | 1.76879348 | -0.8060325640 | -1.567639814 | 0.42017068 |
| Red vines | 2.12406849 | 0.1366822960 | -0.115183020 | 0.27721045 |
| Reese's Miniatures | -1.55210251 | 1.9287569793 | 1.884620322 | 0.48605155 |
| Reese's Peanut Butter cup | -2.28427985 | 1.4648923293 | -0.156138940 | 1.63994489 |
| Reese's pieces | -1.40590761 | 2.3077984818 | 0.136661895 | 1.64348077 |
| Reese's stuffed with pieces | -2.13382398 | 1.0787289654 | -0.673152403 | 1.96066081 |
| Ring pop | 1.19274412 | -1.7069749284 | -1.423826969 | 0.02570015 |
| Rolo | -1.61259322 | 0.1773734932 | -1.931879747 | 1.00697641 |
| Root Beer Barrels | 2.10440254 | -0.8711340556 | -0.594335570 | 0.36204105 |
| Runts | 2.25699185 | -1.1223199934 | -1.557678507 | 0.71996790 |
| Sixlets | 0.81799664 | 1.1888290122 | 1.093105891 | -0.33001942 |
| Skittles original | 1.29259129 | 0.2263705137 | -1.306145308 | 1.05900061 |
| Skittles wildberry | 1.47148517 | 0.1118354559 | -1.232745536 | 0.99503181 |
| Nestle Smarties | -0.27556563 | 1.3792344137 | -0.080047831 | -0.03345921 |
| Smarties candy | 2.60115214 | -0.6047947520 | 0.003482896 | -0.21938457 |
| Snickers | -4.39576792 | -1.7919312516 | 1.434654778 | 1.89861891 |
| Snickers Crisper | -4.01457335 | -0.0347673522 | -1.089868643 | -1.42309414 |
| Sour Patch Kids | 1.81551769 | 0.8879445215 | 0.863881832 | -0.32795118 |
| Sour Patch Tricksters | 1.97326660 | 0.7869473239 | 0.928605869 | -0.38435897 |
| Starburst | 1.50658493 | 0.9437290830 | 0.487658690 | -0.12150268 |
| Strawberry bon bons | 2.80647837 | -1.0331193111 | -0.524069119 | 0.13960292 |
| Sugar Babies | -0.01900559 | -0.8219542293 | -1.802826526 | 0.92212945 |
| Sugar Daddy | 0.19642038 | -1.2073694698 | 0.520140143 | -0.59663517 |
| Super Bubble | 1.99242820 | -0.3915898648 | 1.481310204 | -1.01767057 |
| Swedish Fish | 1.00547407 | 0.5003327040 | -1.068588828 | 0.59499272 |
| Tootsie Pop | 0.84734171 | -1.1060686710 | -0.480874078 | -0.23675349 |
| Tootsie Roll Juniors | -0.40463667 | 0.5848580362 | 0.836999949 | -0.59623669 |
| Tootsie Roll Midgies | 0.66730732 | 1.3709464980 | 1.179339290 | -0.32789249 |
| Tootsie Roll Snack Bars | -1.31149842 | 0.0009721286 | 0.885976952 | -0.78242207 |
| Trolli Sour Bites | 1.85048456 | 0.5304055168 | 0.254559391 | -0.02435072 |
| Twix | -4.12909044 | -0.2180299573 | -1.943536689 | -2.52917855 |
| Twizzlers | 1.56312584 | -0.1794588354 | 1.179917535 | -0.78310886 |
| Warheads | 2.30707033 | -1.2940268825 | 1.004249910 | -1.11380521 |

| | | | | |
|---|---|---|---|---|
| Welch's Fruit Snacks | 1.84808801 | 0.5022006184 | 0.213204782 | -0.03387254 |
| Werther's Original Caramel | 0.68420363 | -2.0146385440 | 0.506488679 | -0.97208672 |
