halloween

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##1. Importing candy data

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

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
```

There are 85 different types.

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

```
sum(candy$fruity==1)
```

```
[1] 38
```

There are 38 fruity candy types in the dataset.

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

```
flextable::flextable(head(candy))
```

chocolate	fruity	caramel	peanutyalmondy	nougat	crispedricewafer	hard	bar	pluribus	s
1	0	1	0	0	1	0	1	0	
1	0	0	0	1	0	0	1	0	
0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	0	
1	0	0	1	0	0	0	1	0	

##2. What is your favorate candy?

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

```
[1] 81.64291
```

```
candy["Reese's Peanut Butter cup", ]$winpercent
```

```
[1] 84.18029
```

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

Reese's peanut butter cup; 84.18 percent.

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

```
[1] 76.7686
```

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

76.77%

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

```
[1] 49.6535
```

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

49.65%

Side-note: the skimr::skim() function

There is a useful skim() function in the skimr package that can help give you a quick overview of a given dataset. Let's install this package and try it on our candy data.

```
library("skimr")
skim(candy)
```

Table 2: Data summary

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

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
chocolate	0	1	0.44	0.50	0.00	0.00	0.00	1.00	1.00	
fruity	0	1	0.45	0.50	0.00	0.00	0.00	1.00	1.00	
caramel	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
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	

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
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?

Win percent, since the other percentages are not multiplied by 100 but rather still in decimal form

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

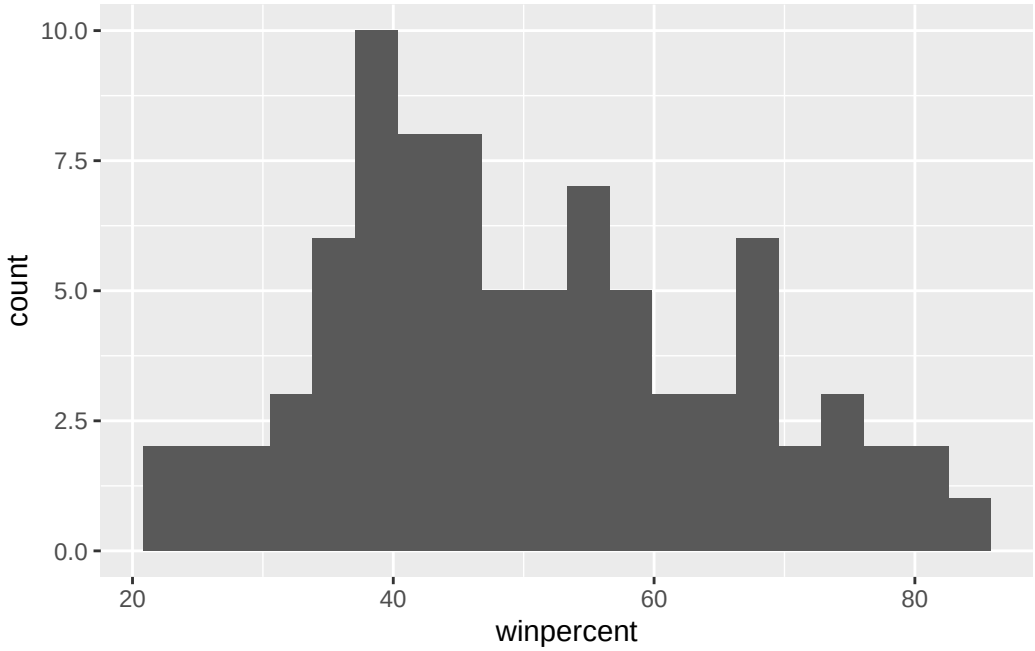
1 means the candy is chocolate, and 0 means the candy is not chocolate.

Hint: look at the "Variable type" print out from the skim() function. Most varables (i.e. columns) are on the zero to one scale but not all. Some columns such as chocolate are exclusively either zero or one values.

A good place to start any exploratory analysis is with a histogram. You can do this most easily with the base R function hist(). Alternatively, you can use ggplot() with geom_hist(). Either works well in this case and (as always) its your choice.

Q8. Plot a histogram of winpercent values

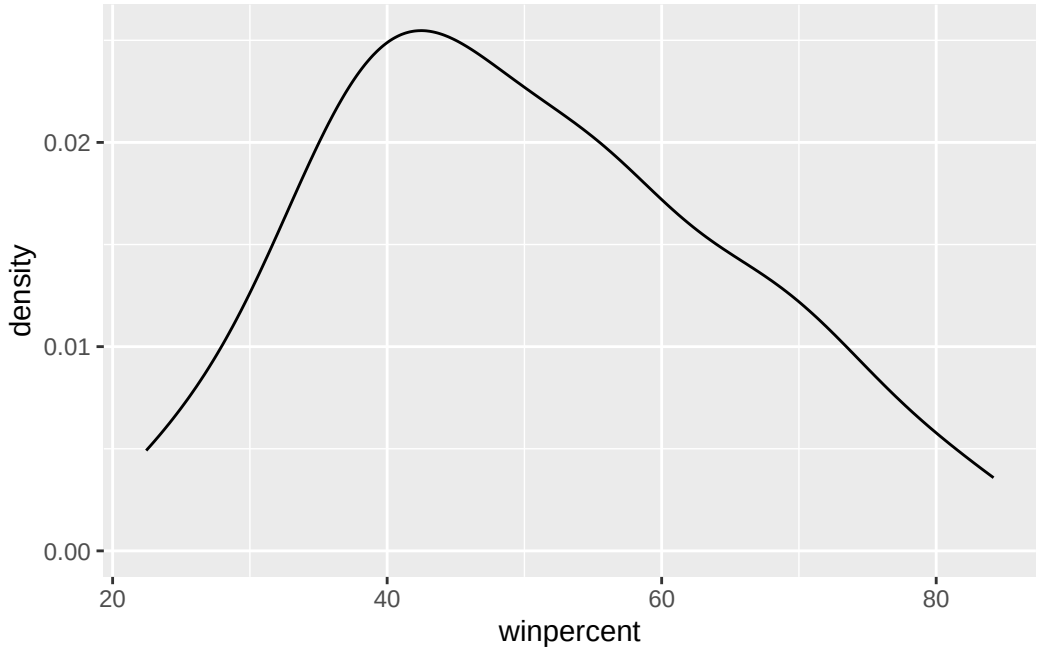
```
library(ggplot2)
ggplot(candy) +
  aes(winpercent) +
  geom_histogram(bins = 20)
```



Q9. Is the distribution of winpercent values symmetrical?

The distribution is not symmetrical.

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



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

