Class 09: Halloween Mini Project

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Today we will take a step back to some data we can taste and explore the correlation structure and principle components of some Halloween candy.

##Data Import

```
candy_file <- "candy-data.txt"
```

```
candy<- read.csv(candy_file, row.names=1)
```

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

```
dim(candy)
```

```
[1] 85 12
```

There are 85 different candy types in this dataset

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

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

```
[1] 38
```

There are 38 fruity candy types are in this dataset

What is your favorite candy?

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

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

```
[1] 81.64291
```

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

```
[1] 65.71629
```

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

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

```
[1] 76.7686
```

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

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

```
[1] 49.6535
```

We can use the skimr package to get a quick overview of a given dataset. This can be useful for the first time you encounter a new dataset.

```r
library(skimr)
skimr::skim(candy)
```

Table 1: Data summary

Name	candy
Number of rows	85
Number of columns	12
Column type frequency:	
numeric	12
Group variables	None

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
chocolate	0	1	0.44	0.50	0.00	0.00	0.00	1.00	1.00	
fruity	0	1	0.45	0.50	0.00	0.00	0.00	1.00	1.00	
caramel	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
peanutyalmondy	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
nougat	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
crispedricewafer	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
hard	0	1	0.18	0.38	0.00	0.00	0.00	0.00	1.00	
bar	0	1	0.25	0.43	0.00	0.00	0.00	0.00	1.00	
pluribus	0	1	0.52	0.50	0.00	0.00	1.00	1.00	1.00	
sugarpercent	0	1	0.48	0.28	0.01	0.22	0.47	0.73	0.99	
pricepercent	0	1	0.47	0.29	0.01	0.26	0.47	0.65	0.98	
winpercent	0	1	50.32	14.71	22.45	39.14	47.83	59.86	84.18	

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

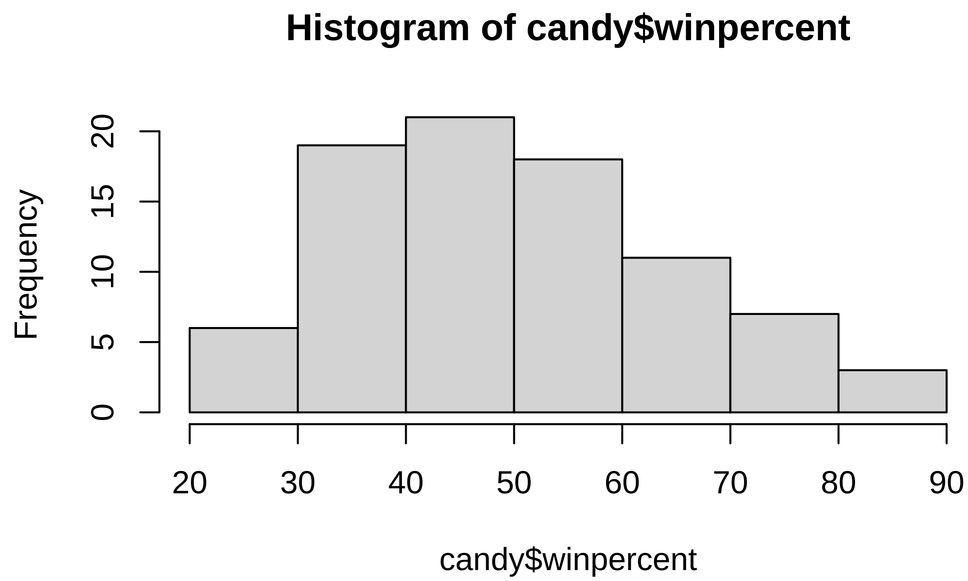
The last column: `candy$winpercent`is on a different scale to all others.

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

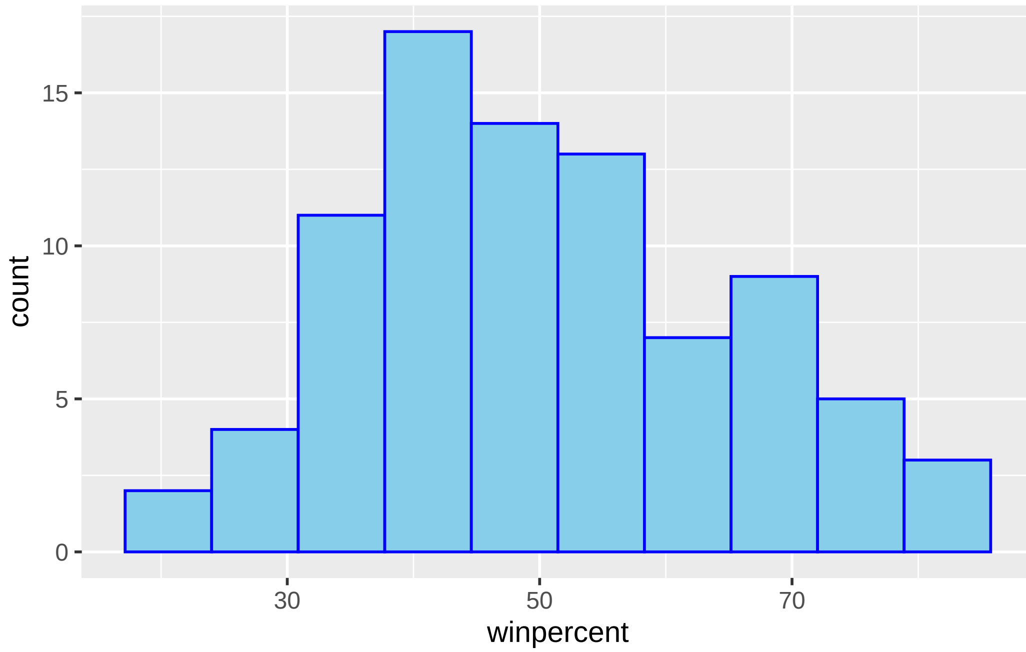
The zero in the candy$chocolate column mean that that candy is not chocolate and then a 1 indicated that it is a chocolate