| Whoppers | -1.42549552 | 1.3654147702 | -2.759982292 | -1.23030133 |
| | PC5 | PC6 | PC7 | PC8 |
| 100 Grand | -0.66236243 | -0.545218405 | -0.14340559 | 0.577224229 |
| 3 Musketeers | -0.16006665 | 0.382588420 | 2.02155526 | -1.502574960 |
| One dime | -0.26977985 | 0.094950530 | -0.77220066 | 0.155622104 |
| One quarter | -0.05093737 | 0.428354037 | -0.59089199 | 0.359134372 |
| Air Heads | 0.33108524 | 0.188791601 | 0.96808076 | 1.012393252 |
| Almond Joy | 1.43200435 | 1.022273480 | -0.66604596 | 0.608261288 |
| Baby Ruth | -0.53157179 | 0.026152894 | -0.27477854 | 0.617961302 |
| Boston Baked Beans | -0.01286555 | 1.147068667 | -1.66290853 | 1.017203801 |
| Candy Corn | -0.92992691 | 0.482570575 | -0.17268382 | -0.433778134 |
| Caramel Apple Pops | -1.26916612 | -0.641471733 | -0.77030933 | 1.705704289 |
| Charleston Chew | -0.48839246 | 1.490541025 | 1.23825892 | -1.445444979 |
| Chewey Lemonhead Fruit Mix | -0.64216946 | 0.867070020 | 0.51175007 | 0.500258867 |
| Chiclets | -0.82031918 | 0.835939962 | -0.06670709 | 0.514147274 |
| Dots | -0.57043885 | 0.625011322 | 0.68287986 | 0.487777458 |
| Dum Dums | 1.60464382 | -0.712637531 | -0.06881335 | -0.229647214 |
| Fruit Chews | -0.64943194 | -0.515343269 | 0.62911226 | 0.295017216 |
| Fun Dip | 1.64564645 | -0.061325594 | -0.22205535 | -0.058799069 |
| Gobstopper | 0.97535806 | 0.006638151 | 0.09322099 | -0.594393205 |
| Haribo Gold Bears | -0.41418743 | -0.076745232 | 0.97316112 | 0.470072508 |
| Haribo Happy Cola | -0.96450884 | 0.897177682 | -0.57777493 | -0.279999961 |
| Haribo Sour Bears | -0.47964306 | 0.144138214 | 0.81700174 | 0.481462045 |
| Haribo Twin Snakes | -0.58554144 | 0.501497845 | 0.56435691 | 0.499888780 |
| Hershey's Kisses | -0.65415252 | -0.956497265 | -0.15459157 | -1.475048333 |
| Hershey's Krackel | 0.64433919 | 0.815979037 | 0.72869731 | -0.058197261 |
| Hershey's Milk Chocolate | 0.45257976 | 1.365951323 | 0.09727415 | -0.537271619 |
| Hershey's Special Dark | 0.48406856 | 1.259690716 | 0.17239789 | -0.542750795 |
| Jawbusters | 0.74872541 | 0.777635266 | -0.86953189 | -0.404938915 |
| Junior Mints | -0.56772916 | -0.100807494 | -0.27701048 | -1.244289684 |
| Kit Kat | 0.74560410 | -0.651964126 | 1.26789202 | -0.308264629 |
| Laffy Taffy | 0.12742282 | -0.323401158 | 0.50907401 | 0.902891431 |
| Lemonhead | 1.59348201 | -0.612577970 | -0.46974919 | -0.088239458 |
| Lifesavers big ring gummies | 0.28553918 | -0.405905368 | 0.76717408 | 0.968451468 |
| Peanut butter M&M's | 0.70534888 | -0.535487043 | -0.31945944 | -0.055419751 |
| M&M's | -0.42260375 | -0.093849007 | 0.23580574 | -1.272394704 |
| Mike & Ike | -0.54748868 | 0.068855836 | 0.96217007 | 0.350296998 |
| Milk Duds | -1.94930706 | -1.088570940 | -1.46793514 | -0.532609515 |
