Class 9: Halloween Candy Mini-Project

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In today's class we will examine some data about candy from the 538 website.

Importing Candy data

```
candy_file <- "candy-data.csv"
candy <- read.csv(candy_file,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
```

Data exploration

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

```
nrow(candy)
```

```
[1] 85
```

There are 85 in this dataset

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

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

```
[1] 38
```

My favorite candy vs yours

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

```
candy["Werther's Original Caramel",]$winpercent
```

```
[1] 41.90431
```

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
```

```
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	

Shortcut for library

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

Table 3: 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?

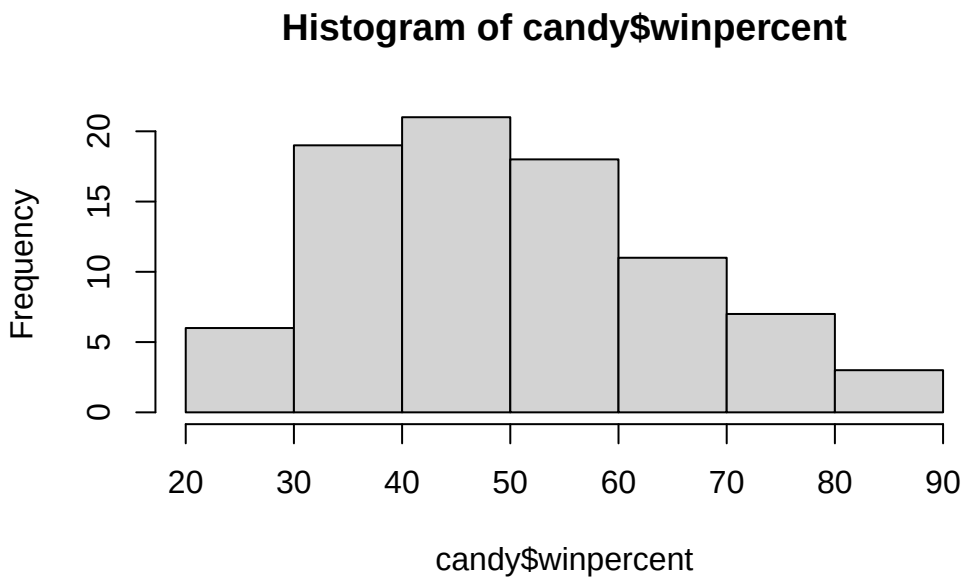
The "winpercent" variable looks to be on a 100% scale while the other variables look like they are on a 0-1 scale for the columns "mean" to "p100".

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

A zero would represent that it does not have what the column represents while a one means the it does have what the column represents (100%).

Q8. Plot a histogram of winpercent values

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

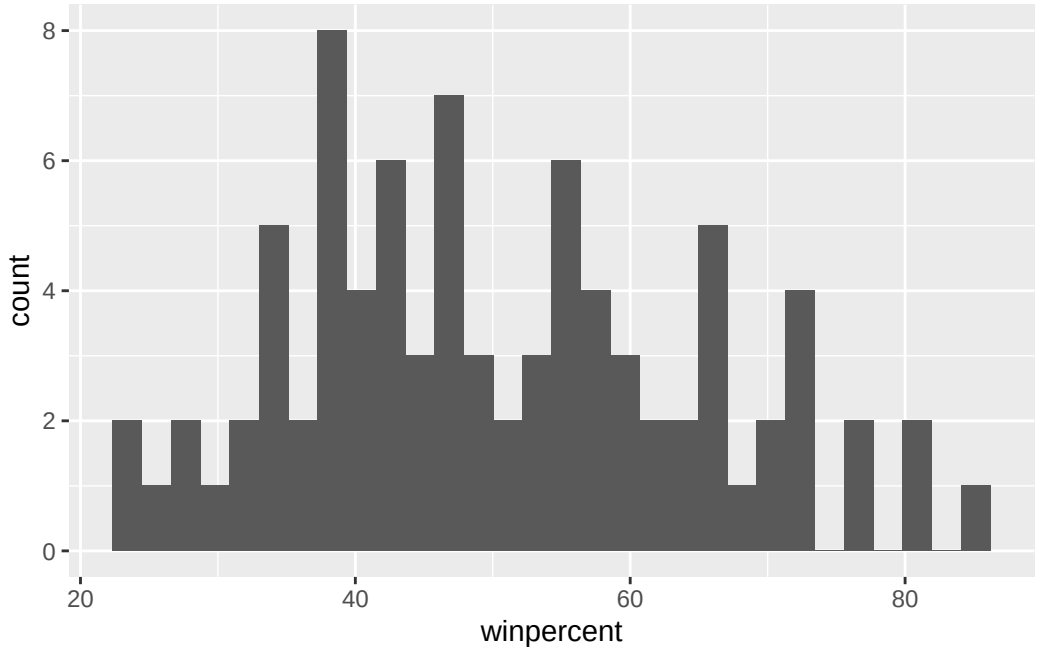



```
library(ggplot2)
```

```
ggplot(candy) +
  aes(winpercent) +
  geom_histogram(binds=7)
```

```
Warning in geom_histogram(binds = 7): Ignoring unknown parameters: `binds`

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



Q9. Is the distribution of winpercent values symmetrical?

No.

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

Below

```
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 
```

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

- first find all chocolate candy
- find their winpercent values
- calculate the mean of these values

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

- then do the same for fruity candy and compare with the mean for chocolate candy

```
fruity.inds <- candy$fruity==1
fruity.win <- candy[fruity.inds,]$winpercent
mean.fruity <- mean(fruity.win)
mean.choc > mean.fruity
```

```
[1] TRUE
```

Q12. Is this difference statistically significant?