> Q8. Plot a histogram of winpercent values

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




```
library(ggplot2)
ggplot(candy)+
  aes(winpercent)+
  geom_histogram(bins=10, color="blue", fill="skyblue")
```



Q9. Is the distribution of winpercent values symmetrical?

No

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 
```

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

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

```
 [1] 66.97173 67.60294 50.34755 56.91455 38.97504 55.37545 62.28448 56.49050
 [9] 59.23612 57.21925 76.76860 71.46505 66.57458 55.06407 73.09956 60.80070
[17] 64.35334 47.82975 54.52645 70.73564 66.47068 69.48379 81.86626 84.18029
[25] 73.43499 72.88790 65.71629 34.72200 37.88719 76.67378 59.52925 48.98265
[33] 43.06890 45.73675 49.65350 81.64291 49.52411
```

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

```
[1] 60.92153
```

```r
fruit.win<- candy[ as.logical(candy$fruity),]$winpercent
mean(fruit.win)
```

```
[1] 44.11974
```

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

```

	Welch Two Sample t-test

data:  choc.win and fruit.win
t = 6.2582, df = 68.882, p-value = 2.871e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 11.44563 22.15795
sample estimates:
mean of x mean of y 
 60.92153  44.11974 
```

This tells us that chocolate is more liked than candy. Where it says mean of x that value is referring to chocolate, and then the mean of y is referring to candy. From there, we can see that the mean of x is larger, indicating that chocolate is more liked.

```r
ans<- t.test(choc.win, fruit.win)
```

Yes with a P-value of 2.8713778×10^{-8}.

> Q12. Is this difference statistically significant?

Yes it is statistically significant

3. Overall Candy Rankings

There are two related functions that can help here, one is the classic `sort()` and `order()`

```r
x<- c(5, 10, 1, 4)
sort( x)
```

```
[1]  1  4  5 10
```

```r
order(x)
```

```
[1] 3 4 1 2
```

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

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

These are the top five least liked candies

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

```r
tail(candy[inds,],5)
```

```
                          chocolate fruity caramel peanutyalmondy 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
                          crispedricewafer 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
```

The top 5 candies in this dataset is snickers, Kit Kat, Twix, Reese's miniatures, and Reese's peanut butter cup.

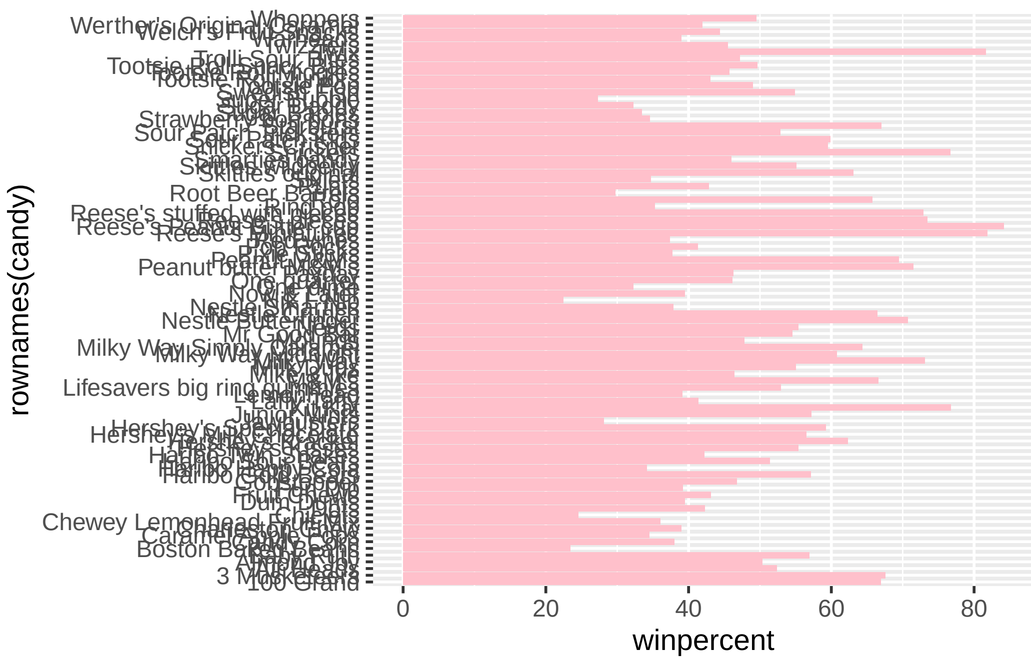
```r
inds<- order(candy$winpercent, decreasing=T)
head(candy[inds,], 5)
```