| Milky Way | -1.43541753 | -0.603255019 | 0.91522507 | -0.708957591 |
| Milky Way Midnight | -1.60495490 | -0.577210751 | 0.75050728 | -0.825932767 |
| Milky Way Simply Caramel | -0.81154750 | -0.095588630 | -0.56663709 | 0.057913957 |

| | | | | |
|---|---|---|---|---|
| Mounds | 0.34136052 | 1.562117376 | -0.17156397 | -0.536908890 |
| Mr Good Bar | 1.49882941 | 1.178267833 | -0.70645139 | 0.710404328 |
| Nerds | 1.05269810 | -0.612484674 | 0.36162582 | -0.677966908 |
| Nestle Butterfinger | 1.66950147 | 0.246674393 | -0.03583585 | 0.547351886 |
| Nestle Crunch | 0.66634611 | 0.310195315 | 0.85793736 | -0.137897493 |
| Nik L Nip | -0.74139722 | 2.364290586 | -0.37097983 | 0.877307522 |
| Now & Later | -0.64458895 | 0.275284807 | 0.43215999 | 0.459054334 |
| Payday | 0.57021053 | 1.685803617 | 0.71659189 | 0.920899230 |
| Peanut M&Ms | 0.67649842 | -0.481270608 | -0.49445201 | -0.017712739 |
| Pixie Sticks | -1.00053741 | -0.249857693 | -0.45261662 | -0.491657159 |
| Pop Rocks | 0.96236780 | 1.036365445 | -0.40726527 | -0.314719629 |
| Red vines | -0.69083254 | -0.068691578 | 0.66734570 | 0.288409391 |
| Reese's Miniatures | 1.52874138 | -1.896976303 | -0.34129661 | 0.391227548 |
| Reese's Peanut Butter cup | 1.62984822 | -1.101118658 | -0.10711621 | 0.504507095 |
| Reese's pieces | 0.71687442 | -0.652294629 | -0.48369702 | 0.001608461 |
| Reese's stuffed with pieces | 1.50741757 | -0.638134777 | -0.27656579 | 0.488051492 |
| Ring pop | 1.69809389 | 1.498435385 | -0.64909630 | 0.323514628 |
| Rolo | -1.75944281 | -0.678446043 | -1.06073297 | -0.430807299 |
| Root Beer Barrels | 0.42962062 | -0.109312144 | -1.19510153 | -1.555611980 |
| Runts | 0.90293644 | -0.227471967 | 0.05500446 | -0.683423916 |
| Sixlets | -0.89038600 | -0.174585492 | -0.66527067 | -1.454385221 |
| Skittles original | -0.37037605 | -0.800924438 | 1.50687697 | 0.245536582 |
| Skittles wildberry | -0.46191313 | -0.492027764 | 1.28849431 | 0.261464394 |
| Nestle Smarties | -0.71703419 | 1.677902657 | -1.00236322 | -0.943766974 |
| Smarties candy | 0.89831080 | -0.766691658 | -0.09224917 | -0.697074269 |
| Snickers | -0.32409247 | -0.999567686 | 0.29375023 | 0.519082351 |
| Snickers Crisper | 0.28905186 | -0.982077142 | -0.99809936 | 1.715122168 |
| Sour Patch Kids | -0.44613213 | -0.989653570 | 1.01684337 | 0.317967197 |
| Sour Patch Tricksters | -0.52684967 | -0.717267988 | 0.82427320 | 0.332012368 |
| Starburst | -0.34591253 | -1.030380238 | 1.20373631 | 0.352584423 |
| Strawberry bon bons | 0.76654988 | -0.423292666 | -0.21835972 | -0.752170933 |
| Sugar Babies | -2.27338367 | 0.557052968 | -1.67505130 | 0.548087948 |
| Sugar Daddy | -1.58729466 | -0.485682924 | -1.85240975 | 0.941435233 |