```
t.test(chocolate.win, fruity.win)
```

```
    Welch Two Sample t-test

data:  chocolate.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
```

p-value = 2.871e-08 is very small, so the difference is statistically significant.

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

```
head(candy[order(candy$winpercent),], n=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
```

```r
x <- c(5,6,3,1,7)
sort(x)
```

```
[1] 1 3 5 6 7
```

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

```
[1] 1 3 5 6 7
```

The order function returns the indices that make the input sorted.

```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
```

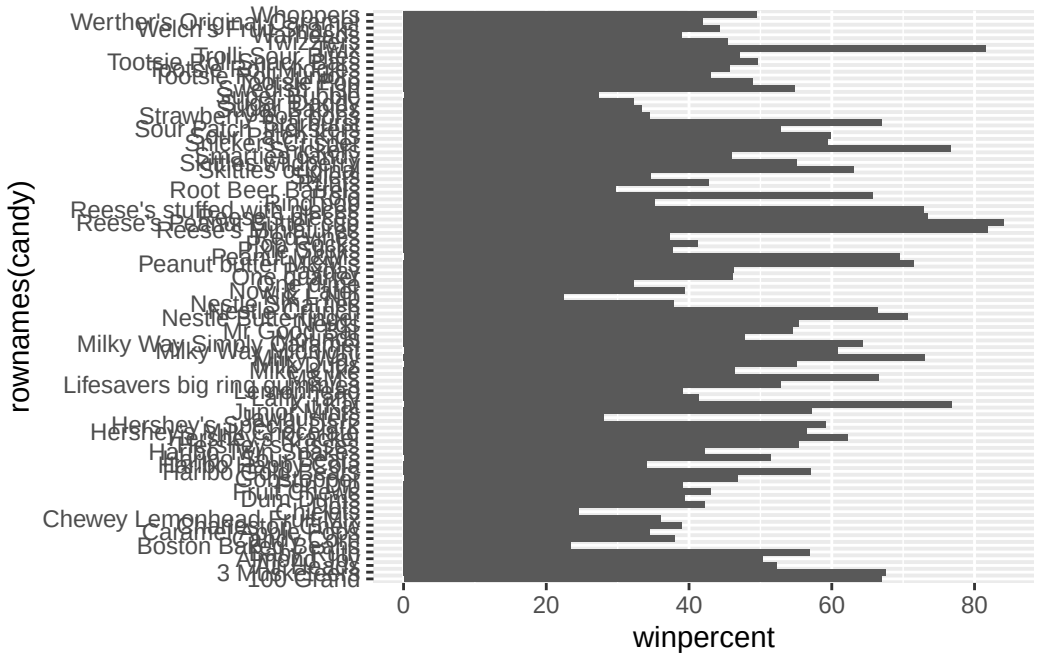
Q14. What are the top 5 all time favorite candy types out of this set?

```
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
```

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

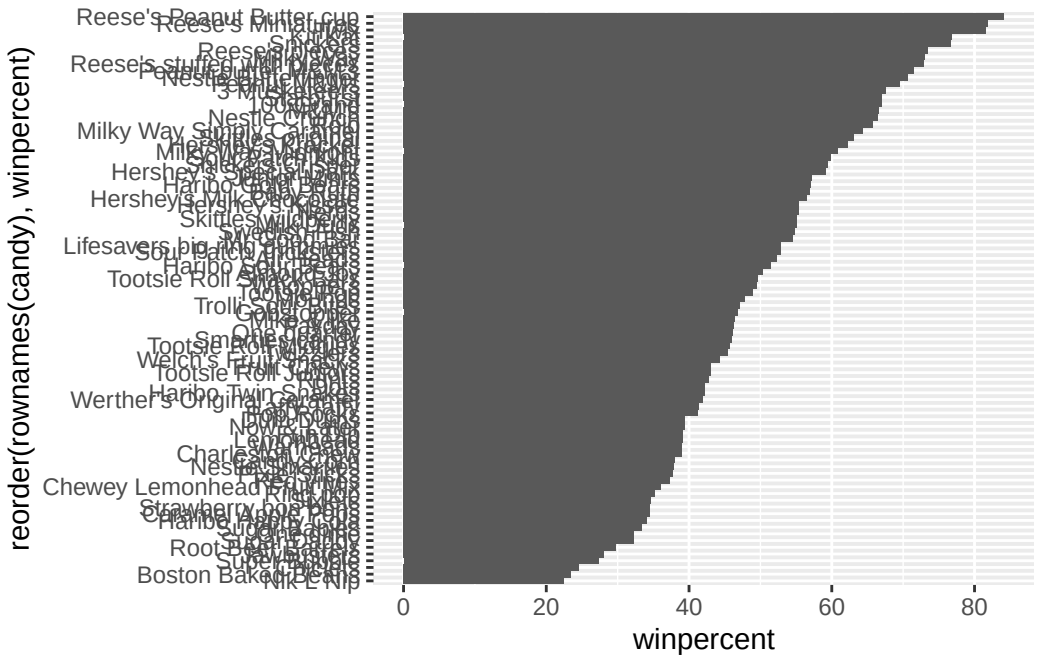
```
ggplot(candy)+
  aes(winpercent, rownames(candy))+
  geom_col()
```



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