```
                          chocolate fruity caramel peanutyalmondy nougat
Reese's Peanut Butter cup         1      0       0              1      0
Reese's Miniatures                1      0       0              1      0
Twix                              1      0       1              0      0
Kit Kat                           1      0       0              0      0
Snickers                          1      0       1              1      1
                          crispedricewafer hard bar pluribus sugarpercent
Reese's Peanut Butter cup                0    0   0        0        0.720
Reese's Miniatures                       0    0   0        0        0.034
Twix                                     1    0   1        0        0.546
Kit Kat                                  1    0   1        0        0.313
Snickers                                 0    0   1        0        0.546
                          pricepercent winpercent
Reese's Peanut Butter cup        0.651   84.18029
Reese's Miniatures               0.279   81.86626
Twix                             0.906   81.64291
Kit Kat                          0.511   76.76860
```

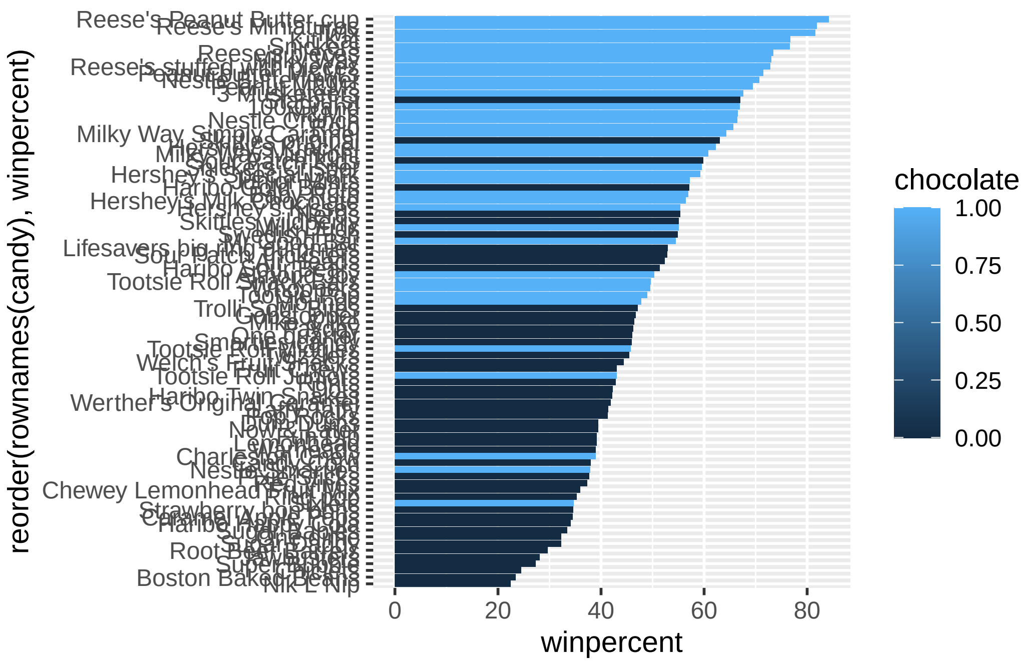
```
Snickers                          0.651   76.67378
```

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

```r
ggplot(candy)+
  aes(winpercent, rownames(candy))+
  geom_col(fill="pink")
```

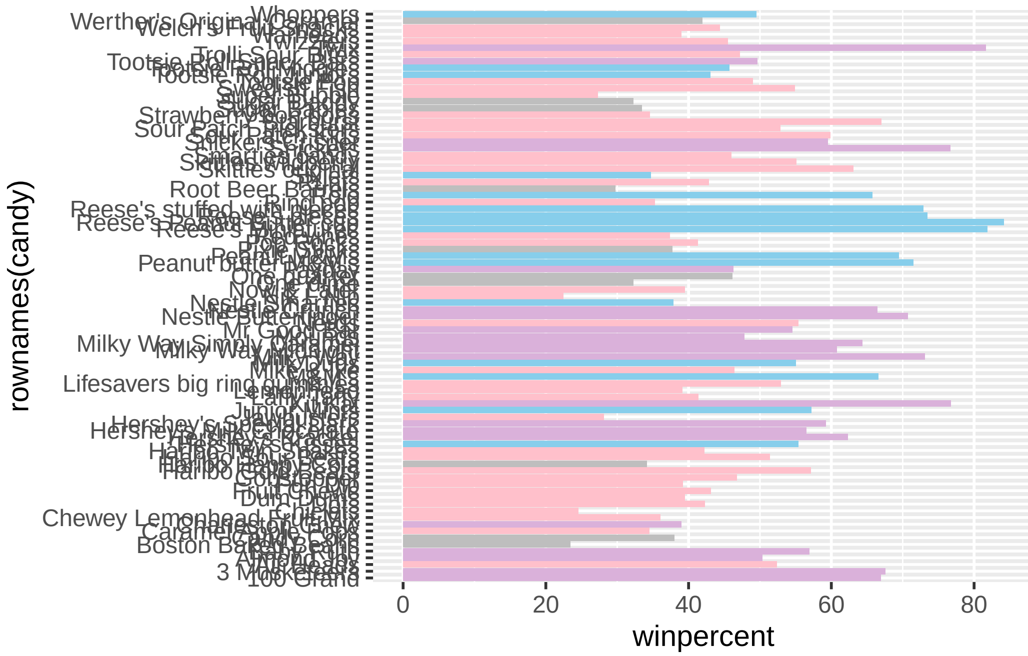