| Super Bubble | -0.03565422 | 0.216125641 | 0.09347559 | 0.939439208 |
| Swedish Fish | -0.39241423 | 0.662591135 | 0.83851208 | 0.624071063 |
| Tootsie Pop | 1.88703233 | -0.633721587 | -0.18826747 | -1.043909239 |
| Tootsie Roll Juniors | 0.05449315 | 0.394706045 | -0.68468874 | -0.662902544 |
| Tootsie Roll Midgies | -0.77589776 | -0.759442617 | -0.35278919 | -1.510639321 |
| Tootsie Roll Snack Bars | 0.28510912 | 0.328392863 | 0.22536722 | -0.875755689 |
| Trolli Sour Bites | -0.56414212 | -0.168850396 | 0.72703429 | 0.389139607 |
| Twix | -0.49203516 | -1.029755076 | 0.13814854 | 0.601927243 |
| Twizzlers | 0.17417770 | -0.481177950 | 0.62061848 | 0.894755897 |
| Warheads | 1.59506307 | -0.576609554 | -0.45482313 | -0.087796992 |

```
Welch's Fruit Snacks        -0.58742724  0.067119205  0.62144223  0.428665533
Werther's Original Caramel   0.00698052 -1.343145309 -2.51219819 -0.091968746
Whoppers                    -0.46170658  0.678567795  0.16799768 -0.639281286
                                    PC9         PC10         PC11
100 Grand                    0.379148201 -0.154099543  0.141903843
3 Musketeers                 0.023832701 -0.155239068 -0.517927160
One dime                    -0.453988975 -0.943783623 -0.515870807
One quarter                 -0.638889823  0.095579648 -0.986719399
Air Heads                   -1.383012190 -0.573723493 -0.514453684
Almond Joy                  -0.139059851 -0.312778705  1.061148660
Baby Ruth                    1.143067977  0.264099876 -0.009085882
Boston Baked Beans           1.396216830 -0.973188567  0.102073964
Candy Corn                  -0.173119296 -1.580718107 -0.026369468
Caramel Apple Pops          -0.916479426 -0.201217892  0.098522113
Charleston Chew              0.265940391 -0.852594237 -0.299018234
Chewey Lemonhead Fruit Mix  -0.056700856 -0.274516517  0.133783407
Chiclets                     0.600474625  0.299142845  0.263138381
Dots                        -0.109595061 -0.122162631  0.085957526
Dum Dums                    -0.385161810 -0.858986682  0.026635152
Fruit Chews                  0.431017129  0.094469913  0.405402342
Fun Dip                     -0.432729164 -0.348623806 -0.240086957
Gobstopper                   0.401434380  0.160051400  0.173108273
Haribo Gold Bears           -0.021735861  0.618649969 -0.035818163
Haribo Happy Cola            0.174940628 -0.664580531 -0.210044044
Haribo Sour Bears            0.026531168  0.479623974  0.007823919
Haribo Twin Snakes           0.104620713  0.254698661  0.078430922
Hershey's Kisses             0.015418665 -0.009459574  0.108560740
Hershey's Krackel            0.589905081 -0.259828939 -0.295461506
