Class 9: Exploratory Analysis of Halloween Candy

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

Data Import

```r
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?

```r
nrow(candy)
```

```
[1] 85
```

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

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

```
[1] 38
```

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

```r
candy["Sour Patch Kids",]$winpercent
```

```
[1] 59.864
```

> 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
```

Exploratory Analysis

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
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?

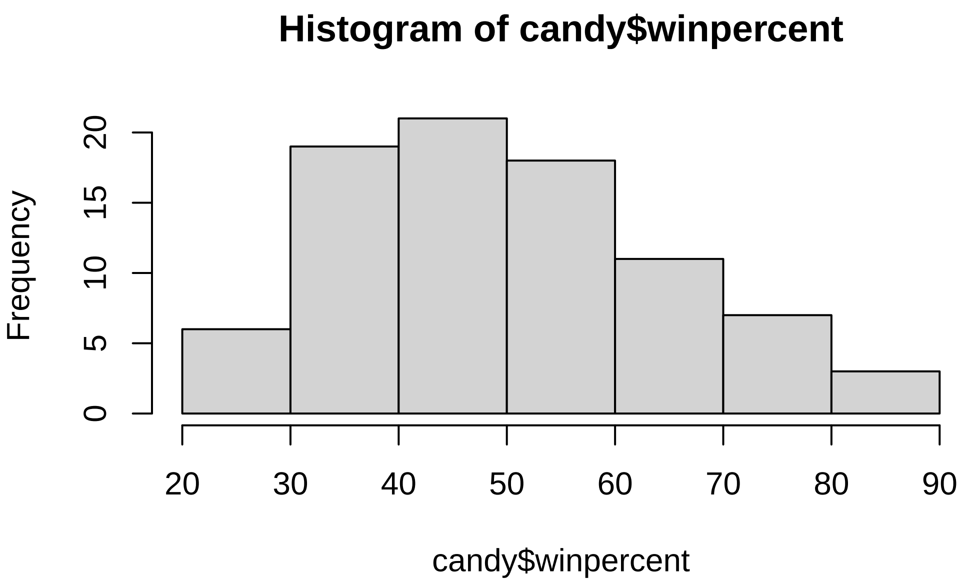
> It looks like the last column `candy$winpercent` is on a different scale to all others.

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

> A zero represents a false and a one represents true. For candy$chocolate, it gives a one to candies that apply and are/have chocolate. The columns indicate if a given candy has a given feature.

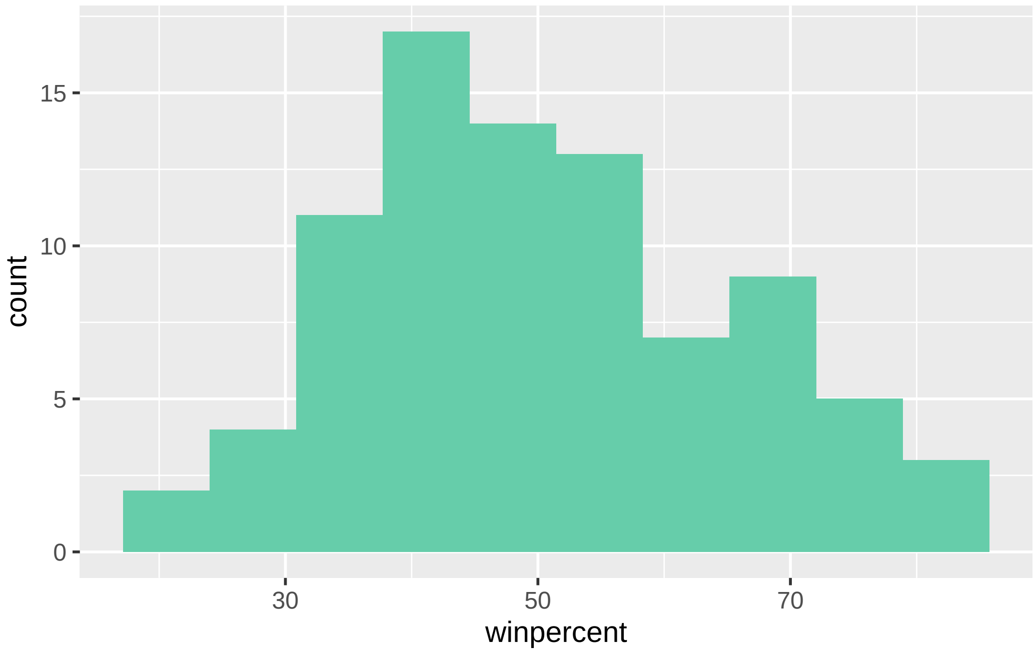
Q8. Plot a histogram of winpercent values

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



```
library(ggplot2)

ggplot(candy)+
  aes(winpercent)+
  geom_histogram(bins = 10,fill="aquamarine3")
```



Q9. Is the distribution of winpercent values symmetrical?

