# Week 3

## R Packages

The packages you will need to install for the week are **VIM**, **lessR**, **ggplot2**, **cluster**, **fpc**, **wbstats**, and **NbClust**.

## Cluster Analysis

In the previous two weeks, we have looked at two supervised learning methods: regression and decision tree. For Week 3, we are going to examine our first unsupervised learning method: clustering. Unsupervised learning is 'unsupervised' because we do not have a target (outcome variable).

Clustering is meant to be used for "knowledge discovery" instead of "prediction." The basis of clustering is what sociologists call "homophily"-or birds of the same feather flock together. The goal of clustering is to find groups, or clusters, in a data set. We want to partition our dataset so that observations within each group are similar to each other while observations in different groups are different from each other.

There are many clustering algorithms, which are based on many different approaches of grouping data points. We will examine the two most common approaches in this class: 1) partitioning and 2) hierarchical. The partitioning approach divides the dataset into multiple partitions. The hierarchical approach disaggregates the dataset into a tree structure (similar to decision trees). We will look at two partitioning methods: k-means and k-medoids. We will talk about k-means in class and briefly discuss k-medoids. One of the tasks for this week's homework assignment is for you to research the k-medoids methods.

## Learning Goal for the Week

What interesting things can we learn from online postings of 30,000 teenagers on a social media site? (Notice that we have no target/outcome variable. We am simply looking for interesting patterns.)

## The Dataset

We will use the Teen Market Segmentation dataset from Chapter 9 in the Lantz textbook. According to Lantz, the dataset is a random sample of 30,000 U.S. high school students who had profiles on a social networking service (SNS) in 2006. The full text of the SNS profiles were downloaded. Each teen's gender, age, and number of SNS friends were recorded. From the top 500 words that appeared across all SNS profiles, a smaller list of 36 words were chosen to represent five categories of interest: extracurricular activities, fashion, religion, romance, and antisocial behavior (Lantz 2013, p. 279).

## Getting Started

```
setwd("C:/Users/corylowe/OneDrive/Code/R Practice Code/Applied Data Mining_Portfolio/Week 3")

teens<-read.csv("snsdata.csv", header=TRUE, sep=",")

str(teens)
```

```
## 'data.frame':    30000 obs. of  40 variables:
##  $ gradyear    : int  2006 2006 2006 2006 2006 2006 2006 2006 2006 2006 ...
##  $ gender      : Factor w/ 2 levels "F","M": 2 1 2 1 NA 1 1 2 1 1 ...
##  $ age         : num  19 18.8 18.3 18.9 19 ...
##  $ friends     : int  7 0 69 0 10 142 72 17 52 39 ...
##  $ basketball  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ football    : int  0 1 1 0 0 0 0 0 0 0 ...
##  $ soccer      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ softball    : int  0 0 0 0 0 0 0 1 0 0 ...
##  $ volleyball  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ swimming    : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ cheerleading: int  0 0 0 0 0 0 0 0 0 0 ...
##  $ baseball    : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ tennis      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ sports      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ cute        : int  0 1 0 1 0 0 0 0 0 1 ...
##  $ sex         : int  0 0 0 0 1 1 0 2 0 0 ...
##  $ sexy        : int  0 0 0 0 0 0 0 1 0 0 ...
##  $ hot         : int  0 0 0 0 0 0 0 0 0 1 ...
##  $ kissed      : int  0 0 0 0 5 0 0 0 0 0 ...
##  $ dance       : int  1 0 0 0 1 0 0 0 0 0 ...
##  $ band        : int  0 0 2 0 1 0 1 0 0 0 ...
##  $ marching    : int  0 0 0 0 0 1 1 0 0 0 ...
##  $ music       : int  0 2 1 0 3 2 0 1 0 1 ...
##  $ rock        : int  0 2 0 1 0 0 0 1 0 1 ...
##  $ god         : int  0 1 0 0 1 0 0 0 0 6 ...
##  $ church      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ jesus       : int  0 0 0 0 0 0 0 0 0 2 ...
##  $ bible       : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hair        : int  0 6 0 0 1 0 0 0 0 1 ...
##  $ dress       : int  0 4 0 0 0 1 0 0 0 0 ...
##  $ blonde      : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ mall        : int  0 1 0 0 0 0 2 0 0 0 ...
##  $ shopping    : int  0 0 0 0 2 1 0 0 0 1 ...
##  $ clothes     : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ hollister   : int  0 0 0 0 0 0 2 0 0 0 ...
##  $ abercrombie : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ die         : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ death       : int  0 0 1 0 0 0 0 0 0 0 ...
##  $ drunk       : int  0 0 0 0 1 1 0 0 0 0 ...
##  $ drugs       : int  0 0 0 0 1 0 0 0 0 0 ...
```

## Exploratory Data Analysis

```
summary(teens)
```

```
##     gradyear     gender           age            friends
##  Min.   :2006   F   :22054   Min.   :  3.086   Min.   :  0.00
##  1st Qu.:2007   M   : 5222   1st Qu.: 16.312   1st Qu.:  3.00
##  Median :2008   NA's: 2724   Median : 17.287   Median : 20.00
##  Mean   :2008                Mean   : 17.994   Mean   : 30.18
```