Hershey's Milk Chocolate    -1.211270861  0.556641044  0.566669950
Hershey's Special Dark      -1.234490726  0.623522410  0.545675013
Jawbusters                   1.175121068  1.211984587  0.107699541
Junior Mints                -0.125729538  0.657349544 -0.278384695
Kit Kat                      0.627262392 -0.428229606 -0.052463331
Laffy Taffy                 -0.694575541 -0.358253574 -0.196159662
Lemonhead                    0.133629280  0.441715610 -0.165939908
Lifesavers big ring gummies -0.856144679  0.130909678 -0.425911984
Peanut butter M&M's          0.267660757 -0.221930007 -0.095957385
M&M's                       -0.712293695  0.050005905 -0.359922697
Mike & Ike                  -0.220487198 -0.593471988  0.252731956
Milk Duds                   -0.136911155  1.039501593  0.120288784
Milky Way                    0.004765911  0.843304841 -0.327048378
Milky Way Midnight           0.046247663 -0.050365745 -0.014682753
Milky Way Simply Caramel    -1.628250067  0.337544026  1.024026651
```

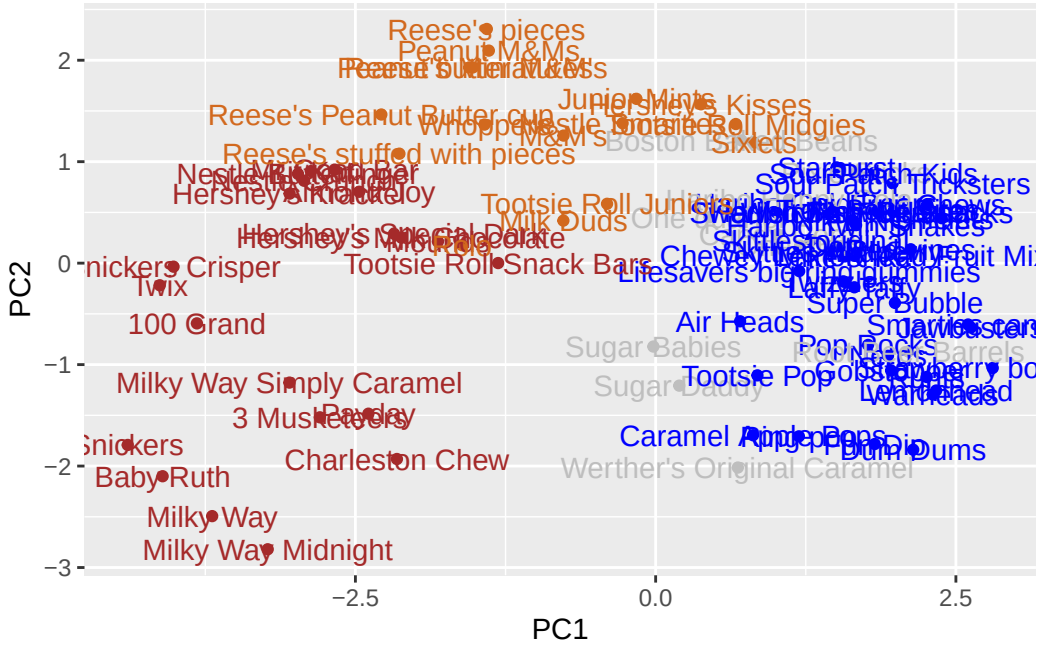
| | | | |
|---|---|---|---|
| Mounds | -1.038014053 | 0.444568191 | 0.664244259 |
| Mr Good Bar | -0.083279402 | 0.319687965 | 0.860817575 |
| Nerds | 0.395546909 | 0.241504770 | 0.214795902 |
| Nestle Butterfinger | -0.418486899 | -0.056067346 | 0.931659519 |
| Nestle Crunch | 0.670459908 | -0.224206267 | -0.210210679 |
| Nik L Nip | 0.390203352 | 1.144571263 | -0.293659295 |
| Now & Later | 0.340332791 | 0.362285847 | 0.182098894 |
| Payday | 1.592516886 | -0.586376631 | -0.517961675 |
| Peanut M&Ms | 0.463012748 | 0.130263439 | -0.124891428 |
| Pixie Sticks | 0.506958178 | -0.721036477 | 0.100340132 |
| Pop Rocks | 0.614743430 | 1.229233468 | -0.196822517 |
| Red vines | 0.116010128 | -0.683310675 | 0.459814126 |
| Reese's Miniatures | -0.201912762 | 0.339292365 | -0.538620165 |
| Reese's Peanut Butter cup | -0.813354976 | -0.127457497 | -0.769615618 |
| Reese's pieces | 0.573552037 | 0.549292897 | -0.190638431 |
| Reese's stuffed with pieces | -0.924164172 | -0.865127171 | -0.632341326 |
| Ring pop | -0.509522417 | 0.693685961 | -0.801535980 |
| Rolo | -0.716390425 | 0.955937401 | -0.177541179 |
| Root Beer Barrels | 0.748159981 | -1.361887249 | 0.275586696 |
| Runts | 0.490713003 | -0.186267132 | 0.357472263 |
| Sixlets | 0.120551003 | -0.694412596 | 0.295248736 |
| Skittles original | -0.396609466 | -0.492989386 | 0.235345367 |
| Skittles wildberry | -0.329109954 | -0.687411685 | 0.296377074 |
| Nestle Smarties | -0.095850762 | 0.891841882 | -0.546823295 |
| Smarties candy | 0.957784710 | 0.645048933 | 0.369028845 |
| Snickers | 1.040500931 | 0.639420129 | -0.064039216 |
| Snickers Crisper | 1.597773064 | -0.876877339 | 0.668926998 |