Not symmetrical from the histogram.

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 
```

The median is below 50.

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
mean(choc.win)
```

```
[1] 60.92153
```

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

```
[1] 44.11974
```

Chocolate candy is higher ranked than fruit candy on average.

Q12. Is this difference statistically significant?

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

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

3. Overall Candy Rankings

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

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

```
x <- c(5,10,1,4)
sort(x,decreasing =T)
```

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

```
order(x)
```

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

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

Nik L Nip, Boston Baked Beans, Chiclets, Super Bubble & Jawbusters.

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

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

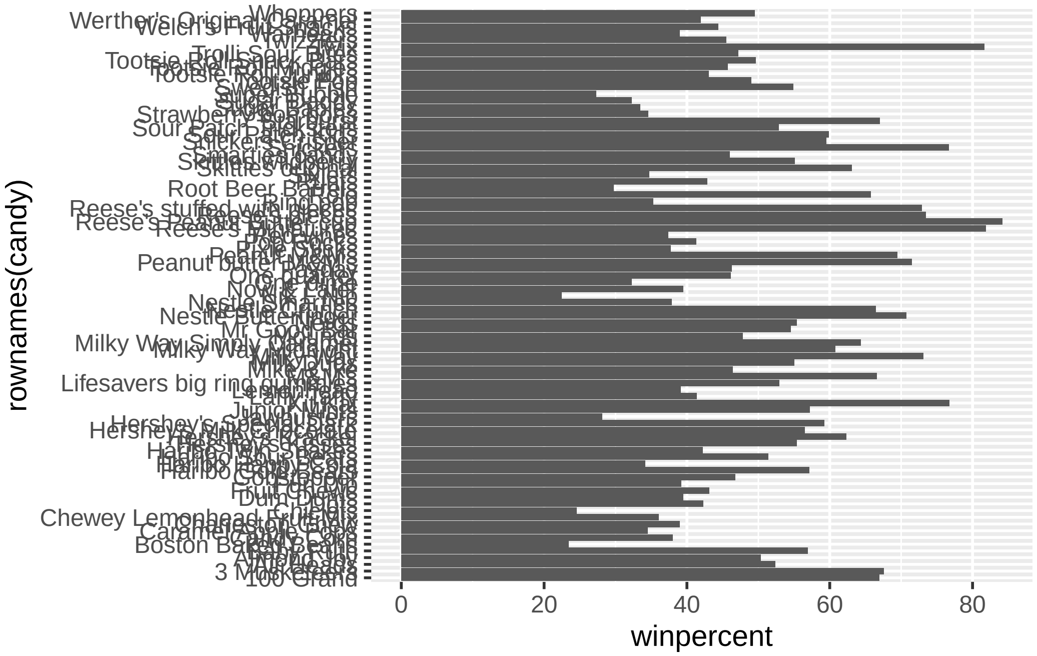
```
                          chocolate fruity caramel peanutyalmondy nougat
Reese's Peanut Butter cup         1      0       0              1      0
Reese's Miniatures                1      0       0              1      0
Twix                              1      0       1              0      0
Kit Kat                           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
```

Reese’s Peanut Butter cup, Reese’s Miniatures, Twix, Kit Kat, Snikcers.

Make a bar plot with ggplot and order it by `winpercent` values.