```
#/ fig-height: 10
#/ fig-width: 7

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




```
ggsave("mybarplot.png", height=10)
```

```
Saving 5.5 x 10 in image
```

Add my custom colors to my barplot

```
my_cols=rep("black", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "red"
my_cols[as.logical(candy$bar)] = "purple"
my_cols[as.logical(candy$fruity)] = "orange"
```

```
#/ fig-height: 10
#/ fig-width: 7

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

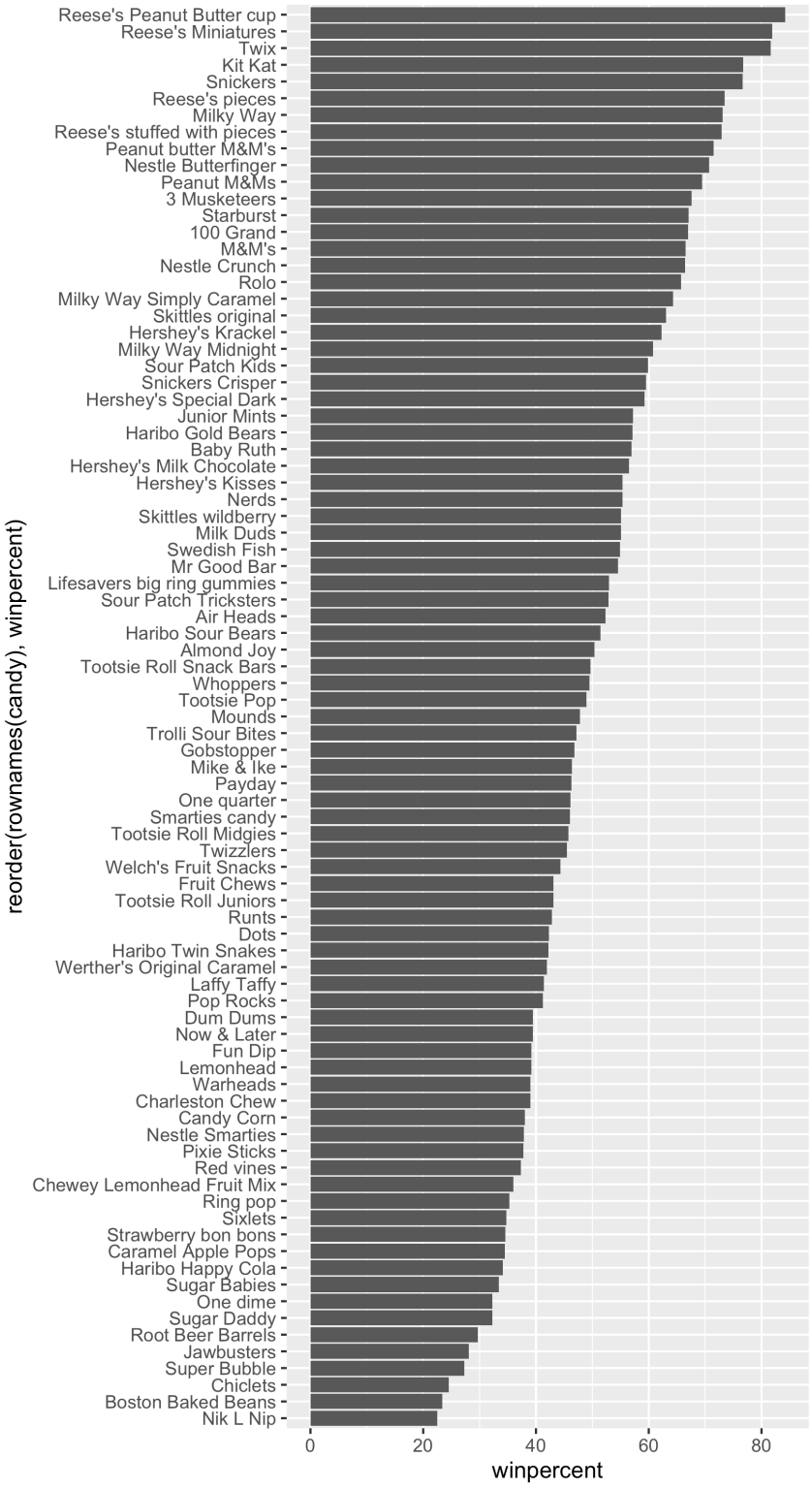
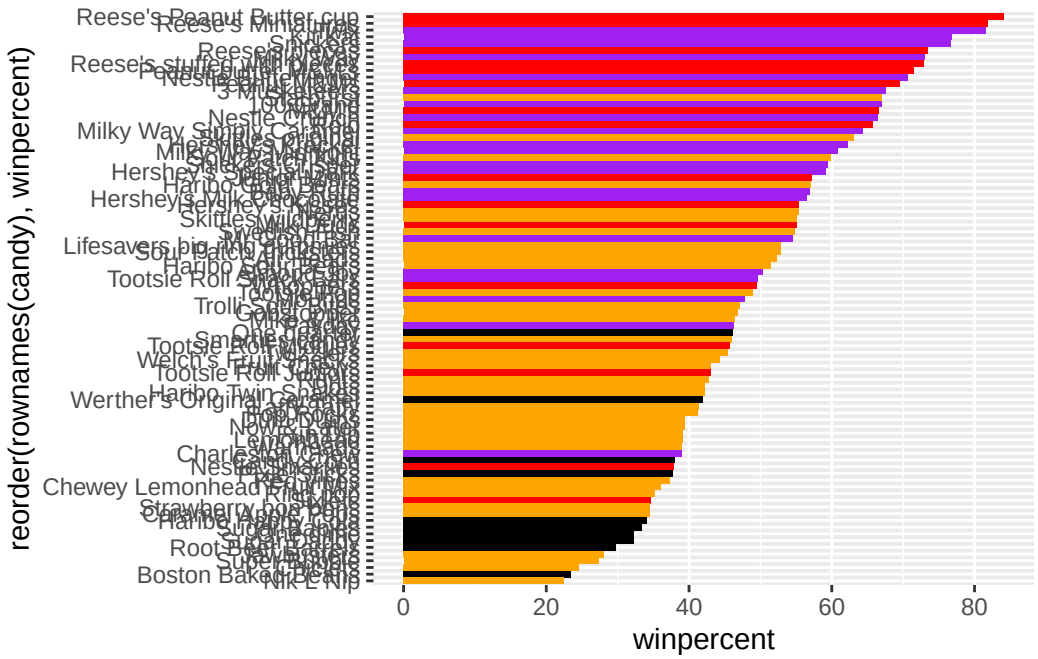


Figure 1: Exported image that is bigger so I can read it



Q17. What is the worst ranked chocolate candy?

Sixlets

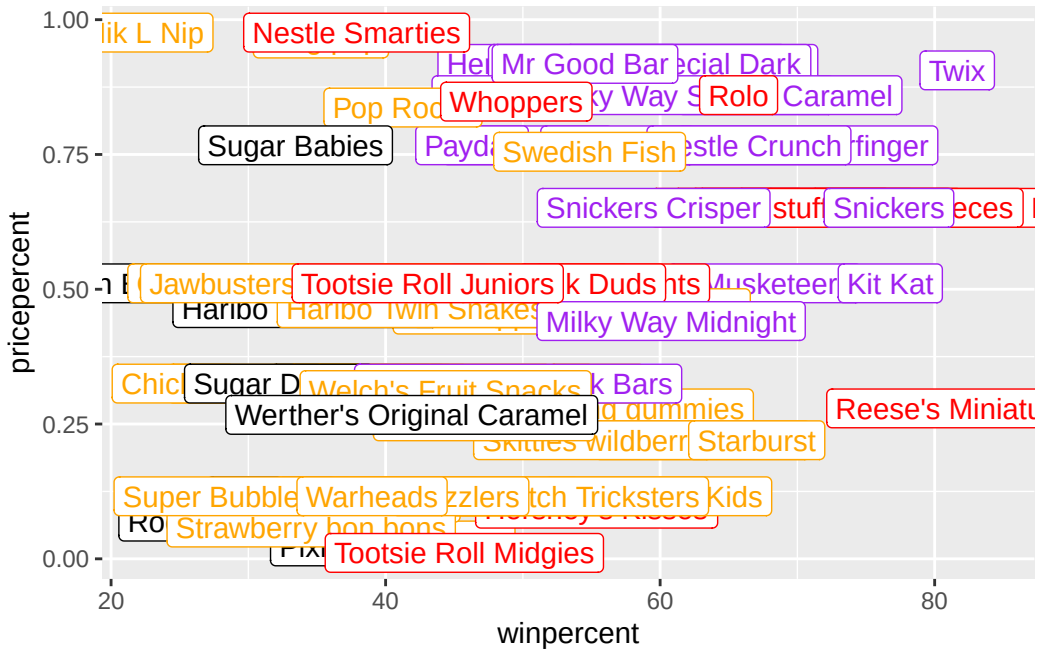
Q18. What is the best ranked fruity candy?

Starburst

Plot of winpercent vs pricepercent