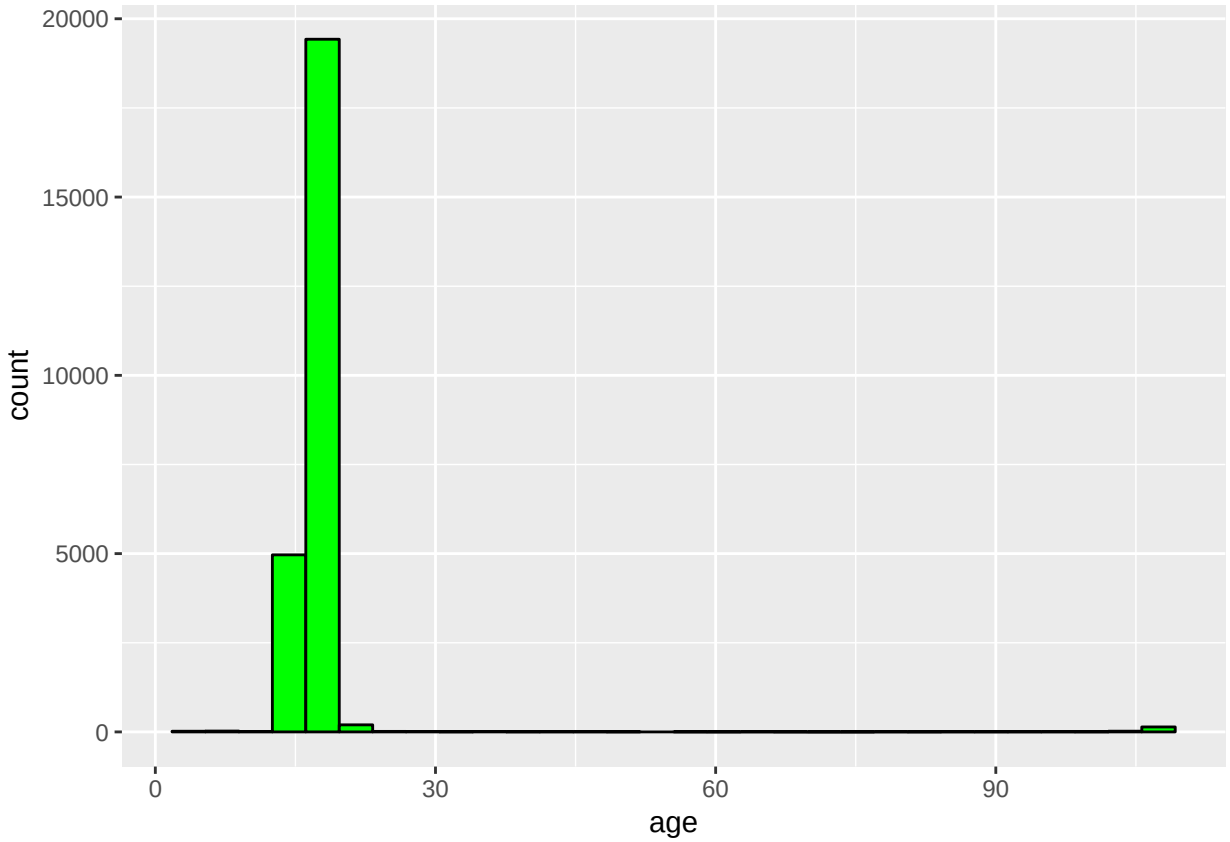
```
##  3rd Qu.:2008                3rd Qu.: 18.259   3rd Qu.: 44.00
##  Max.   :2009                Max.   :106.927   Max.   :830.00
##                              NA's   :5086
##    basketball         football           soccer           softball
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000
##  Median : 0.0000   Median : 0.0000   Median : 0.0000   Median : 0.0000
##  Mean   : 0.2673   Mean   : 0.2523   Mean   : 0.2228   Mean   : 0.1612
##  3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000
##  Max.   :24.0000   Max.   :15.0000   Max.   :27.0000   Max.   :17.0000
##
##    volleyball         swimming        cheerleading       baseball
##  Min.   : 0.0000   Min.   : 0.0000   Min.   :0.0000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.:0.0000   1st Qu.: 0.0000
##  Median : 0.0000   Median : 0.0000   Median :0.0000   Median : 0.0000
##  Mean   : 0.1431   Mean   : 0.1344   Mean   :0.1066   Mean   : 0.1049
##  3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.:0.0000   3rd Qu.: 0.0000
##  Max.   :14.0000   Max.   :31.0000   Max.   :9.0000   Max.   :16.0000
##
##      tennis             sports           cute              sex
##  Min.   : 0.00000   Min.   : 0.00   Min.   : 0.0000   Min.   :  0.0000
##  1st Qu.: 0.00000   1st Qu.: 0.00   1st Qu.: 0.0000   1st Qu.:  0.0000
##  Median : 0.00000   Median : 0.00   Median : 0.0000   Median :  0.0000
##  Mean   : 0.08733   Mean   : 0.14   Mean   : 0.3229   Mean   :  0.2094
##  3rd Qu.: 0.00000   3rd Qu.: 0.00   3rd Qu.: 0.0000   3rd Qu.:  0.0000
##  Max.   :15.00000   Max.   :12.00   Max.   :18.0000   Max.   :114.0000
##
##       sexy              hot              kissed            dance
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000
##  Median : 0.0000   Median : 0.0000   Median : 0.0000   Median : 0.0000
##  Mean   : 0.1412   Mean   : 0.1266   Mean   : 0.1032   Mean   : 0.4252
##  3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000
##  Max.   :18.0000   Max.   :10.0000   Max.   :26.0000   Max.   :30.0000
##
##       band            marching           music              rock
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000
##  Median : 0.0000   Median : 0.0000   Median : 0.0000   Median : 0.0000
##  Mean   : 0.2996   Mean   : 0.0406   Mean   : 0.7378   Mean   : 0.2433
##  3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 1.0000   3rd Qu.: 0.0000
##  Max.   :66.0000   Max.   :11.0000   Max.   :64.0000   Max.   :21.0000
##
##       god              church            jesus             bible
##  Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.00000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.: 0.00000
##  Median : 0.0000   Median : 0.0000   Median : 0.0000   Median : 0.00000
##  Mean   : 0.4653   Mean   : 0.2482   Mean   : 0.1121   Mean   : 0.02133
##  3rd Qu.: 1.0000   3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.: 0.00000
##  Max.   :79.0000   Max.   :44.0000   Max.   :30.0000   Max.   :11.00000
##
##       hair             dress            blonde             mall
##  Min.   : 0.0000   Min.   :0.000   Min.   :  0.0000   Min.   : 0.0000
##  1st Qu.: 0.0000   1st Qu.:0.000   1st Qu.:  0.0000   1st Qu.: 0.0000
```

```
##  Median : 0.0000   Median :0.000   Median :  0.0000   Median : 0.0000
##  Mean   : 0.4226   Mean   :0.111   Mean   :  0.0989   Mean   : 0.2574
##  3rd Qu.: 0.0000   3rd Qu.:0.000   3rd Qu.:  0.0000   3rd Qu.: 0.0000
##  Max.   :37.0000   Max.   :9.000   Max.   :327.0000   Max.   :12.0000
##
##     shopping         clothes         hollister        abercrombie
##  Min.   : 0.000   Min.   :0.0000   Min.   :0.00000   Min.   :0.00000
##  1st Qu.: 0.000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.00000
##  Median : 0.000   Median :0.0000   Median :0.00000   Median :0.00000
##  Mean   : 0.353   Mean   :0.1485   Mean   :0.06987   Mean   :0.05117
##  3rd Qu.: 1.000   3rd Qu.:0.0000   3rd Qu.:0.00000   3rd Qu.:0.00000
##  Max.   :11.000   Max.   :8.0000   Max.   :9.00000   Max.   :8.00000
##
##       die              death             drunk             drugs
##  Min.   : 0.0000   Min.   : 0.0000   Min.   :0.00000   Min.   : 0.00000
##  1st Qu.: 0.0000   1st Qu.: 0.0000   1st Qu.:0.00000   1st Qu.: 0.00000
##  Median : 0.0000   Median : 0.0000   Median :0.00000   Median : 0.00000
##  Mean   : 0.1841   Mean   : 0.1142   Mean   :0.08797   Mean   : 0.06043
##  3rd Qu.: 0.0000   3rd Qu.: 0.0000   3rd Qu.:0.00000   3rd Qu.: 0.00000
##  Max.   :22.0000   Max.   :14.0000   Max.   :8.00000   Max.   :16.00000
##
```