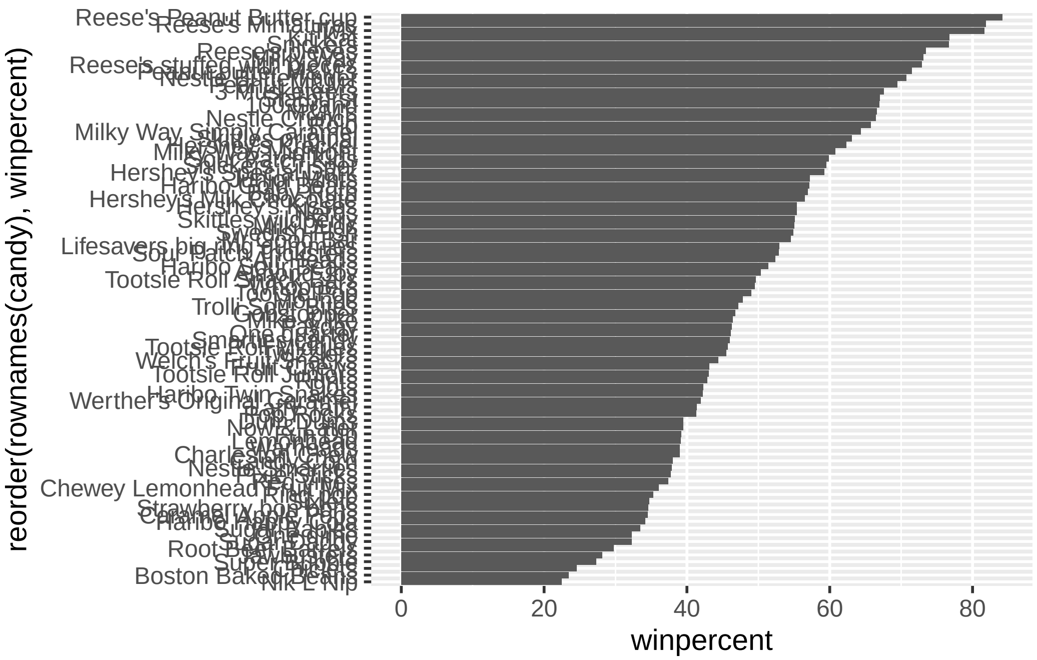
Q15. Make a first barplot of candy ranking based on `winpercent` values.

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



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

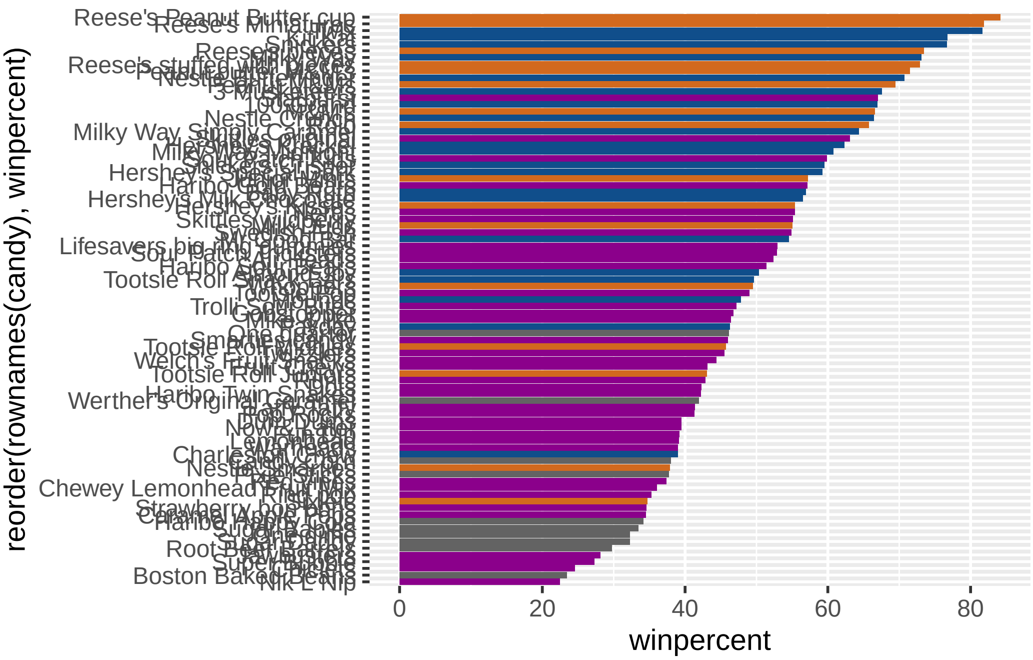
```r
ggplot(candy)+
  aes(winpercent,reorder(rownames(candy),winpercent))+
  geom_col()
```



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

```
my_cols=rep("grey39", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "chocolate"
my_cols[as.logical(candy$bar)] = "dodgerblue4"
my_cols[as.logical(candy$fruity)] = "darkmagenta"

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