```
#/ fig-height: 10
#/ fig-width: 7

ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols)+
  geom_label(col=my_cols)
```

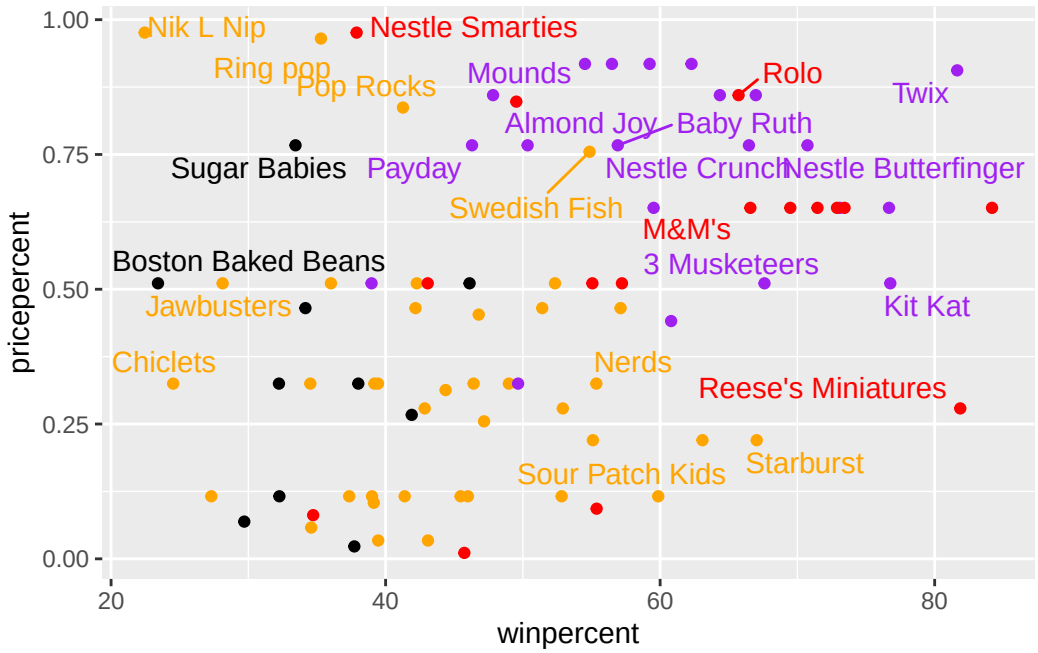


There are just too many labels in thisd above plot to be readable. We can use the `ggrepel` package to do a better job of placing labels so they minimize text overlap.

```
library(ggrepel)

ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols)+
  geom_text_repel(col=my_cols, max.overlaps=8)
```

```
Warning: ggrepel: 61 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



5 Exploring the correlation structure

```
library(corrplot)
```

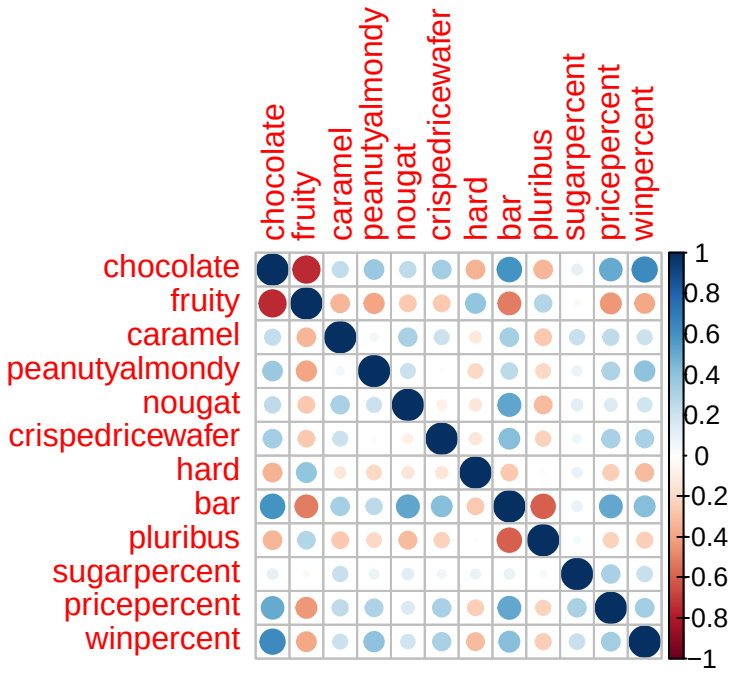
```
corrplot 0.92 loaded
```

```
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
```

```
corrplot(cij)
```



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

Chocolate and fruity seem to be the most anti-correlate.

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

Chocolate and winpercent are most positively correlated.

6. Principal component analysis

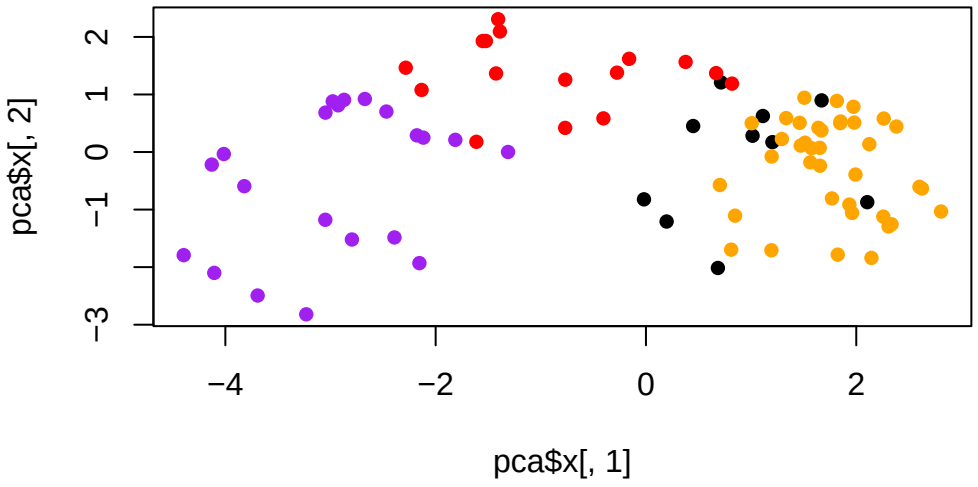
We will perform a PCA of the candy. Key-question: do we need to scale the data before PCA?

```
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
```