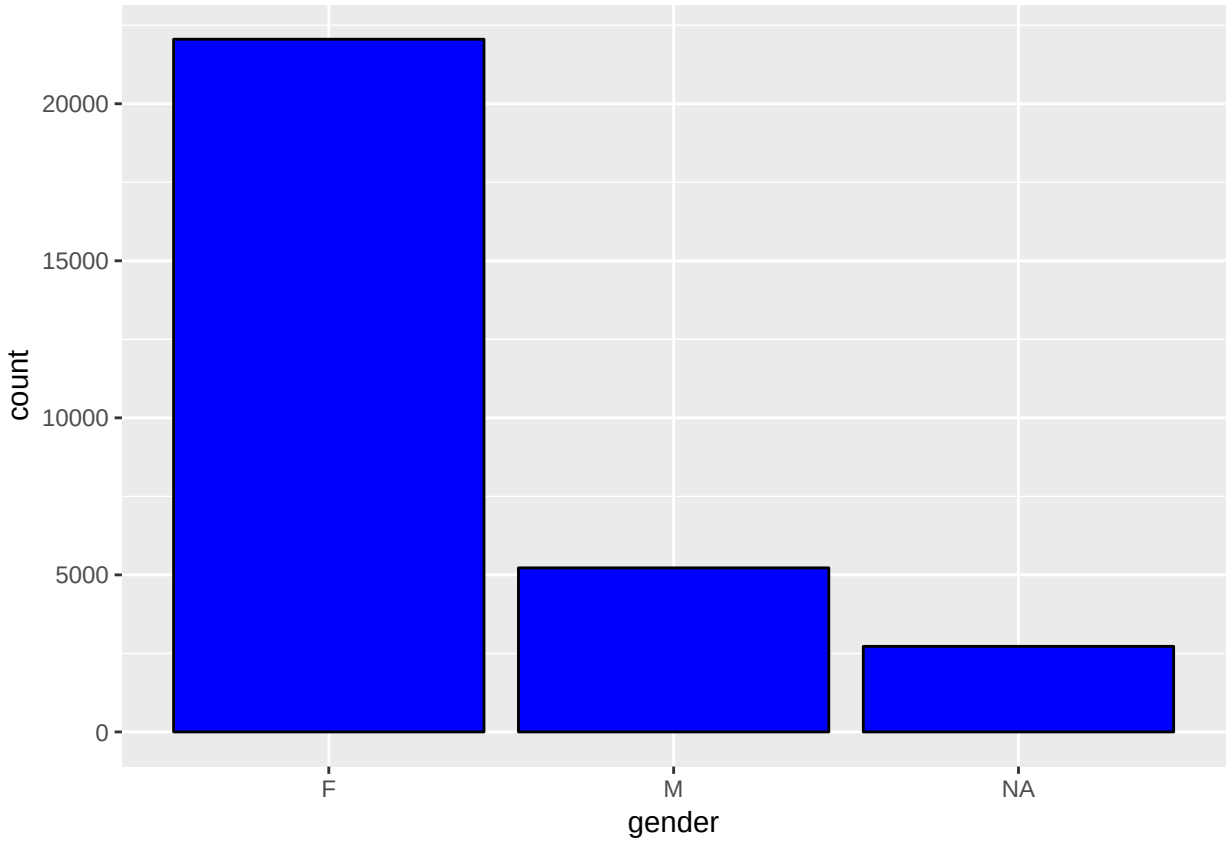
### Problematic Data Values

```
library (ggplot2)

ggplot(data=teens) + geom_histogram(aes(x=age), fill="green", color="black")
```

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

## Warning: Removed 5086 rows containing non-finite values (stat_bin).
```




```
ggplot(data=teens) + geom_bar(aes(x=gender), fill="blue", color="black")
```




The age variable has a very large range. Minimum age is 3.086. Maximum age is 106.927. There are also 5,086 missing values.

The gender variable has 2,724 missing values. We should also note the gender distribution: 22,054 females and 5,222 males.

Let's see the percentage of missing values for our variables:

```
pMiss <- function(x){sum(is.na(x))/length(x)*100}
apply(teens,2,pMiss)
```

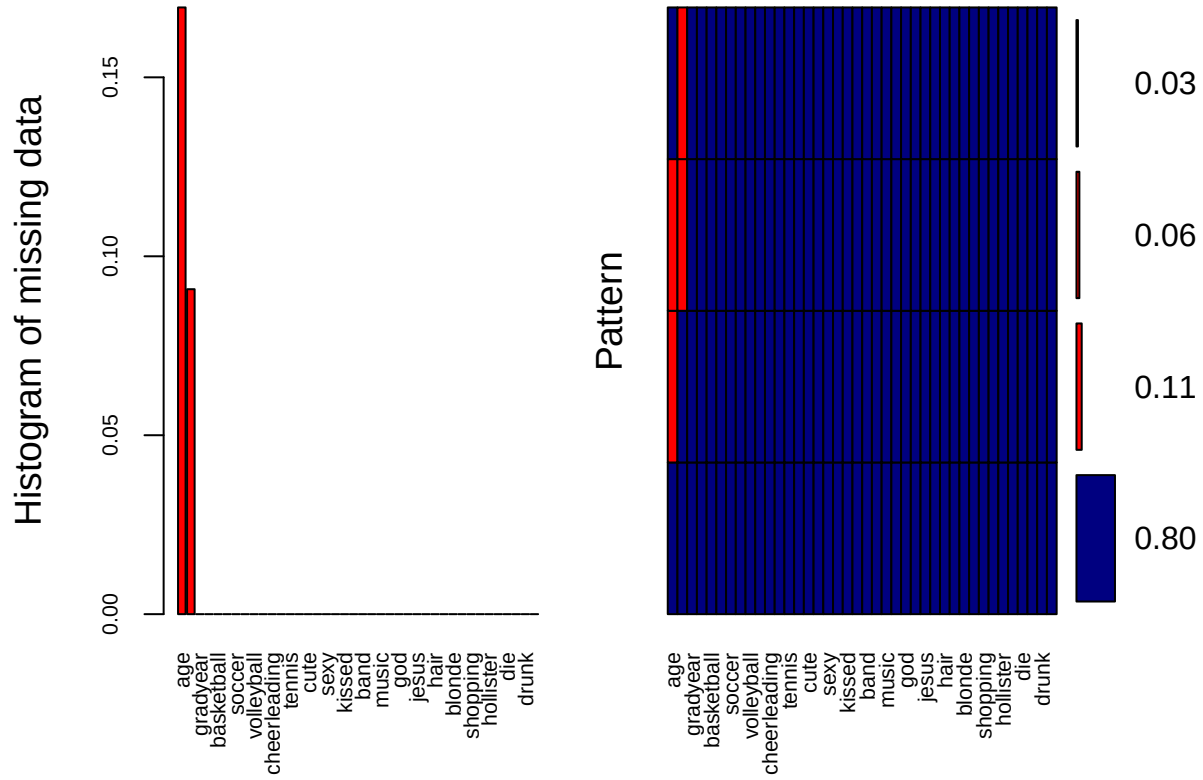
```
##     gradyear       gender          age      friends   basketball
##      0.00000      9.08000     16.95333      0.00000      0.00000
##     football       soccer     softball   volleyball     swimming
##      0.00000      0.00000      0.00000      0.00000      0.00000
## cheerleading     baseball       tennis       sports         cute
##      0.00000      0.00000      0.00000      0.00000      0.00000
##          sex         sexy          hot       kissed        dance
##      0.00000      0.00000      0.00000      0.00000      0.00000
##         band     marching        music         rock          god
##      0.00000      0.00000      0.00000      0.00000      0.00000
##       church        jesus        bible         hair        dress
##      0.00000      0.00000      0.00000      0.00000      0.00000
##       blonde         mall     shopping      clothes    hollister
##      0.00000      0.00000      0.00000      0.00000      0.00000
##  abercrombie          die        death        drunk        drugs
##      0.00000      0.00000      0.00000      0.00000      0.00000
```

Let's visualize what we just found above:

```
library(VIM)
```

```
## Loading required package: colorspace

## Loading required package: grid

## Loading required package: data.table

## VIM is ready to use.
##  Since version 4.0.0 the GUI is in its own package VIMGUI.
##
##           Please use the package to use the new (and old) GUI.

## Suggestions and bug-reports can be submitted at: https://github.com/alexkowa/VIM/issues

##
## Attaching package: 'VIM'

## The following object is masked from 'package:datasets':
##
##     sleep
```

```
aggr_plot <- aggr(teens, col=c('navyblue','red'), numbers=TRUE, sortVars=TRUE, labels=names(teens), cex
```



```
##
##  Variables sorted by number of missings:
##      Variable     Count
##           age 0.1695333
##        gender 0.0908000
##      gradyear 0.0000000
##       friends 0.0000000
##    basketball 0.0000000
##      football 0.0000000
##        soccer 0.0000000
##      softball 0.0000000
##    volleyball 0.0000000
##      swimming 0.0000000
##  cheerleading 0.0000000
##      baseball 0.0000000
##        tennis 0.0000000
##        sports 0.0000000
##          cute 0.0000000
##           sex 0.0000000
##          sexy 0.0000000
##           hot 0.0000000
##        kissed 0.0000000
##         dance 0.0000000
##          band 0.0000000
##      marching 0.0000000
##         music 0.0000000
##          rock 0.0000000
##           god 0.0000000
##        church 0.0000000
##         jesus 0.0000000
##         bible 0.0000000
##          hair 0.0000000
##         dress 0.0000000
##        blonde 0.0000000
##          mall 0.0000000
##      shopping 0.0000000
##       clothes 0.0000000
##     hollister 0.0000000
##   abercrombie 0.0000000
##           die 0.0000000
##         death 0.0000000
##         drunk 0.0000000
##         drugs 0.0000000
```

Source: The two code chunks above are from this entry from Rblogger.

16% of data values for age is missing. 9% of data values for gender is missing. If we compound the fact that some people did not report their true age, this variable is our "bigger" problem. Let's tackle it first.

## One Proble at a Time: Recoding Age via Imputation

First, we need to make an assumption: **Teenagers are between the age of 13 and 20.** Anyone who does not have a reported age in this assumed range will be recoded as "NA."