```
ggsave("mybarplot.png", width=4,height=7.5)
```

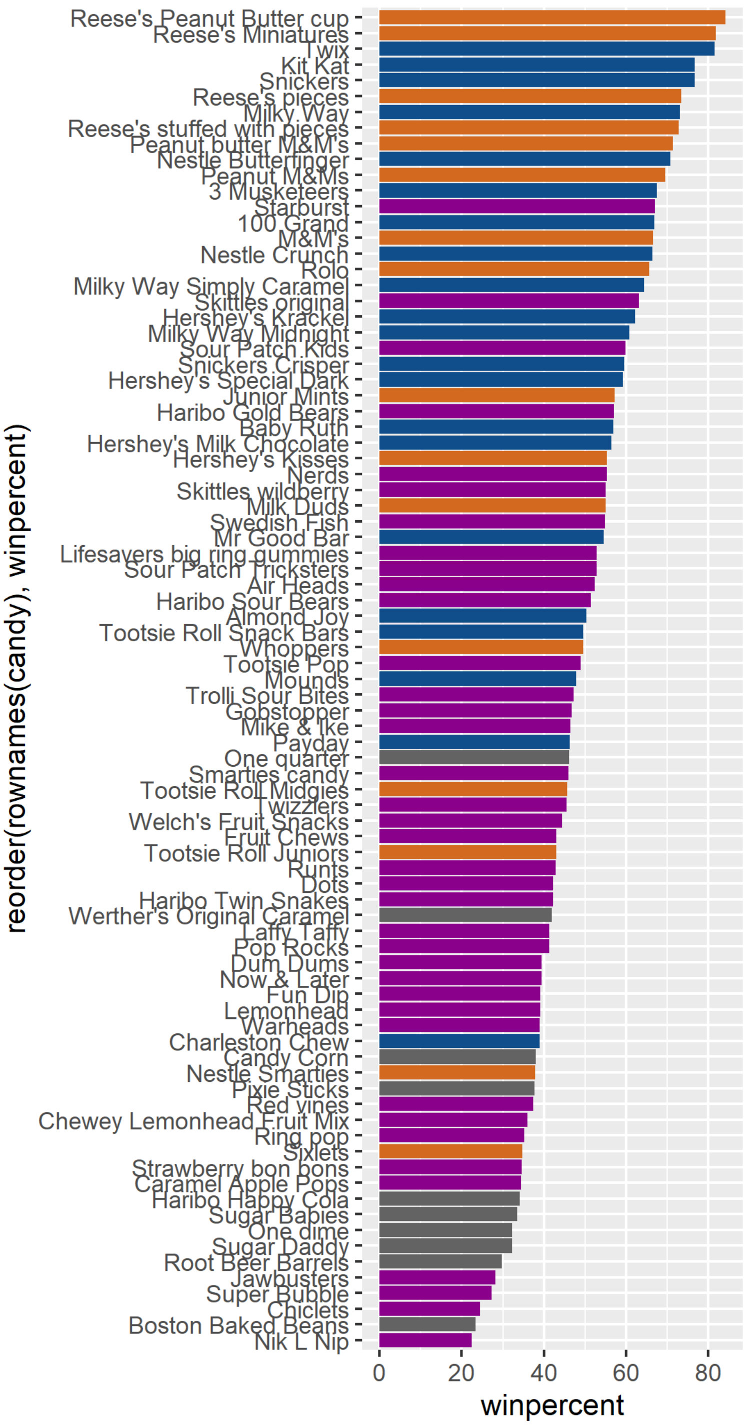


Figure 1: My silly barplot image

Q17. What is the worst ranked chocolate candy?

Sixlets.

Q18. What is the best ranked fruity candy?

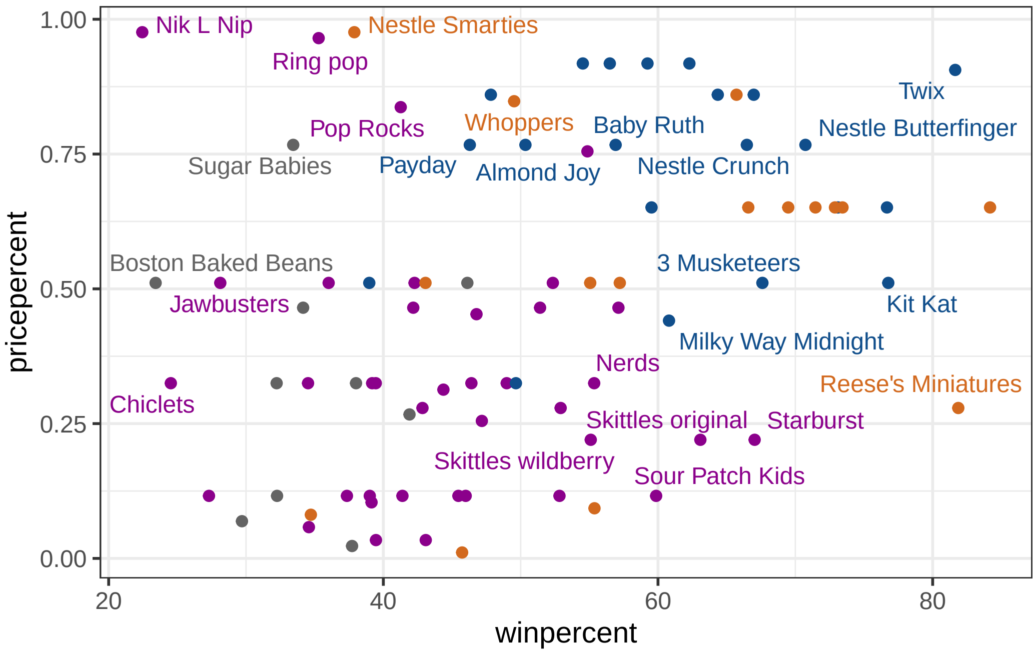
Starbust.

4. Winpercent vs Pricepercent