```r
ggplot(candy)+
  aes(x=winpercent, y=reorder(rownames(candy), winpercent), fill=chocolate)+
  geom_col()
```



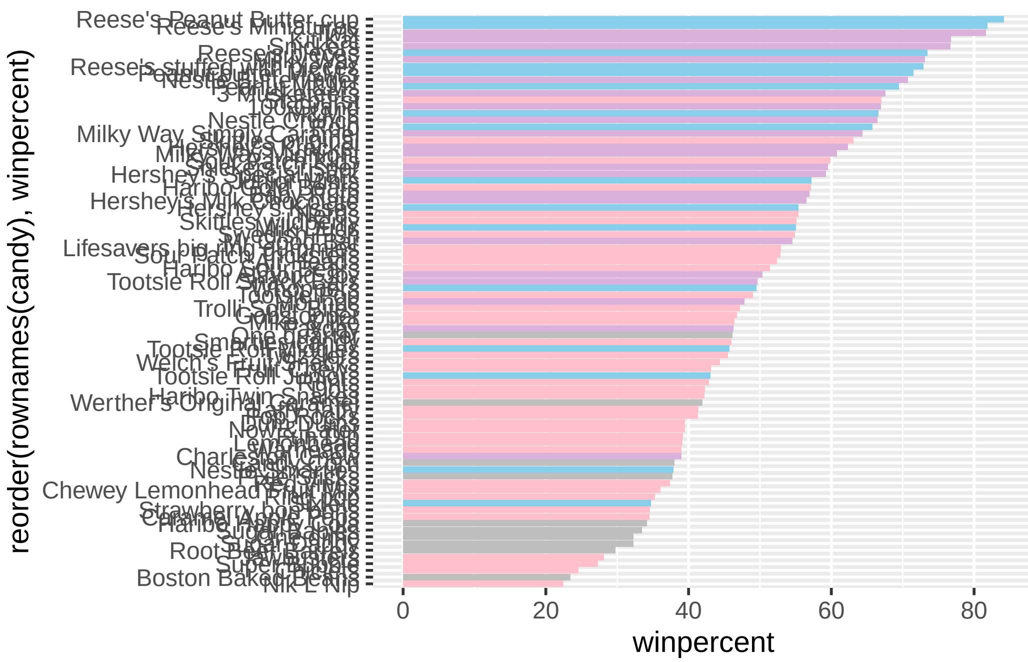
Here we want a custom color vector to color each bar the way we want, with `chocolate` and `fruity` candy together with whether it is a bar or not.