```
teens$age <- ifelse(teens$age >= 13 & teens$age < 20,
                    teens$age, NA)
```

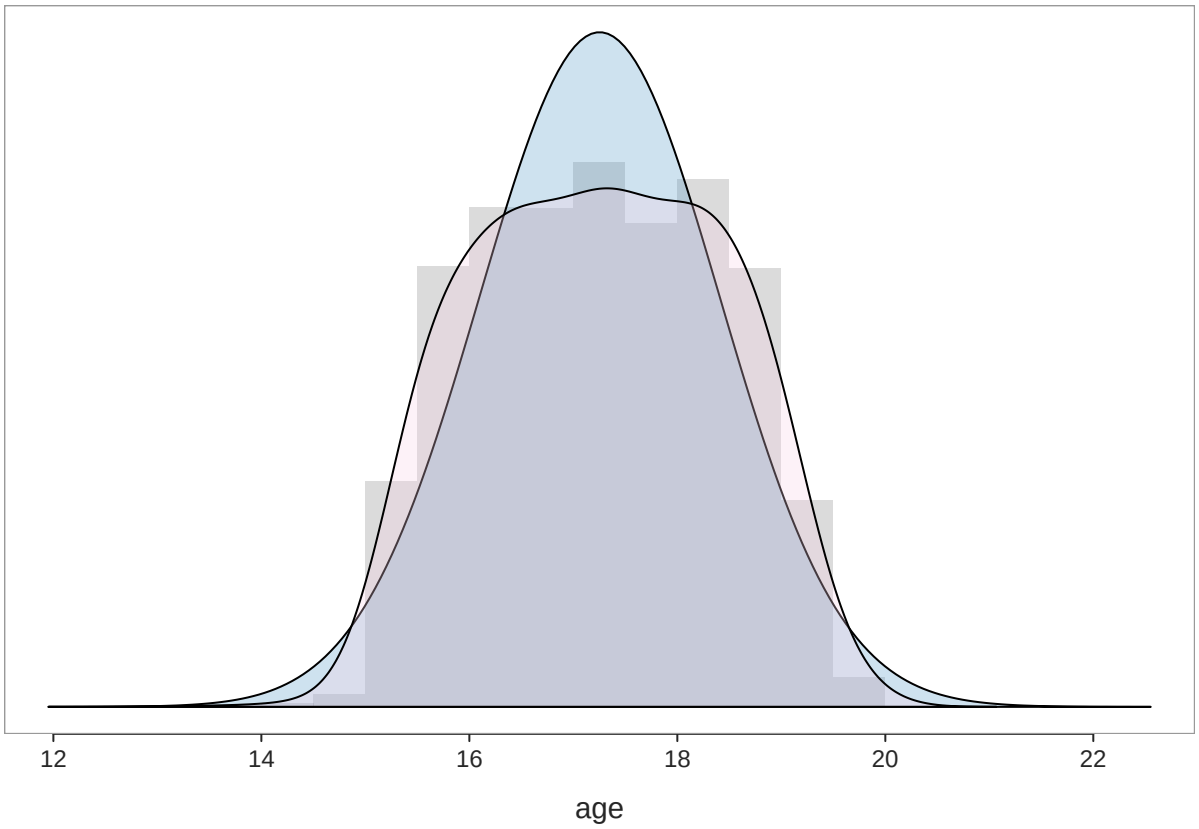
To handle the missing age values, we will use imputation. It is common to impute missing values with expected values (i.e. what we expect those values to be). Mean and median imputations are common techniques. If the distribution is normal, we use mean imputation. If the distribution is skewed, we use median imputation.

We will use a package called lessR to draw a histogram of the age and then superimposes a normal curve on top for comparison purpose.

```
library(lessR)
```

```
##
## lessR 3.7.9     feedback: gerbing@pdx.edu     web: lessRstats.com/new
## ---------------------------------------------------------------------
## 1. mydata <- Read("")      Read text, Excel, SPSS, SAS or R data file
## 2. Help()                  Get help
## 3. hs(), bc(), or ca()     All histograms, all bar charts, or both
## 4. Plot(X) or Plot(X,Y)    For continuous and categorical variables
##                            numerical X: Violin, Box, Scatter plot
## 5. by1= , by2=             Trellis graphics, a plot for each by1, by2
## 6. reg(Y ~ X, Rmd="eg")    Regression + R markdown file that, when
##                            knit, provides full interpretative output
## 7. style("lightbronze")    Return to previous, more neutral theme
##    style(show=TRUE)        all color/style options and current values
## 8. getColors()             create many types of color palettes

##
## Attaching package: 'lessR'

## The following object is masked from 'package:data.table':
##
##     set
```

```
Density(age, data=teens)
```




```
##
##
## Sample Size:  24477
## Missing Values:  5523
##
## Density bandwidth for general curve: 0.3580
## For a smoother curve, increase bandwidth with option: bw
##
## Sample size out of range for Shapiro-Wilk normality test.
##
##
## (Box plot) Outliers: 5
##
## Small       Large
## -----       -----
##  13.0
##  13.1
##  13.1
##  13.1
##  13.4
```

The distribution looks normal. Let's proceed with mean imputation.

```
# Finding the mean age by cohort

mean(teens$age) # Doesn't work b/c of NA
```

```
## [1] NA
```

```
mean(teens$age, na.rm = TRUE) #This tells R to ignore NA in calculating the mean.
```

```
## [1] 17.25243
```

```
# Review age by cohort
aggregate(data = teens, age ~ gradyear, mean, na.rm = TRUE)
```

```
##   gradyear      age
## 1     2006 18.65586
## 2     2007 17.70617
## 3     2008 16.76770
## 4     2009 15.81957
```

```
# Calculating the expected age for each person
# This creates a new variable called ave_age
ave_age <- ave(teens$age, teens$gradyear,
                FUN = function(x) mean(x, na.rm = TRUE))

#print(ave_age) #To view average age table created above.


teens$age <- ifelse(is.na(teens$age), ave_age, teens$age)
#Removes the missing values and replaces with mean age.