```
library(ggrepel)

# How about a plot of price vs win
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols, size=3.3, max.overlaps = 6)+
  theme_bw()
```

```
Warning: ggrepel: 61 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?

```r
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
```

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

```r
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
```

5. Correlation Structure

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

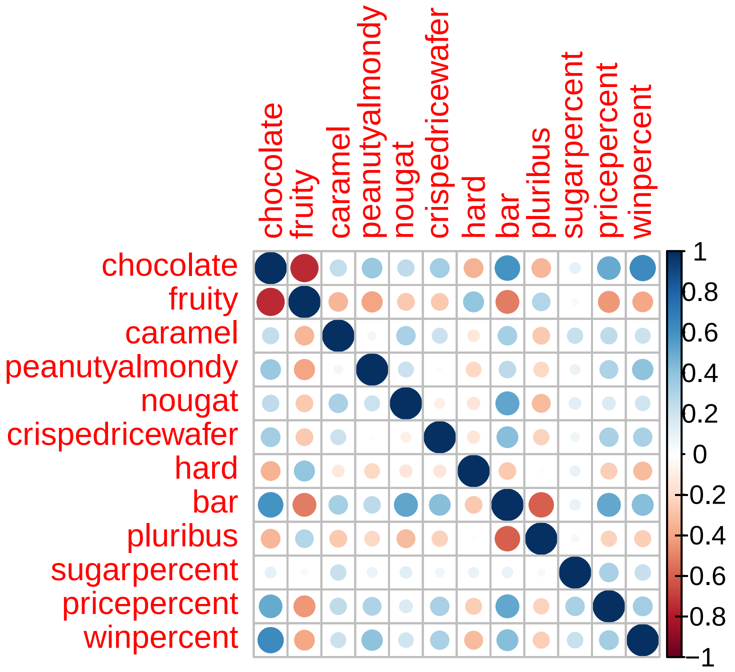
```
                  chocolate      fruity     caramel peanutyalmondy      nougat
chocolate         1.0000000 -0.74172106  0.24987535     0.37782357  0.25489183
fruity           -0.7417211  1.00000000 -0.33548538    -0.39928014 -0.26936712
caramel           0.2498753 -0.33548538  1.00000000     0.05935614  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 fruit are negatively correlated.

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

```
[1] -0.74
```

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

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