```
mean(candy$winpercent)
```

```
[1] 50.31676
```

The center of the distribution is above 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?

```
mean_chocolate <- mean(candy$winpercent[candy$chocolate == 1])
mean_fruity <- mean(candy$winpercent[candy$fruity==1])
mean_chocolate>mean_fruity
```

```
[1] TRUE
```

On average, chocolate candy is higher ranked than fruit candy, since its average win percent is 60.9% versus fruity candy's win percent of 44.1%.

```
#1 Find all chocolate candy in the dataset
choc.inds <- candy$chocolate==1
choc.candy <- candy[choc.inds,]
#2 Extract their winpercent values
choc.win <- choc.candy$winpercent
#3 Find the mean of the values
choc.mean <- mean(choc.win)
#4-6 Do the same for fruity candy
fruity.inds <- candy$fruity==1
fruity.candy <- candy[fruity.inds,]
fruity.win <- fruity.candy$winpercent
fruity.mean <- mean(fruity.win)
#7 Which mean value is higher?
choc.mean>fruity.mean
```

```
[1] TRUE
```

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
```

Yes it is.

Hint: The chocolate, fruity, nougat etc. columns indicate if a given candy has this feature (i.e. one if it has nougart, zero if it does not etc.). We can turn these into logical (a.k.a. TRUE/FALSE) values with the as.logical() function. We can then use this logical vector to access the coresponding candy rows (those with TRUE values). For

example to get the winpercent values for all nougat contaning candy we can use the code: candy$winpercent[as.logical(candy$nougat)]. In addation the functions mean() and t.test() should help you answer the last two questions here.