# Check to make sure missing values are eliminated
summary(teens$age)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   13.03   16.28   17.24   17.24   18.21   20.00
```

## Second Problem: Missing Gender Values

We have three possible levels: female, male, and NA (no reported gender). We will create two dummy variables to handle the gender missing values: 1) female and 2) no_gender.

```
teens$female <- ifelse(teens$gender == "F" &
                         !is.na(teens$gender), 1, 0)
#If female & not missing gender value = 1
#Else = 0 (this includes male & missing values)

teens$no_gender <- ifelse(is.na(teens$gender), 1, 0)
#If gender is unknown then no_gender = 1. This is how we extract out the "missing values" versus "male"

# Check our recoding work
table(teens$gender, useNA = "ifany") #We have 2,724 cases of unknown gender.
```

```
##
##     F     M  <NA>
## 22054  5222  2724
```

```
table(teens$female, useNA = "ifany")
```

```
##
##     0     1
##  7946 22054
```

```
table(teens$no_gender, useNA = "ifany") #We have 2,724 cases of unknown gender. This matches up with ou
```

```
##
##     0     1
## 27276  2724
```

# What Do We Want to Examine?

We want to cluster what these 30,000 teenagers talked about on their SNS profiles with regards to the five categories of interests: extracurricular activities, fashion, religion, romance, and antisocial behavior.

```
interests <- teens[5:40] #Take the 5th through the 40th variables into the model.
```

# Let's Talk Cluster Analysis

## Partitioning Approach

General process:

1. Choose the number of clusters (k)
2. Partition the dataset into k clusters so that the sum of squared distances is minimized between the data points (p) and some center point [c(i)] in each cluster.

Two questions naturally arise from above:

**Question 1**: How do we determine the center points?

**Answer**: We select a clustering algorithm. We will examine k-means and k-medoids.

**Question 2**: How do you measure the distance between the data points and center points?

**Answer**: We use either Euclidean (straight line) or Manhattan distance (city block).

## K-Means Clustering

We will begin by building a cluster model with five clusters. There's no right place to start. Just pick a k value that you think is most suitable and start.

Remember that in k-means, the starting centroids are randomly chosen.

**nstart** is the number of times the starting points are re-sampled. Think of it this way: R does clustering assignment for each data point 25 times and picks the center that have the lowest within cluster variation. The "best" centroids become the starting point by which kmeans will continue to iterate. Typically you can set nstart to between 20 and 25 to find the best overall random start. See Morissette & Chartier (2013)

paper for explanations of the different kmeans algorithms. We recommen reviewing Table 5 in the paper for additional information on the various kmeans algorithm.

**iter.max** = maximum number of iterations before stopping (unless convergence is already achieved before max iterations).

**The default algorithm is Hartigan-Wong, which minimizes the within-cluster sum of squares.**

```
set.seed(123)
teen_clusters_5 <- kmeans(interests, centers=5)
```

Let's see what are the outputs from kmeans:

```
names(teen_clusters_5)
```

```
## [1] "cluster"      "centers"      "totss"        "withinss"
## [5] "tot.withinss" "betweenss"    "size"         "iter"
## [9] "ifault"
```

Size: Number of people in each cluster. Cluster 3 has the most number of people. Follows by Clusters 5 & 1.

```
teen_clusters_5$size
```

```
## [1]  4216  1538 18973   773  4500
```

Let's see each row and its assigned cluster.