```
[1] 0.6
```

Principal 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 others in the dataset.

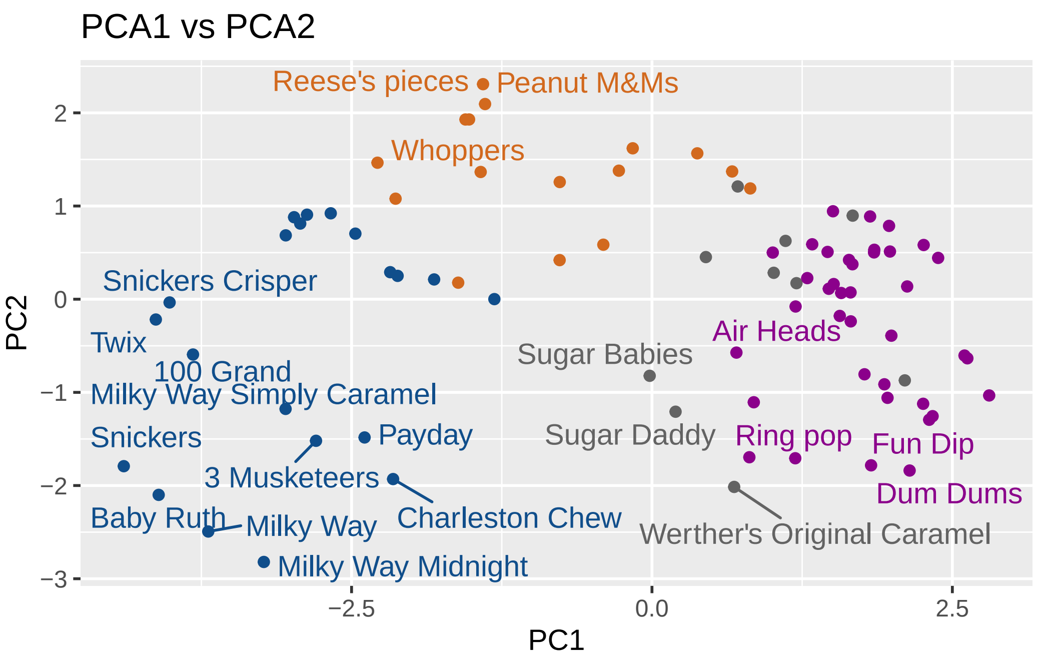
```r
pca <-prcomp(candy,scale=T)
summary(pca)
```

```
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
```

First main result figure is my “PCA plot”

```r
ggplot(pca$x) +
  aes(PC1, PC2,label=rownames(pca$x))+
  geom_point(col=my_cols)+
  geom_text_repel(max.overlaps = 7,col=my_cols)+
  labs(title = "PCA1 vs PCA2")
```

```
Warning: ggrepel: 64 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



```
theme_bw()
```

```
List of 136
 $ line                            :List of 6
  ..$ colour       : chr "black"
  ..$ linewidth    : num 0.5
  ..$ linetype     : num 1
  ..$ lineend      : chr "butt"
  ..$ arrow        : logi FALSE
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_line" "element"
 $ rect                            :List of 5
  ..$ fill         : chr "white"
  ..$ colour       : chr "black"
  ..$ linewidth    : num 0.5
  ..$ linetype     : num 1
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_rect" "element"
 $ text                            :List of 11
  ..$ family       : chr ""
  ..$ face         : chr "plain"
  ..$ colour       : chr "black"
  ..$ size         : num 11
  ..$ hjust        : num 0.5
  ..$ vjust        : num 0.5
  ..$ angle        : num 0
  ..$ lineheight   : num 0.9
  ..$ margin       : 'margin' num [1:4] 0points 0points 0points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : logi FALSE
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ title                           : NULL
 $ aspect.ratio                    : NULL
 $ axis.title                      : NULL
 $ axis.title.x                    :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 1
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 2.75points 0points 0points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.title.x.top                :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 0
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 0points 2.75points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.title.x.bottom             : NULL
 $ axis.title.y                    :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 1
  ..$ angle        : num 90
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 2.75points 0points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.title.y.left               : NULL
 $ axis.title.y.right              :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 1
  ..$ angle        : num -90
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 0points 0points 2.75points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text                       :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : chr "grey30"
  ..$ size         : 'rel' num 0.8
  ..$ hjust        : NULL
  ..$ vjust        : NULL
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : NULL
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text.x                     :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 1
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 2.2points 0points 0points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text.x.top                 :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : NULL
  ..$ vjust        : num 0
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 0points 2.2points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text.x.bottom              : NULL
 $ axis.text.y                     :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : num 1
  ..$ vjust        : NULL
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 2.2points 0points 0points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text.y.left                : NULL
 $ axis.text.y.right               :List of 11
```

```
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : num 0
  ..$ vjust        : NULL
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 0points 0points 2.2points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.text.theta                : NULL
 $ axis.text.r                    :List of 11
  ..$ family       : NULL
  ..$ face         : NULL
  ..$ colour       : NULL
  ..$ size         : NULL
  ..$ hjust        : num 0.5
  ..$ vjust        : NULL
  ..$ angle        : NULL
  ..$ lineheight   : NULL
  ..$ margin       : 'margin' num [1:4] 0points 2.2points 0points 2.2points
  .. ..- attr(*, "unit")= int 8
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ axis.ticks                     :List of 6
  ..$ colour       : chr "grey20"
  ..$ linewidth    : NULL
  ..$ linetype     : NULL
  ..$ lineend      : NULL
  ..$ arrow        : logi FALSE
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_line" "element"
 $ axis.ticks.x                   : NULL
 $ axis.ticks.x.top               : NULL
 $ axis.ticks.x.bottom            : NULL
 $ axis.ticks.y                   : NULL
 $ axis.ticks.y.left              : NULL
 $ axis.ticks.y.right             : NULL
 $ axis.ticks.theta               : NULL
```