##3. Overall Candy Rankings Let's use the base R order() function together with head() to sort the whole dataset by winpercent. Or if you have been getting into the tidyverse and the dplyr package you can use the arrange() function together with head() to do the same thing and answer the following questions:

```
x <- c(10,2,51)
order(x)
```

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

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

	chocolate	fruity	caramel	peanutyalmondy	nougat	crispedricewafer	hard	bar	pluribus	sugarpercent	pricepercent	winpercent
Nik L Nip	0	1	0	0	0	0	0	0	1	0.197	0.976	22.44534
Boston Baked Beans	0	0	0	1	0	0	0	0	1	0.313	0.511	23.41782
Chiclets	0	1	0	0	0	0	0	0	1	0.046	0.325	24.52499
Super Bubble	0	1	0	0	0	0	0	0	0	0.162	0.116	27.30386
Jawbusters	0	1	0	0	0	0	1	0	1	0.093	0.511	28.12744

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

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

```
tail(candy[ord.ind,], 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
```

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

Snickers, Kit Kat, Twix, Reese's Miniatures, Reese's Peanut Butter cup

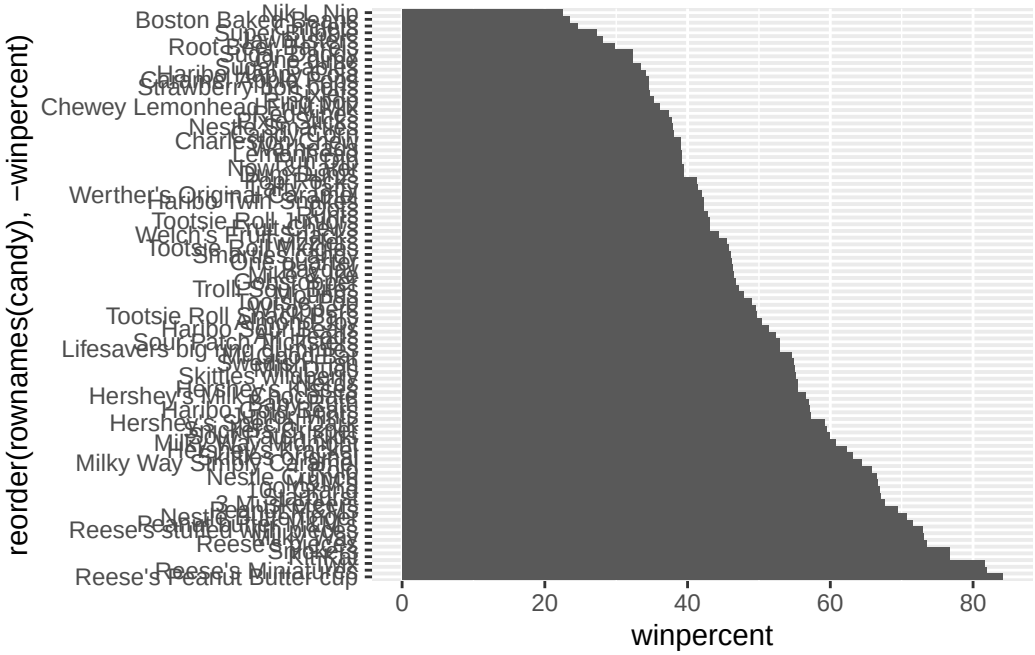
Hint: Using base R we could use head(candy[order(candy$winpercent),], n=5), whilst using dplyr we have: candy %>% arrange(winpercent) %>% head(5). Which apprach do you prefer and why?