```
mycols<- rep("gray", nrow(candy))
mycols[as.logical(candy$chocolate)] <- "skyblue"
mycols[as.logical(candy$fruity)] <- "pink"
mycols[as.logical(candy$bar)] <- "#DAB1DA"
ggplot(candy)+
  aes(winpercent, rownames(candy))+
  geom_col(fill=mycols)
```



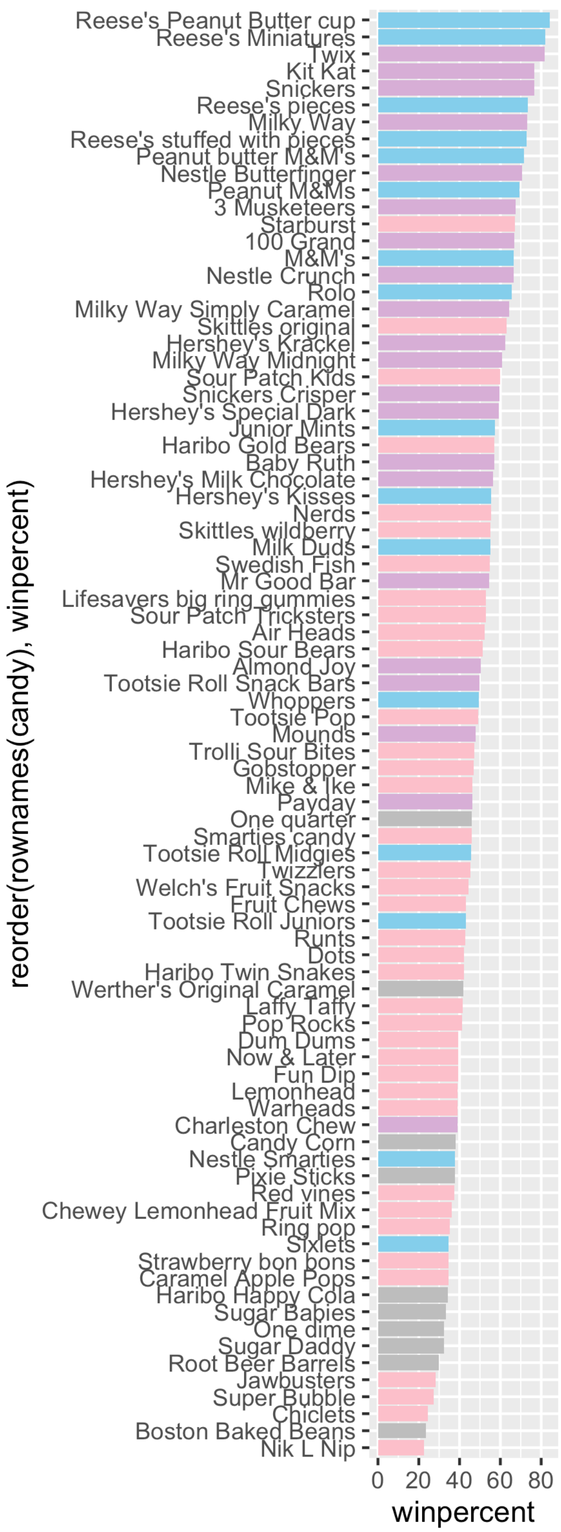
Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent?

```
mycols<- rep("gray", nrow(candy))
mycols[as.logical(candy$chocolate)] <- "skyblue"
mycols[as.logical(candy$fruity)] <- "pink"
mycols[as.logical(candy$bar)] <- "#DAB1DA"



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




```r
ggsave("mybarplot.png", width=3, height=8)
```

The pink represent the fruity candy and then the sky blue represents the chocolate



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
reorder(rownames(candy), winpercent)
0
20
40
60
80
winpercent

Q17. What is the worst ranked chocolate candy?

The worst ranked chocolate candy is Sixlet

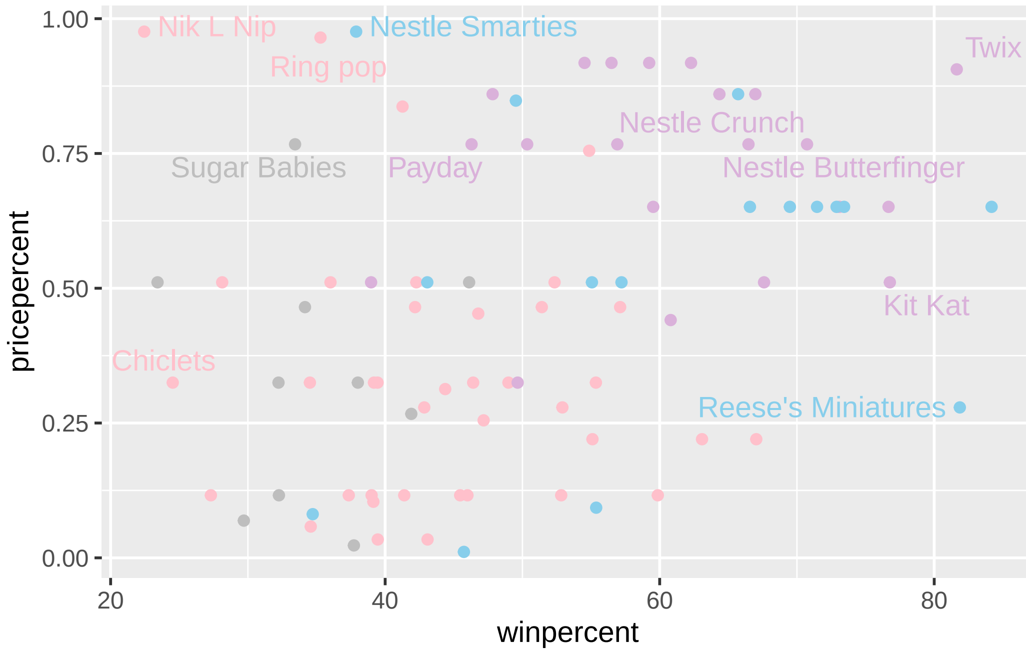
Q18. What is the best ranked fruity candy?