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



Make a ggplot version of this figure:

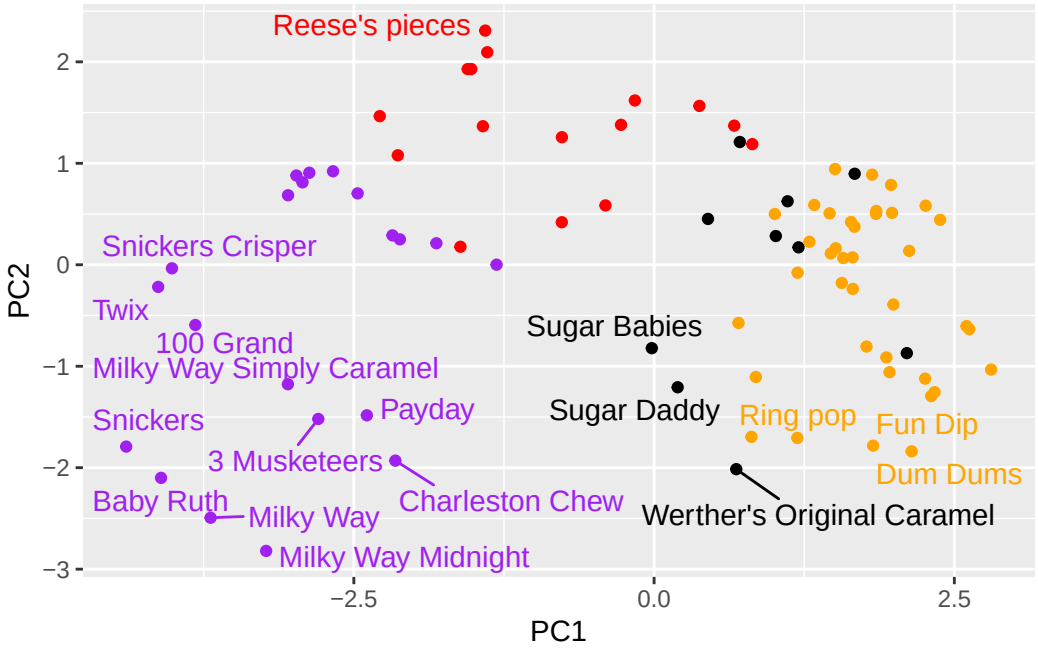
```
# Make a new data-frame with our PCA results and candy data
my_data <- cbind(candy, pca$x[,1:3])
head(my_data)
```

```
              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        PC1
```

```
100 Grand       0   1        0       0.732       0.860   66.97173 -3.8198617
3 Musketeers    0   1        0       0.604       0.511   67.60294 -2.7960236
One dime        0   0        0       0.011       0.116   32.26109  1.2025836
One quarter     0   0        0       0.011       0.511   46.11650  0.4486538
Air Heads       0   0        0       0.906       0.511   52.34146  0.7028992
Almond Joy      0   1        0       0.465       0.767   50.34755 -2.4683383
                    PC2        PC3
100 Grand    -0.5935788 -2.1863087
3 Musketeers -1.5196062  1.4121986
One dime      0.1718121  2.0607712
One quarter   0.4519736  1.4764928
Air Heads    -0.5731343 -0.9293893
Almond Joy    0.7035501  0.8581089
```

```
ggplot(my_data) +
  aes(PC1, PC2,
      label=rownames(my_data)
      )+
  geom_point(col=my_cols)+
  geom_text_repel(col=my_cols, max.overlaps=6)
```

```
Warning: ggrepel: 67 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



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