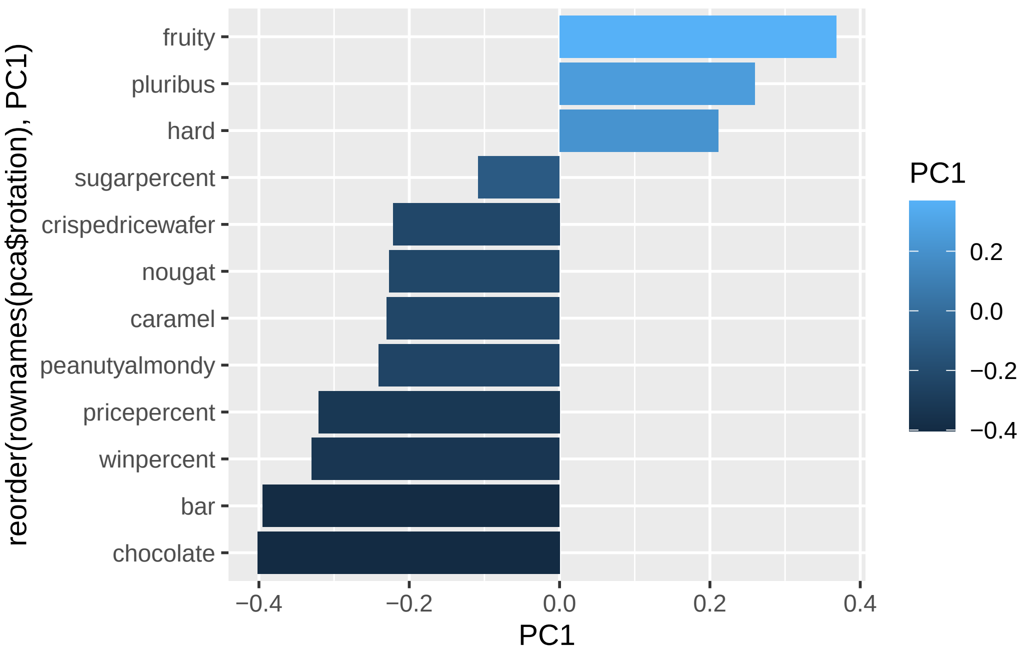
```
$ axis.ticks.r                    : NULL
$ axis.minor.ticks.x.top          : NULL
$ axis.minor.ticks.x.bottom       : NULL
$ axis.minor.ticks.y.left         : NULL
$ axis.minor.ticks.y.right        : NULL
$ axis.minor.ticks.theta          : NULL
$ axis.minor.ticks.r              : NULL
$ axis.ticks.length               : 'simpleUnit' num 2.75points
 ..- attr(*, "unit")= int 8
$ axis.ticks.length.x             : NULL
$ axis.ticks.length.x.top         : NULL
$ axis.ticks.length.x.bottom      : NULL
$ axis.ticks.length.y             : NULL
$ axis.ticks.length.y.left        : NULL
$ axis.ticks.length.y.right       : NULL
$ axis.ticks.length.theta         : NULL
$ axis.ticks.length.r             : NULL
$ axis.minor.ticks.length         : 'rel' num 0.75
$ axis.minor.ticks.length.x       : NULL
$ axis.minor.ticks.length.x.top   : NULL
$ axis.minor.ticks.length.x.bottom: NULL
$ axis.minor.ticks.length.y       : NULL
$ axis.minor.ticks.length.y.left  : NULL
$ axis.minor.ticks.length.y.right : NULL
$ axis.minor.ticks.length.theta   : NULL
$ axis.minor.ticks.length.r       : NULL
$ axis.line                       : list()
 ..- attr(*, "class")= chr [1:2] "element_blank" "element"
$ axis.line.x                     : NULL
$ axis.line.x.top                 : NULL
$ axis.line.x.bottom              : NULL
$ axis.line.y                     : NULL
$ axis.line.y.left                : NULL
$ axis.line.y.right               : NULL
$ axis.line.theta                 : NULL
$ axis.line.r                     : NULL
$ legend.background               :List of 5
 ..$ fill         : NULL
 ..$ colour       : logi NA
 ..$ linewidth    : NULL
 ..$ linetype     : NULL
 ..$ inherit.blank: logi TRUE
 ..- attr(*, "class")= chr [1:2] "element_rect" "element"
```

```
$ legend.margin                   : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5poi
 ..- attr(*, "unit")= int 8
$ legend.spacing                  : 'simpleUnit' num 11points
 ..- attr(*, "unit")= int 8
$ legend.spacing.x                : NULL
$ legend.spacing.y                : NULL
$ legend.key                      : NULL
$ legend.key.size                 : 'simpleUnit' num 1.2lines
 ..- attr(*, "unit")= int 3
$ legend.key.height               : NULL
$ legend.key.width                : NULL
$ legend.key.spacing              : 'simpleUnit' num 5.5points