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

HINT: Use the aes(winpercent, rownames(candy)) for your first ggplot like so:

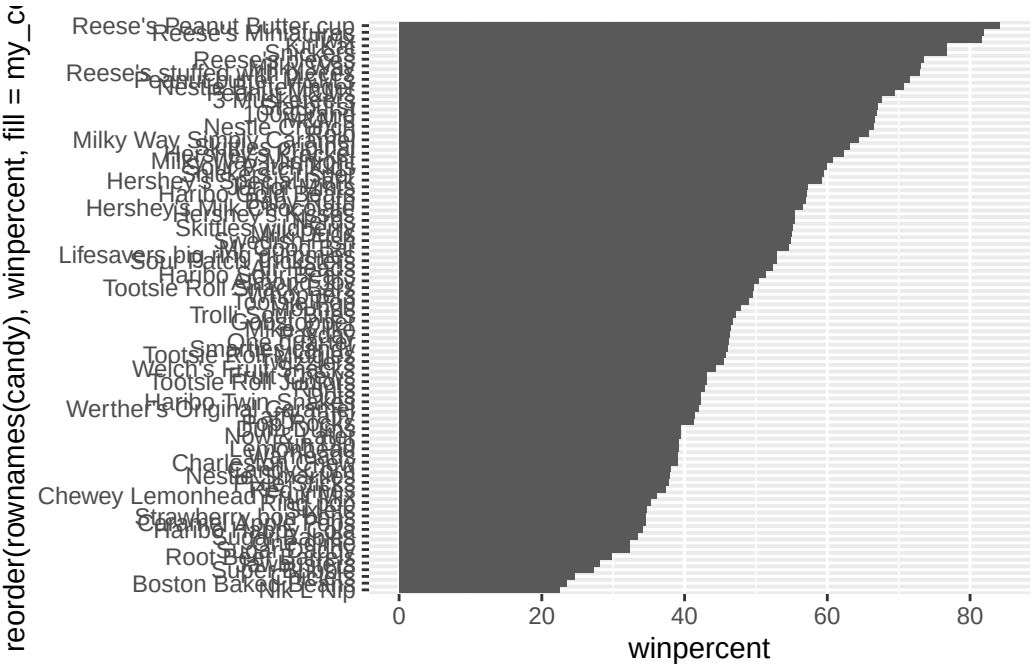
Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent? HINT: You can use aes(winpercent, reorder(rownames(candy),winpercent)) to improve your plot.

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




```
my_cols <- rep("black", nrow(candy))

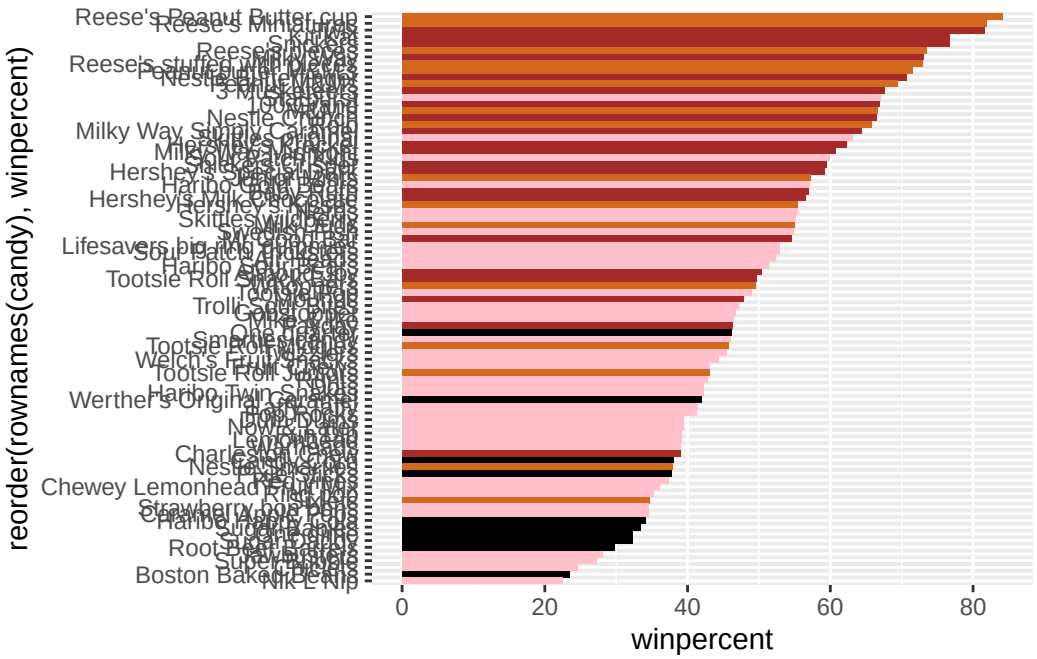
ggplot(candy) +
  aes(x=winpercent,
      y=reorder(rownames(candy), winpercent,
      fill=my_cols)) +
  geom_col()
```



Time to add some useful color Let's setup a color vector (that signifies candy type) that we can then use for some future plots. We start by making a vector of all black values (one for each candy). Then we overwrite chocolate (for chocolate candy), brown (for candy bars) and red (for fruity candy) values.