```
teen_clusters_5$cluster
```

```
##     [1] 3 4 1 3 1 1 3 3 3 2 3 3 3 3 1 3 3 3 3 3 3 3 3 2 3 3 3 2 3 2 3 5 3 1
##    [35] 3 3 3 3 3 4 3 3 5 1 3 1 5 2 3 1 3 1 5 3 3 3 1 4 3 3 3 3 4 3 1 3 3 1
##    [69] 1 1 1 3 3 3 3 3 3 3 3 3 5 3 3 5 3 3 3 3 3 3 1 3 5 3 3 3 5 3 3 3 3 3
##   [103] 1 5 1 3 3 3 5 1 3 3 3 1 3 3 4 3 5 3 3 2 3 3 3 3 2 3 1 3 3 2 5 2 3 3
##   [137] 5 3 5 3 1 2 1 3 3 3 2 3 2 3 3 3 3 3 3 3 3 3 2 3 3 3 3 5 5 3 3 3 5 3
##   [171] 5 3 3 3 3 1 3 5 4 2 3 3 1 3 3 1 2 5 5 3 1 3 3 3 4 1 1 3 3 3 3 3 1 3
##   [205] 3 5 3 1 5 5 1 3 3 3 3 5 2 3 3 3 5 3 3 3 1 3 3 3 3 3 5 5 3 3 3 1 3 1
##   [239] 3 3 3 3 4 3 3 3 3 3 1 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3
##   [273] 1 3 3 3 1 3 5 1 3 5 1 3 5 1 3 3 3 3 3 3 3 1 3 3 5 3 5 3 3 3 3 5 3 3
##   [307] 3 2 3 3 3 1 2 1 3 5 3 3 2 3 3 3 3 2 3 3 1 1 1 3 3 3 3 5 1 3 1 3 2 3
##   [341] 3 2 1 3 1 1 3 3 3 3 3 3 1 3 3 5 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3
##   [375] 1 3 3 3 3 3 3 1 3 1 2 3 3 3 3 3 2 3 3 1 4 2 3 3 5 3 3 3 3 3 3 3 3 3
##   [409] 2 3 3 3 3 5 4 3 3 3 5 3 3 3 3 3 2 5 5 5 3 3 3 3 3 5 3 3 5 3 3 3 3 3
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## [27031] 3 5 3 3 5 3 5 4 3 1 3 3 3 5 3 3 5 5 3 1 3 4 3 3 5 5 5 3 2 3 3 3 3 1
## [27065] 3 4 3 1 1 3 3 5 3 3 3 3 3 3 3 1 2 3 5 3 3 2 3 3 3 1 3 5 3 3 2 2 3 3 1
## [27099] 5 5 2 3 3 1 3 3 2 3 3 3 3 3 3 4 3 1 5 3 3 5 5 3 3 3 3 3 5 3 3 3 1 1
## [27133] 1 3 3 3 5 4 3 3 1 3 1 3 3 3 3 2 3 3 5 3 3 1 3 3 3 3 3 3 3 3 1 3 5 2
## [27167] 1 3 3 1 3 3 3 5 3 1 3 5 3 3 3 3 3 3 5 5 1 3 3 1 3 1 2 5 1 3 5 1 3 3
## [27201] 2 3 3 3 5 3 3 1 3 3 3 1 3 3 3 3 2 3 3 3 4 3 3 3 2 3 3 1 3 3 3 3 1 3
## [27235] 1 1 1 5 3 5 3 3 3 1 3 2 3 5 5 5 5 5 5 1 3 3 5 5 1 4 1 5 3 4 3 5 5 1
## [27269] 2 3 3 3 5 1 3 5 4 3 3 3 1 5 3 3 3 5 3 3 5 3 3 3 3 5 3 3 3 3 2 5 5 1
## [27303] 3 3 3 3 3 3 3 5 5 3 3 1 3 5 3 3 1 1 3 3 3 5 1 3 3 3 3 3 3 5 1 1 3 3
## [27337] 3 3 3 3 3 3 3 5 5 3 3 3 3 3 3 3 1 3 5 3 1 3 3 2 2 5 3 3 3 3 3 3 3 3
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## [27405] 3 1 3 3 3 2 3 5 3 5 3 3 3 3 5 3 1 1 2 1 3 3 3 3 3 3 2 3 3 5 3 1 1 3
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## [27507] 3 5 2 3 3 5 1 3 3 3 3 3 3 3 3 5 3 3 3 5 1 2 3 5 3 5 3 3 3 3 3 3 5 3
## [27541] 3 3 1 3 3 3 5 5 5 3 2 5 5 1 3 3 1 3 3 5 5 1 3 3 3 3 3 2 1 5 1 3 5 3
## [27575] 3 3 3 1 5 3 3 5 5 3 3 2 5 5 3 5 3 5 3 3 2 5 3 5 5 3 3 1 3 3 5 3 1 5
## [27609] 1 3 5 3 5 4 3 3 5 2 1 3 3 3 5 3 3 5 3 5 1 3 5 3 3 3 3 3 3 3 1 4 3 3
## [27643] 3 3 3 1 3 5 3 3 3 3 5 3 5 3 1 5 3 5 3 3 1 2 3 3 3 5 3 3 3 3 3 5 3 5
## [27677] 3 3 5 3 3 3 3 3 5 5 5 3 3 3 3 3 3 3 1 2 1 3 3 5 5 3 5 5 3 5 3 3 3 2
## [27711] 3 3 3 1 3 4 3 4 1 3 3 3 3 3 3 5 2 3 5 3 3 2 3 3 3 5 3 3 3 2 4 3 3 2
## [27745] 5 5 1 5 3 3 1 3 4 5 3 1 3 4 3 3 3 1 3 3 3 5 3 5 1 5 3 3 3 4 5 1 3 2
## [27779] 5 3 3 3 3 3 3 2 3 3 3 3 3 3 5 3 5 1 3 3 3 3 2 3 5 5 3 3 3 5 3 1 1 3
## [27813] 3 2 3 1 3 4 3 3 3 3 3 3 3 3 2 1 5 3 5 3 1 3 3 3 5 3 3 5 3 5 5 3 2 3
## [27847] 3 3 3 1 3 3 1 3 3 3 5 3 3 3 1 3 3 5 2 3 1 2 3 3 3 5 3 1 3 3 3 1 3 5
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## [27915] 1 3 1 3 3 3 3 3 3 3 2 3 3 3 5 3 3 5 3 3 5 5 3 3 3 3 2 3 3 1 3 1 5 2
## [27949] 2 3 3 3 3 5 3 1 3 1 3 3 3 3 3 1 5 3 3 3 3 3 3 3 3 3 1 3 5 5 5 5 5 1
## [27983] 5 2 3 5 5 3 3 3 5 5 5 3 5 1 5 5 3 5 4 3 3 5 5 2 3 5 5 5 1 2 5 5 5 3
## [28017] 5 5 3 3 5 3 3 3 4 2 3 3 3 3 5 3 1 5 3 1 1 3 5 3 5 3 3 1 3 3 2 3 3 1
## [28051] 3 1 3 3 1 3 3 3 3 5 3 3 3 3 1 3 2 3 4 3 3 5 3 3 3 3 5 2 3 3 2 3 1 3
## [28085] 2 5 3 3 3 3 3 5 1 3 4 3 5 5 1 5 3 3 1 4 3 5 3 3 1 1 3 3 3 5 3 5 3 3
## [28119] 3 1 1 1 3 5 3 3 3 3 3 3 5 3 2 3 1 5 3 3 5 3 3 2 3 3 2 3 2 3 5 3 3 3
## [28153] 3 2 1 3 2 3 3 3 2 3 5 3 3 3 1 1 3 3 5 3 3 5 3 5 5 3 3 1 5 3 5 3 2 3
## [28187] 5 5 5 5 3 3 3 3 3 3 3 3 3 5 1 3 3 3 4 5 3 3 1 5 3 3 1 3 3 3 3 3 3 3
## [28221] 3 4 3 1 3 3 1 5 5 3 3 3 5 5 2 5 1 2 3 3 1 4 4 3 1 1 3 1 5 3 1 3 3 3
## [28255] 5 3 1 3 3 2 5 3 4 1 3 5 3 5 3 5 4 3 3 1 3 3 3 3 5 1 3 3 3 3 5 3 3 5
```