The best ranked fruity candy is Nik L Nip

4. Winpercent vs Pricepercent

```r
mycols<- rep("gray", nrow(candy))
mycols[as.logical(candy$chocolate)] <- "skyblue"
mycols[as.logical(candy$fruity)] <- "pink"
mycols[as.logical(candy$bar)] <- "#DAB1DA"


library(ggrepel)
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col= mycols) +
  geom_text_repel(col= mycols, size=3.75, max.overlaps = 5)
```

```
Warning: ggrepel: 74 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

> 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 is Nik L Nip, Ring pop, Sugar Babies, Nestle Smarties, Pop rock

5. Correlation Structure

```
cij<- cor(candy)
cij
```

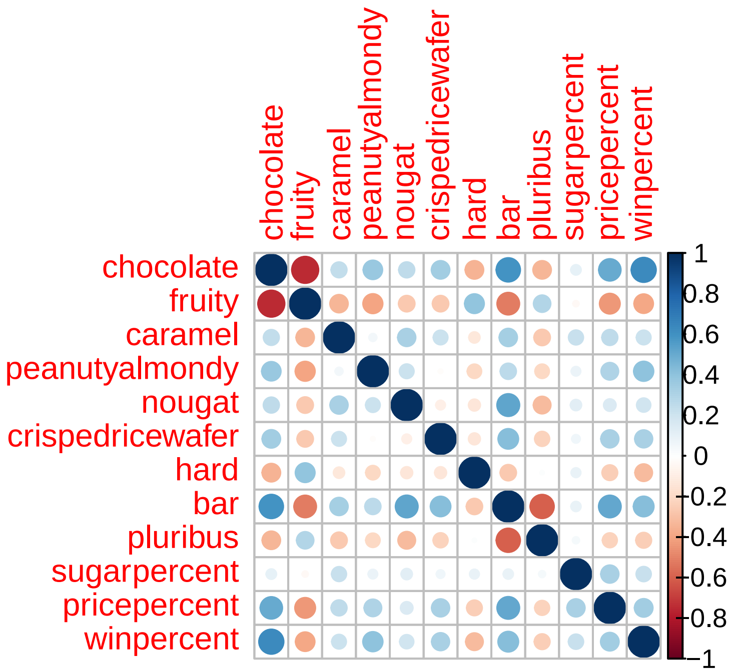
```
                 chocolate      fruity     caramel peanutyalmondy      nougat
chocolate        1.0000000 -0.74172106  0.24987535     0.37782357  0.25489183
fruity          -0.7417211  1.00000000 -0.33548538    -0.39928014 -0.26936712
caramel          0.2498753 -0.33548538  1.00000000     0.05935614  0.32849280
peanutyalmondy   0.3778236 -0.39928014  0.05935614     1.00000000  0.21311310
nougat           0.2548918 -0.26936712  0.32849280     0.21311310  1.00000000
```

```
crispedricewafer  0.3412098 -0.26936712  0.21311310    -0.01764631 -0.08974359
hard             -0.3441769  0.39067750 -0.12235513    -0.20555661 -0.13867505
bar               0.5974211 -0.51506558  0.33396002     0.26041960  0.52297636
pluribus         -0.3396752  0.29972522 -0.26958501    -0.20610932 -0.31033884
sugarpercent      0.1041691 -0.03439296  0.22193335     0.08788927  0.12308135
pricepercent      0.5046754 -0.43096853  0.25432709     0.30915323  0.15319643
winpercent        0.6365167 -0.38093814  0.21341630     0.40619220  0.19937530
                 crispedricewafer        hard         bar    pluribus
chocolate              0.34120978 -0.34417691  0.59742114 -0.33967519
fruity                -0.26936712  0.39067750 -0.51506558  0.29972522
caramel                0.21311310 -0.12235513  0.33396002 -0.26958501
peanutyalmondy        -0.01764631 -0.20555661  0.26041960 -0.20610932
nougat                -0.08974359 -0.13867505  0.52297636 -0.31033884
crispedricewafer       1.00000000 -0.13867505  0.42375093 -0.22469338
hard                  -0.13867505  1.00000000 -0.26516504  0.01453172
bar                    0.42375093 -0.26516504  1.00000000 -0.59340892
pluribus              -0.22469338  0.01453172 -0.59340892  1.00000000
sugarpercent           0.06994969  0.09180975  0.09998516  0.04552282
pricepercent           0.32826539 -0.24436534  0.51840654 -0.22079363
winpercent             0.32467965 -0.31038158  0.42992933 -0.24744787
                 sugarpercent pricepercent winpercent
chocolate          0.10416906    0.5046754  0.6365167
fruity            -0.03439296   -0.4309685 -0.3809381
caramel            0.22193335    0.2543271  0.2134163
peanutyalmondy     0.08788927    0.3091532  0.4061922
nougat             0.12308135    0.1531964  0.1993753
crispedricewafer   0.06994969    0.3282654  0.3246797
hard               0.09180975   -0.2443653 -0.3103816
bar                0.09998516    0.5184065  0.4299293
pluribus           0.04552282   -0.2207936 -0.2474479
sugarpercent       1.00000000    0.3297064  0.2291507
pricepercent       0.32970639    1.0000000  0.3453254
winpercent         0.22915066    0.3453254  1.0000000
```