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

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



Now, for the first time, using this plot we can answer questions like: > Q17. What is the worst ranked chocolate candy?

Sixlets

Q18. What is the best ranked fruity candy?

Starburst

##4. Taking a look at pricepercent What about value for money? What is the the best candy for the least money? One way to get at this would be to make a plot of winpercent vs the pricepercent variable. The pricepercent variable records the percentile rank of the candy's price against all the other candies in the dataset. Lower vales are less expensive and high values more expensive.

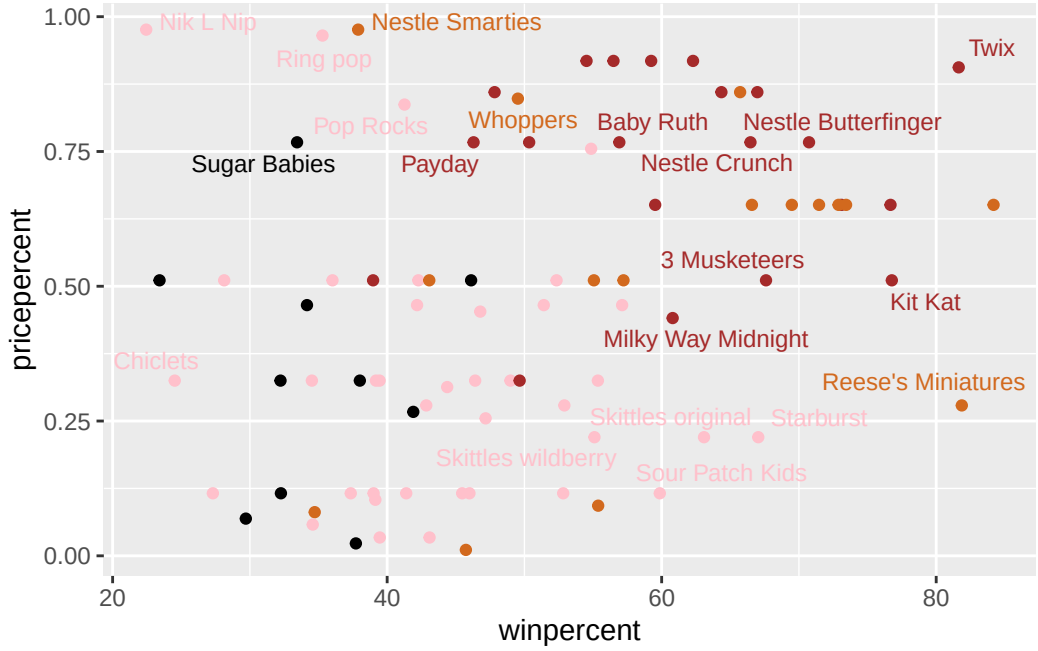
To this plot we will add text labels so we can more easily identify a given candy. There is a regular geom_label() that comes with ggplot2. However, as there are quite a few candys in our dataset lots of these labels will be overlapping and hard to read. To help with this we can use the geom_text_repel() function from the ggrepel package.

```
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 = 5)
```

```
Warning: ggrepel: 65 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?

```
ord1 <- order(candy$winpercent, decreasing = TRUE)
head( candy[ord1,c(11,12)], n=5 )
```

```
                         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
```

The candy that is the highest ranked in terms of winpercent for the least money is 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 most expensive candy types are Nik L Nip, Nestle Smarties, Ring pop, Hershey's Krackel, Hersey's Milk Chocolates. Of these, the least popular is Nik L Nip.

Hint: To see which candy is the most expensive (and which is the least expensive) we can order() the dataset by pricepercent.