 ..- attr(*, "unit")= int 8
$ legend.key.spacing.x            : NULL
$ legend.key.spacing.y            : NULL
$ legend.frame                    : NULL
$ legend.ticks                    : NULL
$ legend.ticks.length             : 'rel' num 0.2
$ legend.axis.line                : NULL
$ legend.text                     :List of 11
 ..$ family       : NULL
 ..$ face         : NULL
 ..$ colour       : NULL
 ..$ size         : 'rel' num 0.8
 ..$ hjust        : NULL
 ..$ vjust        : NULL
 ..$ angle        : NULL
 ..$ lineheight   : NULL
 ..$ margin       : NULL
 ..$ debug        : NULL
 ..$ inherit.blank: logi TRUE
 ..- attr(*, "class")= chr [1:2] "element_text" "element"
$ legend.text.position            : NULL
$ legend.title                    :List of 11
 ..$ family       : NULL
 ..$ face         : NULL
 ..$ colour       : NULL
 ..$ size         : NULL
 ..$ hjust        : num 0
 ..$ vjust        : NULL
 ..$ angle        : NULL
 ..$ lineheight   : NULL
 ..$ margin       : NULL
```

```
  ..$ debug        : NULL
  ..$ inherit.blank: logi TRUE
  ..- attr(*, "class")= chr [1:2] "element_text" "element"
 $ legend.title.position           : NULL
 $ legend.position                 : chr "right"
 $ legend.position.inside          : NULL
 $ legend.direction                : NULL
 $ legend.byrow                    : NULL
 $ legend.justification            : chr "center"
 $ legend.justification.top        : NULL
 $ legend.justification.bottom     : NULL
 $ legend.justification.left       : NULL
 $ legend.justification.right      : NULL
 $ legend.justification.inside     : NULL
 $ legend.location                 : NULL
 $ legend.box                      : NULL
 $ legend.box.just                 : NULL
 $ legend.box.margin               : 'margin' num [1:4] 0cm 0cm 0cm 0cm
  ..- attr(*, "unit")= int 1
 $ legend.box.background           : list()
  ..- attr(*, "class")= chr [1:2] "element_blank" "element"
 $ legend.box.spacing              : 'simpleUnit' num 11points
  ..- attr(*, "unit")= int 8
  [list output truncated]
 - attr(*, "class")= chr [1:2] "theme" "gg"
 - attr(*, "complete")= logi TRUE
 - attr(*, "validate")= logi TRUE
```

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

```
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?

> Fruity and pluribus are picked up strongly by PC1 in the positive direction. This does make sense as people