```r
library(corrplot)
```

```
corrplot 0.95 loaded
```

```r
corrplot(cij)
```



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

Chocolate and fruity are negatively correlated

```
round(cij["chocolate", "fruity"], 2)
```

```
[1] -0.74
```

The two in the code above gives us two decimal places if we ran it without the 2 we would get a value of -1

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

```
round(cij["chocolate", "bar"], 2)
```

```
[1] 0.6
```

Principle Component Analysis (PCA)

We need to be sure to scale our input `candy` data before PCA as we have the `winpercent` column on a different scale to all other in the data set

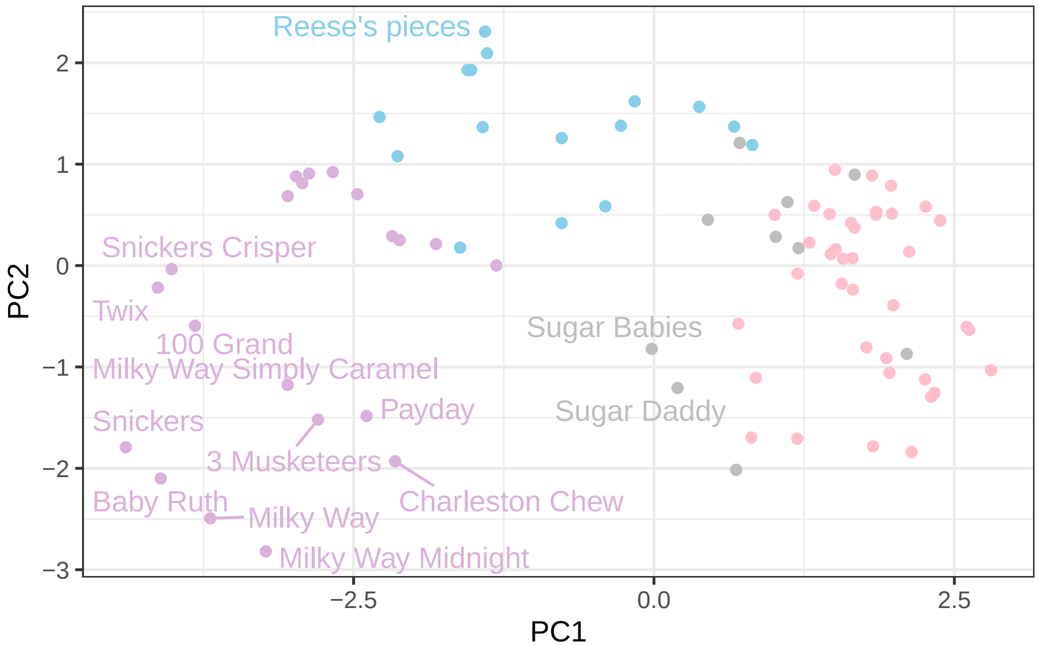
```
pca<- prcomp(candy, scale=T)
summary(pca)
```

```
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
```

The first PCA captures 36% variance

```
library(ggrepel)
ggplot(pca$x)+
  aes(PC1, PC2, label=rownames(pca$x))+
  geom_point(col=mycols) +
  geom_text_repel(col= mycols, size=3.75, max.overlaps = 5)+
  theme_bw()
```

```
Warning: ggrepel: 71 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



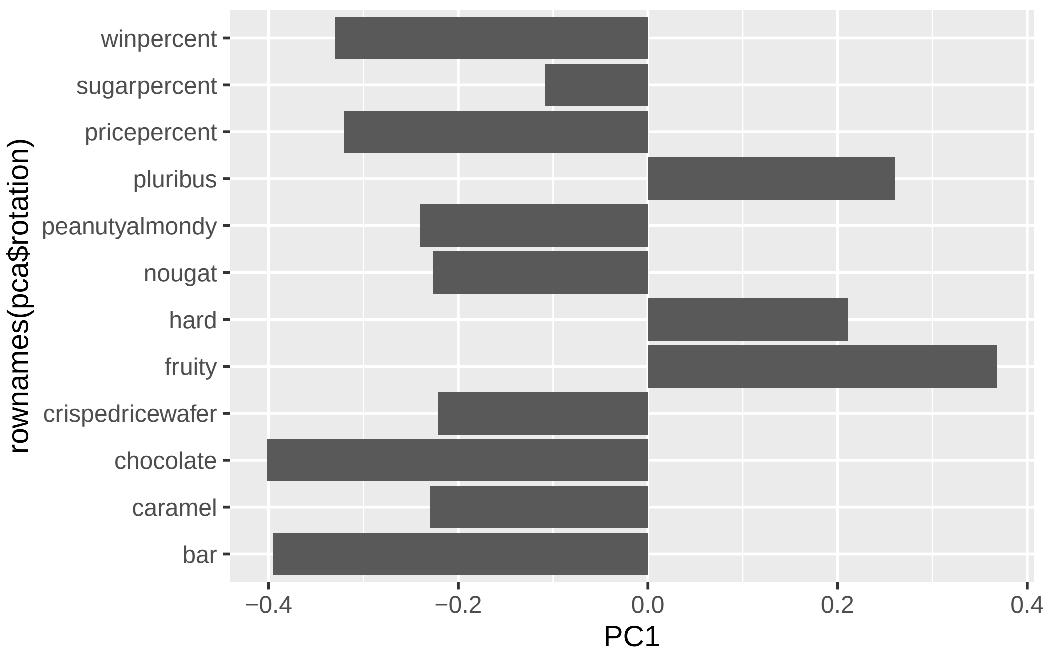
The second main PCA result is in the `pca$rotation` we can plot this to generate a so-called "loading" plot.

```
pca$rotation
```