```
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
```

Q21 is optional

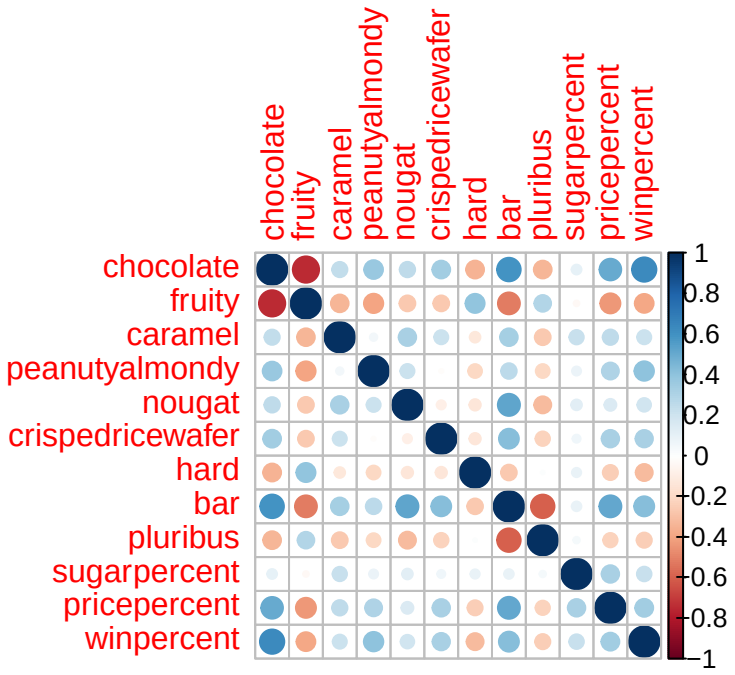
##5. Exploring the correlation structure Now that we've explored the dataset a little, we'll see how the variables interact with one another. We'll use correlation and view the results with the corrplot package to plot a correlation matrix.

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

```
library(corrplot)
```

```
corrplot 0.95 loaded
```

```
corrplot(cij)
```



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

Chocolate and fruity

Q23. Similarly, what two variables are most positively correlated? HINT: Do you like chocolaty fruity candies?

Chocolate and win percent

##6. Principal Component Analysis

The main function in base R for this is `prcomp()` and we want to set `scale=TRUE` here.

```
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
```

Let's look at our first main result figure: the PCA plot of PC1 vs PC2.

```
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

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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