```
ord <- order(candy$pricepercent, decreasing = TRUE)
head( candy[ord,c(11,12)], n=5 )
```

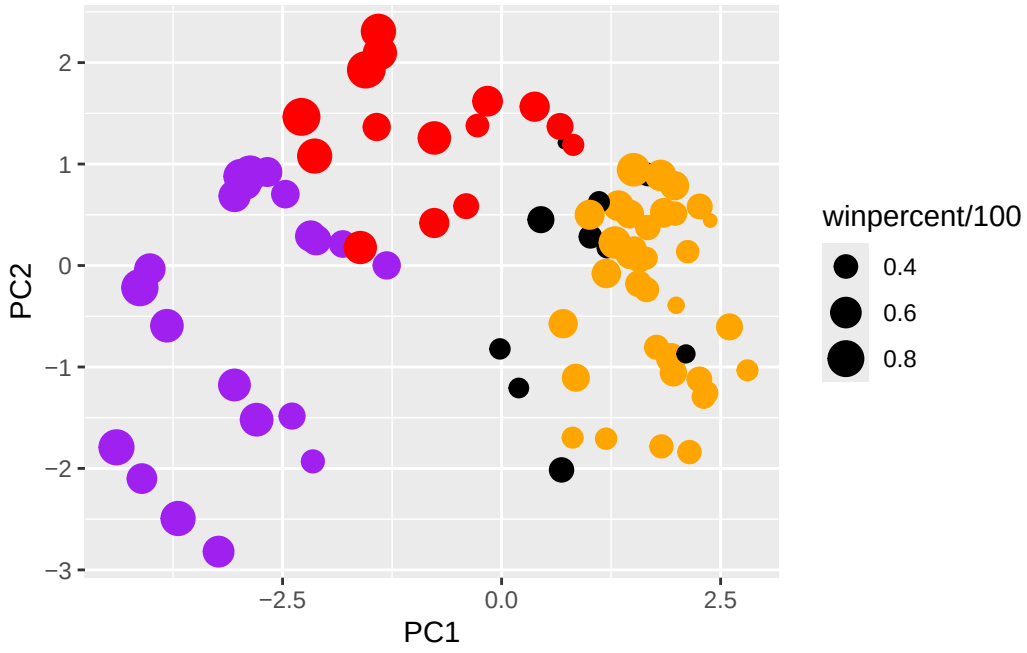
```
                      pricepercent winpercent
Nik L Nip                    0.976   22.44534
Nestle Smarties              0.976   37.88719
Ring pop                     0.965   35.29076
Hershey's Krackel            0.918   62.28448
Hershey's Milk Chocolate     0.918   56.49050
```

Least popular

Make this a bit nicer

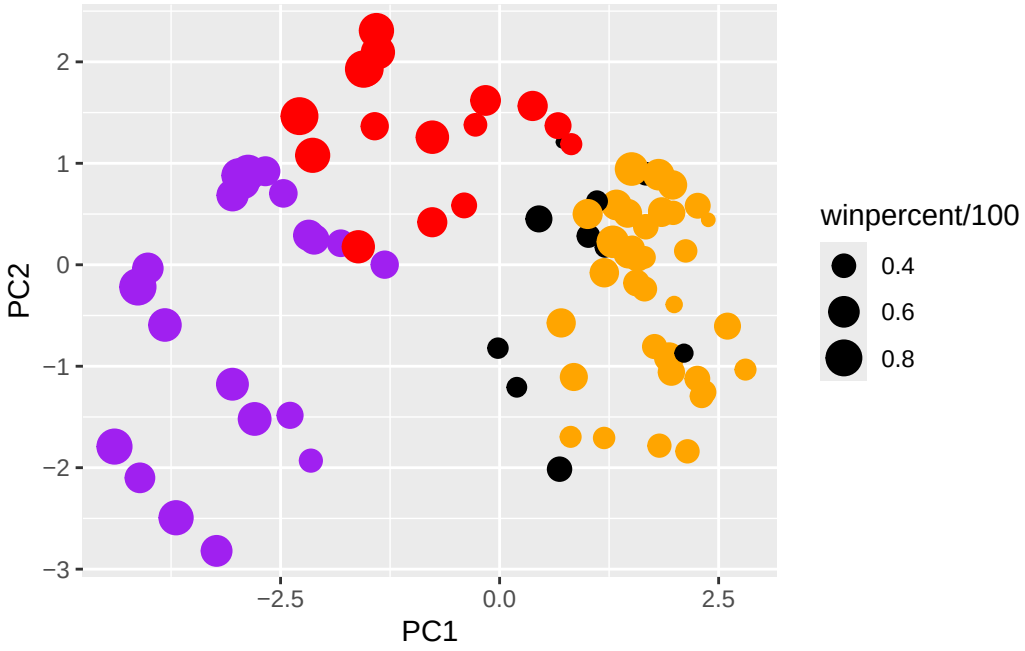
```
ggplot(my_data) +
  aes(PC1, PC2,
      label=rownames(my_data),
      size=winpercent/100,
      text-rownames(my_data))+
```

```
  geom_point(col=my_cols)
```



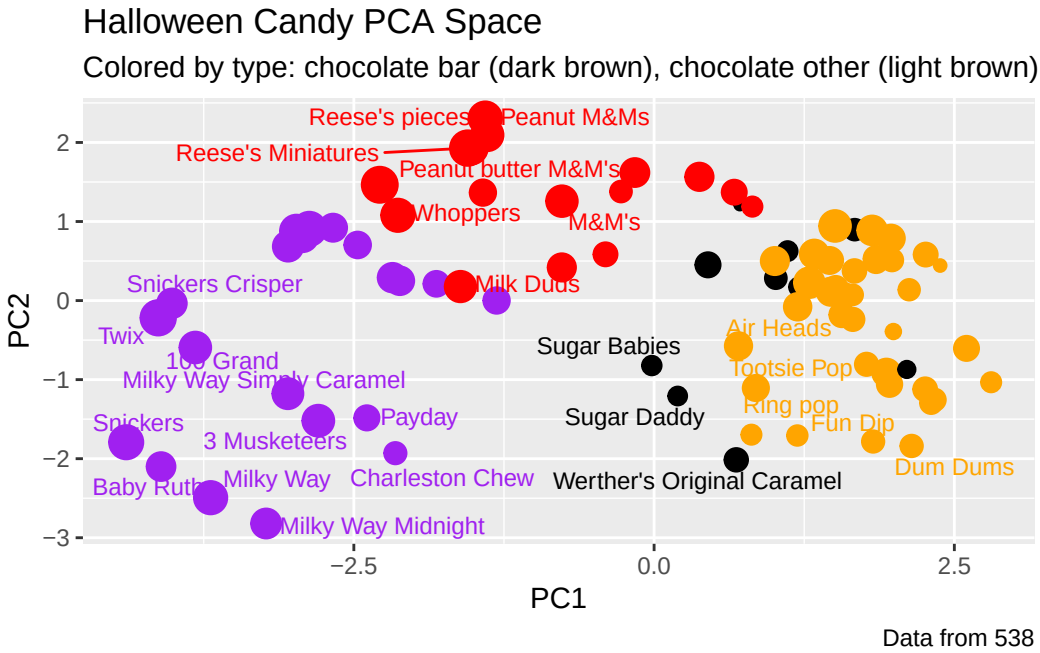

```
library(ggrepel)
p <- ggplot(my_data) +
        aes(x=PC1, y=PC2,
            size=winpercent/100,
            text=rownames(my_data),
            label=rownames(my_data)) +
        geom_point(col=my_cols)