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

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

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

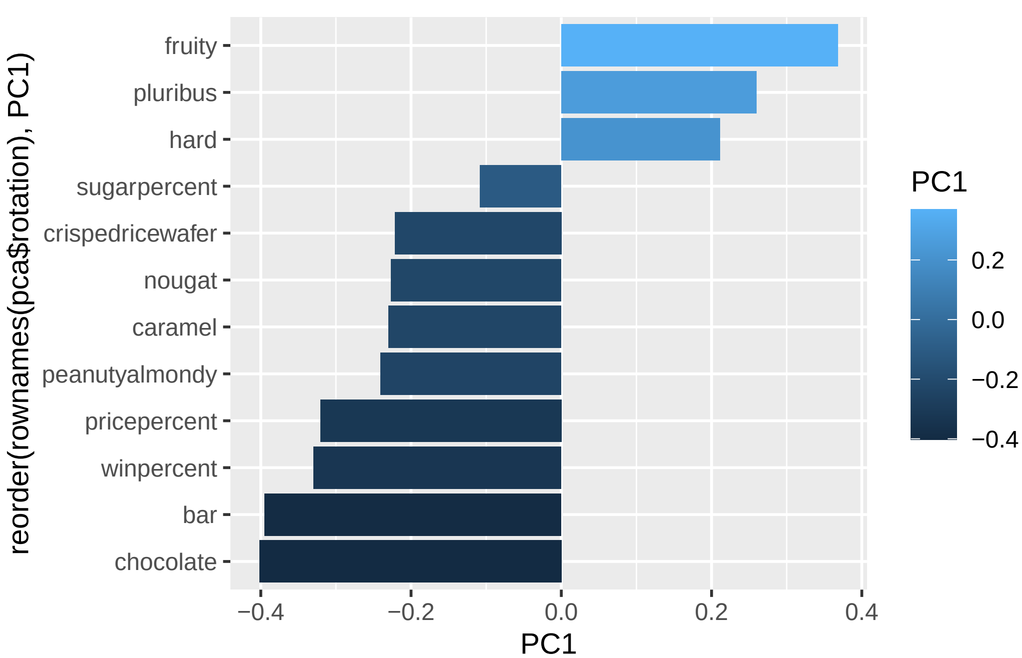



```
pca$rotation
```

```
                        PC1         PC2         PC3          PC4          PC5
chocolate        -0.4019466  0.21404160  0.01601358 -0.016673032  0.066035846
fruity            0.3683883 -0.18304666 -0.13765612 -0.004479829  0.143535325
caramel          -0.2299709 -0.40349894 -0.13294166 -0.024889542 -0.507301501
peanutyalmondy   -0.2407155  0.22446919  0.18272802  0.466784287  0.399930245
nougat           -0.2268102 -0.47016599  0.33970244  0.299581403 -0.188852418
crispedricewafer -0.2215182  0.09719527 -0.36485542 -0.605594730  0.034652316
hard              0.2111587 -0.43262603 -0.20295368 -0.032249660  0.574557816
bar              -0.3947433 -0.22255618  0.10696092 -0.186914549  0.077794806
pluribus          0.2600041  0.36920922 -0.26813772  0.287246604 -0.392796479
sugarpercent     -0.1083088 -0.23647379 -0.65509692  0.433896248  0.007469103
pricepercent     -0.3207361  0.05883628 -0.33048843  0.063557149  0.043358887
winpercent       -0.3298035  0.21115347 -0.13531766  0.117930997  0.168755073
                         PC6         PC7         PC8          PC9         PC10
chocolate        -0.09018950 -0.08360642 -0.49084856 -0.151651568  0.107661356
fruity           -0.04266105  0.46147889  0.39805802 -0.001248306  0.362062502
caramel          -0.40346502 -0.44274741  0.26963447  0.019186442  0.229799010
peanutyalmondy   -0.09416259 -0.25710489  0.45771445  0.381068550 -0.145912362
nougat            0.09012643  0.36663902 -0.18793955  0.385278987  0.011323453
crispedricewafer -0.09007640  0.13077042  0.13567736  0.511634999 -0.264810144
```

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

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



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

The graph shows that fruity, pluribus, and hard are all positively correlated and the for the bars on the other side such as sugarpercent, nougat, etc are all negatively correlated