| Sour Patch Kids | 0.319739180 | 0.748914211 | 0.190355889 |
| Sour Patch Tricksters | 0.379260358 | 0.577472316 | 0.244173747 |
| Starburst | 0.178115491 | 0.966910650 | 0.055007728 |
| Strawberry bon bons | 0.831798717 | -0.257396978 | 0.567295681 |
| Sugar Babies | -0.204221618 | -0.392704656 | -0.026264253 |
| Sugar Daddy | -0.751459910 | -0.659787353 | -0.269135682 |
| Super Bubble | -0.530802993 | -0.601257076 | -0.099471654 |
| Swedish Fish | -0.159360361 | 0.838989403 | -0.260036175 |
| Tootsie Pop | -0.721118894 | 0.326836317 | -0.137911107 |
| Tootsie Roll Juniors | -1.149669881 | -0.284072969 | -0.704615875 |
| Tootsie Roll Midgies | 0.074811904 | -0.471079914 | 0.266947340 |
| Tootsie Roll Snack Bars | -1.078720446 | -0.723988086 | 1.173413519 |
| Trolli Sour Bites | 0.215399333 | 0.265589321 | 0.205354764 |
| Twix | 0.390371217 | 0.606070076 | -0.048120393 |
| Twizzlers | -0.729052624 | -0.258947465 | -0.227333151 |
| Warheads | 0.096482954 | 0.378764818 | -0.167107014 |

```
Welch's Fruit Snacks         0.229115315  0.300496305  0.173167709
Werther's Original Caramel   0.028457521  0.448967578 -0.298604763
Whoppers                     1.212121185 -1.054026246 -1.220426934
                                        PC12
100 Grand                    0.0646988318
3 Musketeers                -0.1839471662
One dime                    -0.5107477914
One quarter                 -0.9582719109
Air Heads                    0.0442992399
Almond Joy                   0.1889347102
Baby Ruth                    0.5798508261
Boston Baked Beans          -0.1012981497
Candy Corn                  -0.6799350975
Caramel Apple Pops           0.6962504166
Charleston Chew              0.5494017342
Chewey Lemonhead Fruit Mix   0.3105973331
Chiclets                     0.5337581991
Dots                         0.1503797578
Dum Dums                     0.1849692597
Fruit Chews                  0.1399898762
Fun Dip                      0.1237990873
Gobstopper                  -0.1944414618
Haribo Gold Bears           -0.2638818244
Haribo Happy Cola           -0.6879064447
Haribo Sour Bears           -0.1176800541
Haribo Twin Snakes           0.1188546962
Hershey's Kisses             0.1984492942
Hershey's Krackel           -0.0817067486
Hershey's Milk Chocolate    -0.3573702410
Hershey's Special Dark      -0.4277036644
Jawbusters                   0.1337584661
Junior Mints                 0.0649489483
Kit Kat                     -0.3769186469
Laffy Taffy                  0.3026020451
Lemonhead                    0.0619011170
Lifesavers big ring gummies -0.0228900695
Peanut butter M&M's          0.1200218111
M&M's                       -0.1023879726
Mike & Ike                   0.1113757406