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 (dark brown), chocolate other (light brown
       caption="Data from 538")
```

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




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

How do the original variable contribute of our PCs? FOr this we look at the loading component of our results object i.e. the "pca$rotation' object.

```
head(pca$rotation)
```

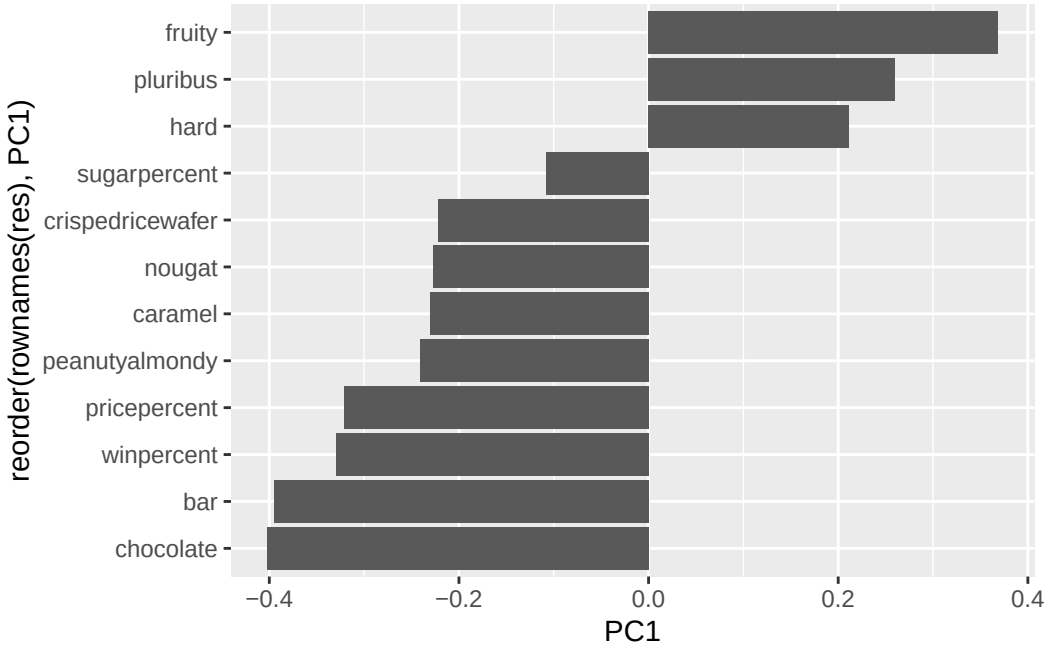
```
                    PC1         PC2         PC3         PC4         PC5
chocolate     -0.4019466  0.21404160  0.01601358 -0.016673032  0.06603585
fruity         0.3683883 -0.18304666 -0.13765612 -0.004479829  0.14353533
caramel       -0.2299709 -0.40349894 -0.13294166 -0.024889542 -0.50730150
peanutyalmondy -0.2407155  0.22446919  0.18272802  0.466784287  0.39993025
nougat        -0.2268102 -0.47016599  0.33970244  0.299581403 -0.18885242
crispedricewafer -0.2215182  0.09719527 -0.36485542 -0.605594730  0.03465232
                    PC6         PC7         PC8         PC9         PC10
chocolate     -0.09018950 -0.08360642 -0.4908486 -0.151651568  0.10766136
fruity        -0.04266105  0.46147889  0.3980580 -0.001248306  0.36206250
caramel       -0.40346502 -0.44274741  0.2696345  0.019186442  0.22979901
peanutyalmondy -0.09416259 -0.25710489  0.4577145  0.381068550 -0.14591236
nougat         0.09012643  0.36663902 -0.1879396  0.385278987  0.01132345
crispedricewafer -0.09007640  0.13077042  0.1356774  0.511634999 -0.26481014
```

```
                      PC11       PC12
chocolate          0.1004528 0.69784924
fruity             0.1749490 0.50624242
caramel            0.1351582 0.07548984
peanutyalmondy     0.1124428 0.12972756
nougat            -0.3895447 0.09223698
crispedricewafer -0.2261562 0.11727369
```

Make a barplot with ggplot and order the bars by their value. Recall that you need a data.frame as input for ggplot

```
res <- as.data.frame(pca$rotation)

ggplot(res) +
  aes(PC1, reorder(rownames(res), PC1)
      )+
  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 picked up strongly by PC1 in the positive direction. This makes sense based on the corelation structure in the dataset. Hard candies usually come in a bag or

box of multiple candies and they tend to be fruity rather than chocolate.