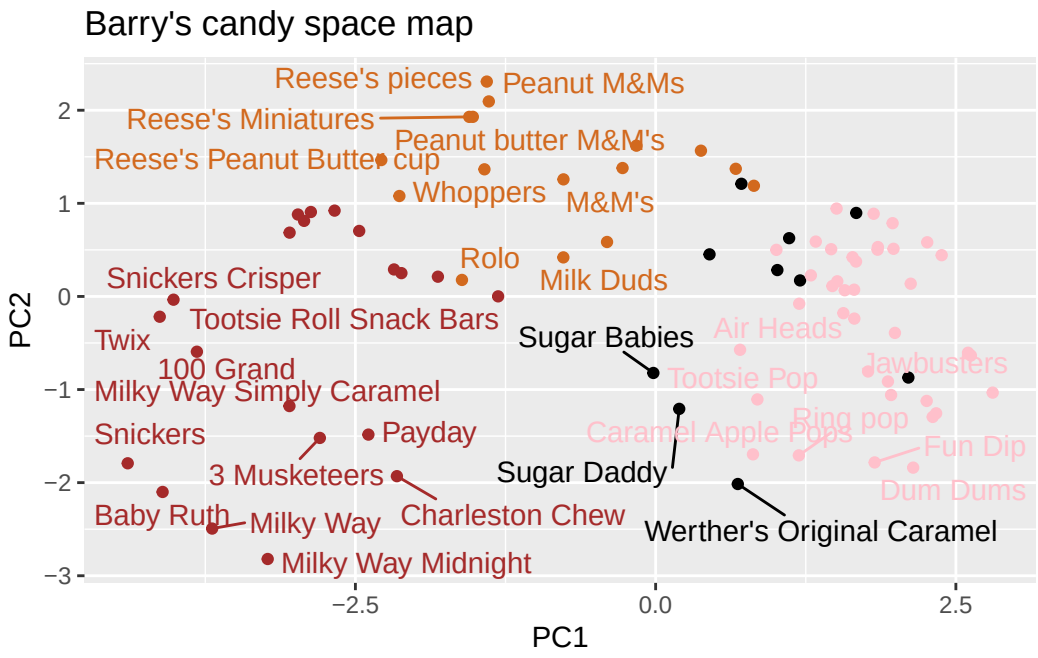
```
Tootsie Roll Snack Bars     -1.078720446 -0.723988086  1.173413519
Trolli Sour Bites            0.215399333  0.265589321  0.205354764
Twix                         0.390371217  0.606070076 -0.048120393
Twizzlers                   -0.729052624 -0.258947465 -0.227333151
Warheads                     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=my_cols) +
  geom_text_repel(col=my_cols) +
  labs(title = "Barry's candy space map")
```

```
Warning: ggrepel: 54 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```

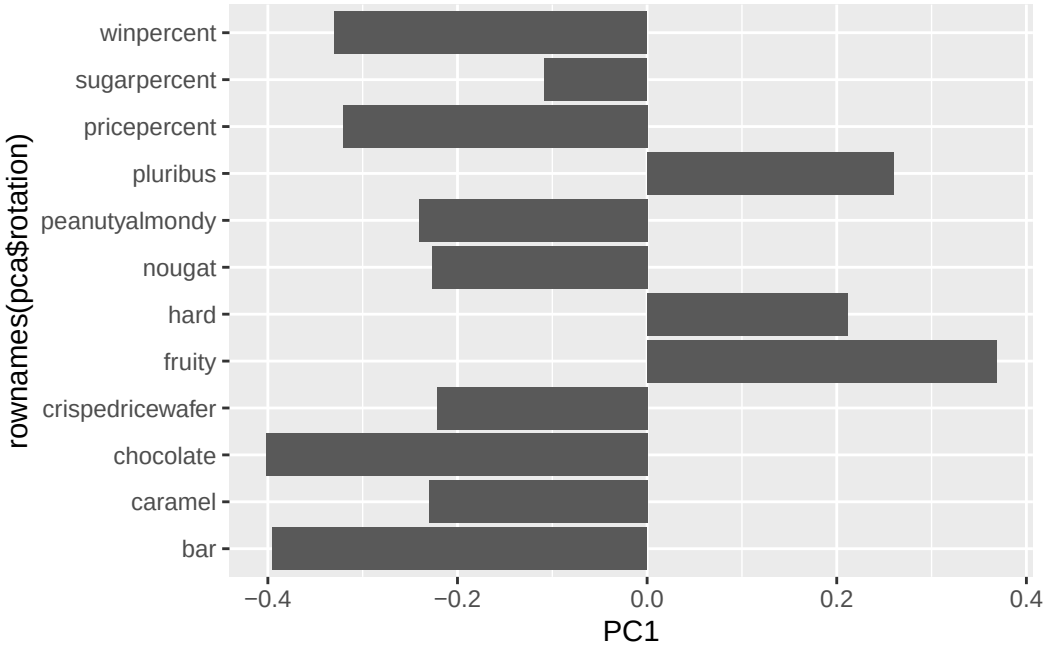


Don't forget about your variable "loadings" - how the original variables contribute to your new PCs...

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



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

Pluribus, hard, and fruity. This makes sense because fruity candies like Starbusts are often hard and have multiple flavors.

HINT. pluribus means the candy comes in a bag or box of multiple candies.

Alternative way with dplyr for the first few questions:

```
library(dplyr)
candy|> nrow()
```

```
[1] 85
```

```
round(mean(candy$winpercent), 4)
```

```
[1] 50.3168
```

```
candy |> select(winpercent)
```

	winpercent
100 Grand	66.97173
3 Musketeers	67.60294
One dime	32.26109
One quarter	46.11650
Air Heads	52.34146
Almond Joy	50.34755
Baby Ruth	56.91455
Boston Baked Beans	23.41782
Candy Corn	38.01096
Caramel Apple Pops	34.51768
Charleston Chew	38.97504
Chewey Lemonhead Fruit Mix	36.01763
Chiclets	24.52499
Dots	42.27208
Dum Dums	39.46056
Fruit Chews	43.08892
Fun Dip	39.18550
Gobstopper	46.78335
Haribo Gold Bears	57.11974
Haribo Happy Cola	34.15896
Haribo Sour Bears	51.41243
Haribo Twin Snakes	42.17877
Hershey's Kisses	55.37545
Hershey's Krackel	62.28448
Hershey's Milk Chocolate	56.49050
Hershey's Special Dark	59.23612
Jawbusters	28.12744
Junior Mints	57.21925
Kit Kat	76.76860
Laffy Taffy	41.38956
Lemonhead	39.14106
Lifesavers big ring gummies	52.91139
Peanut butter M&M's	71.46505
M&M's	66.57458
Mike & Ike	46.41172
Milk Duds	55.06407
Milky Way	73.09956
Milky Way Midnight	60.80070
Milky Way Simply Caramel	64.35334

Mounds	47.82975
Mr Good Bar	54.52645
Nerds	55.35405
Nestle Butterfinger	70.73564
Nestle Crunch	66.47068
Nik L Nip	22.44534
Now & Later	39.44680
Payday	46.29660
Peanut M&Ms	69.48379
Pixie Sticks	37.72234
Pop Rocks	41.26551
Red vines	37.34852
Reese's Miniatures	81.86626
Reese's Peanut Butter cup	84.18029
Reese's pieces	73.43499
Reese's stuffed with pieces	72.88790
Ring pop	35.29076
Rolo	65.71629
Root Beer Barrels	29.70369
Runts	42.84914
Sixlets	34.72200
Skittles original	63.08514
Skittles wildberry	55.10370
Nestle Smarties	37.88719
Smarties candy	45.99583
Snickers	76.67378
Snickers Crisper	59.52925
Sour Patch Kids	59.86400
Sour Patch Tricksters	52.82595
Starburst	67.03763
Strawberry bon bons	34.57899
Sugar Babies	33.43755
Sugar Daddy	32.23100
Super Bubble	27.30386
Swedish Fish	54.86111
Tootsie Pop	48.98265
Tootsie Roll Juniors	43.06890
Tootsie Roll Midgies	45.73675
Tootsie Roll Snack Bars	49.65350
Trolli Sour Bites	47.17323
Twix	81.64291
Twizzlers	45.46628
Warheads	39.01190

```
Welch's Fruit Snacks          44.37552
Werther's Original Caramel    41.90431
Whoppers                      49.52411
```

```
win <- candy$winpercent
win.mean <- mean(win)
round(win.mean)
```

```
[1] 50
```

```
candy %>% select(winpercent)
```

```
                           winpercent
100 Grand                    66.97173
3 Musketeers                 67.60294
One dime                     32.26109
One quarter                  46.11650
Air Heads                    52.34146
Almond Joy                   50.34755
Baby Ruth                    56.91455
Boston Baked Beans           23.41782
Candy Corn                   38.01096
Caramel Apple Pops           34.51768
Charleston Chew              38.97504
Chewey Lemonhead Fruit Mix   36.01763
Chiclets                     24.52499
Dots                         42.27208
Dum Dums                     39.46056
Fruit Chews                  43.08892
Fun Dip                      39.18550
Gobstopper                   46.78335
Haribo Gold Bears            57.11974
Haribo Happy Cola            34.15896
Haribo Sour Bears            51.41243
Haribo Twin Snakes           42.17877
Hershey's Kisses             55.37545
Hershey's Krackel            62.28448
Hershey's Milk Chocolate     56.49050
Hershey's Special Dark       59.23612
Jawbusters                   28.12744
Junior Mints                 57.21925
```

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Sugar Daddy	32.23100
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Twix	81.64291
Twizzlers	45.46628
Warheads	39.01190
Welch's Fruit Snacks	44.37552
Werther's Original Caramel	41.90431
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