Milk Duds                    0.3400578947
Milky Way                   -0.1552479006
Milky Way Midnight           0.2304632793
Milky Way Simply Caramel    -0.2533060125
```

```
Mounds                        -0.1415021722
Mr Good Bar                    0.0210418054
Nerds                         -0.3936975444
Nestle Butterfinger           -0.3100685916
Nestle Crunch                 -0.1731325150
Nik L Nip                      0.4597035356
Now & Later                    0.1806417362
Payday                        -0.7729766006
Peanut M&Ms                    0.1319358415
Pixie Sticks                  -0.7378511713
Pop Rocks                     -0.1936682261
Red vines                      0.3438211129
Reese's Miniatures            -0.0689054242
Reese's Peanut Butter cup     -0.1005437626
Reese's pieces                -0.0005861225
Reese's stuffed with pieces    0.2335945192
Ring pop                       0.0735408387
Rolo                           0.0787870205
Root Beer Barrels             -0.7082327026
Runts                         -0.0585635801
Sixlets                        0.7459023430
Skittles original             -0.2795750540
Skittles wildberry            -0.0751177198
Nestle Smarties                0.4628839641
Smarties candy                -0.2022435492
Snickers                       0.0911696493
Snickers Crisper               0.6306015108
Sour Patch Kids               -0.3186623415
Sour Patch Tricksters         -0.1383715363
Starburst                     -0.5130782116
Strawberry bon bons            0.1543709171
Sugar Babies                  -0.4541934821
Sugar Daddy                   -0.2885121237
Super Bubble                   0.6537195364
Swedish Fish                  -0.2507351031
Tootsie Pop                    1.2506316262
Tootsie Roll Juniors           0.5695856300
Tootsie Roll Midgies           0.4724506497
Tootsie Roll Snack Bars       -0.0373596827
Trolli Sour Bites              0.0146955266
Twix                          -0.3530484324
Twizzlers                      0.1981702880
Warheads                       0.0702649429
```

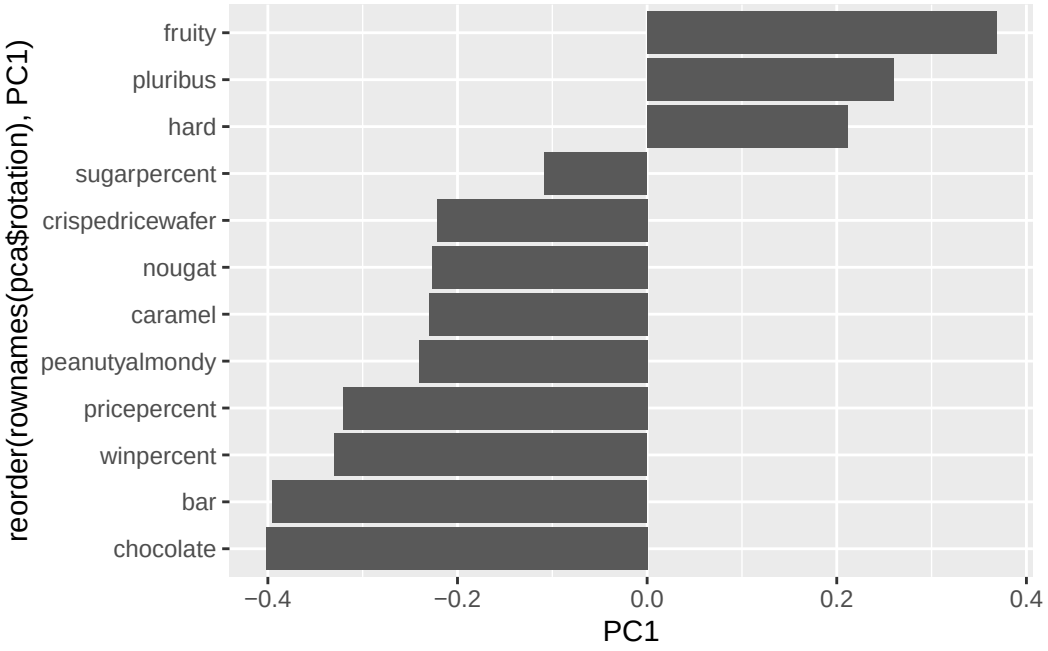
```
Welch's Fruit Snacks          0.0727669700
Werther's Original Caramel   -0.8335356607
Whoppers                      0.7201599382
```

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




Finally let's look how the original variables contribute to the PCs, start with pc1

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




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

Answer: The variable picked up strongly by PC1 in the positive direction are fruity, pluribus, and hard. This is a little bit confusing since fruity, pluribus, and hard are usually associated with being unpopular.