```
## [28289] 3 3 3 3 5 5 1 3 3 3 3 3 5 3 1 3 3 3 3 3 3 3 3 3 2 3 1 2 3 3 5 3 2 3
## [28323] 4 3 1 5 3 1 5 1 3 5 1 1 3 3 5 3 3 1 3 3 3 3 3 3 3 3 2 5 5 3 3 3 3 3
## [28357] 5 2 5 5 5 2 3 3 2 3 3 5 5 5 5 3 3 3 3 1 1 5 3 3 1 3 3 3 5 3 1 4 3 5
## [28391] 3 3 3 3 3 3 3 5 3 3 5 5 5 2 4 4 3 3 3 4 1 5 5 1 3 3 4 3 2 2 3 3 5 5
## [28425] 1 3 5 3 3 3 3 1 3 1 5 3 1 3 3 3 5 3 1 3 3 2 3 3 3 5 2 5 1 1 5 3 5 3
## [28459] 2 5 1 3 3 2 3 3 5 1 3 3 3 5 3 1 3 3 5 3 1 3 3 3 3 3 1 3 5 1 3 1 3 1
## [28493] 1 3 3 5 5 3 3 3 1 5 3 2 1 5 3 3 3 3 5 2 3 3 5 2 3 3 1 3 3 3 3 3 1 3
## [28527] 3 3 3 3 3 2 3 1 5 3 3 3 3 2 5 1 3 1 5 3 1 3 2 3 1 2 4 3 5 5 3 3 3 3
## [28561] 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 5 3 3 1 2 3 5 3 3 1 3 3 1 3 4 3 3 5 3
## [28595] 5 1 1 3 2 3 5 3 5 3 3 2 5 5 3 5 3 3 3 3 3 3 3 1 1 3 3 3 3 1 3 3 3 3
## [28629] 5 3 1 5 5 3 5 3 3 3 3 3 3 3 3 1 5 3 2 5 3 3 2 3 5 3 3 3 2 1 3 3 1 3
## [28663] 3 3 3 3 3 2 5 2 3 3 3 5 5 3 3 3 3 1 1 3 3 3 3 3 3 5 3 3 5 1 3 3 3 3
## [28697] 3 1 1 3 3 5 1 5 3 3 1 5 5 3 1 3 5 3 1 3 3 5 5 3 1 3 3 3 3 3 3 3 3 3
## [28731] 3 1 3 5 3 2 3 3 2 3 5 3 3 5 3 1 3 5 3 3 3 5 5 5 3 2 3 3 1 3 5 5 2 3
## [28765] 5 1 5 5 3 3 3 3 3 1 3 3 5 3 3 1 1 1 3 1 5 3 3 3 3 3 1 1 3 5 3 3 3 3
## [28799] 3 1 5 3 3 3 1 4 3 3 3 3 3 3 2 3 5 3 5 1 1 1 3 3 3 3 5 3 3 1 3 3 5 3
## [28833] 5 3 3 5 5 3 1 1 5 3 3 3 5 4 3 3 3 1 2 5 5 4 3 3 3 3 3 3 3 5 3 3 3 1
## [28867] 3 3 5 3 1 5 3 1 3 5 5 1 3 3 3 3 3 3 3 3 5 4 3 3 2 3 3 3 3 1 2 3 5 5
## [28901] 5 3 3 3 3 3 5 3 4 2 3 5 3 5 5 5 3 1 5 1 3 3 3 3 3 5 3 5 3 3 1 3 3 5
## [28935] 3 1 3 3 5 5 3 3 1 3 3 5 3 5 3 4 3 3 3 3 3 4 3 4 5 3 5 3 1 2 3 1 5 4 3
## [28969] 3 3 1 3 5 5 2 3 4 5 5 3 3 5 2 2 1 2 3 3 3 3 3 3 5 5 5 3 3 5 5 3 3 3
## [29003] 3 5 1 3 1 3 4 2 4 3 3 3 3 3 5 3 3 3 5 5 3 3 1 3 5 2 4 3 5 5 5 3 3 3
## [29037] 5 3 3 1 3 1 3 3 3 5 3 1 2 5 3 3 5 5 5 5 3 3 3 3 3 3 2 5 5 3 5 5 3 1
## [29071] 3 3 2 3 3 3 5 3 5 3 3 4 3 1 5 4 5 3 3 3 4 1 3 1 3 5 2 1 3 5 3 5 5 3
## [29105] 1 3 3 3 5 3 5 3 3 5 5 3 3 5 3 3 4 3 5 3 5 5 3 5 3 3 5 4 5 5 3 3 2 1
## [29139] 3 3 3 5 5 3 3 3 3 3 3 1 3 3 3 5 3 3 3 3 1 3 5 2 1 4 5 3 1 2 3 3 5 3
## [29173] 3 3 1 3 3 3 3 5 3 2 3 3 3 3 4 4 3 5 3 3 3 1 1 1 5 5 3 5 5 3 2 3 3 4
## [29207] 1 3 3 5 3 3 1 3 3 3 3 3 3 5 3 3 1 5 3 5 3 3 3 3 4 5 5 5 5 1 3 3 3 3
## [29241] 5 5 5 3 1 2 1 5 5 2 5 5 3 3 5 3 3 5 1 5 3 5 5 3 3 3 3 1 3 5 3 3 3 3
## [29275] 5 3 3 3 3 3 5 5 5 3 3 3 2 3 5 3 3 5 1 3 3 3 5 3 1 5 3 5 3 3 3 1 3 3
## [29309] 5 3 5 3 5 3 4 1 3 3 3 3 3 5 1 3 3 3 3 3 3 3 3 1 3 3 1 3 5 5 3 3 1 5
## [29343] 3 3 5 5 5 2 3 3 3 4 3 3 3 5 5 3 3 3 3 4 3 3 5 2 3 3 3 1 2 2 4 1 3 2
## [29377] 2 3 2 3 3 5 3 1 5 5 5 2 3 3 3 3 3 3 3 3 2 1 5 2 3 1 5 1 2 3 3 5 3 3
## [29411] 3 5 3 3 2 2 3 3 3 3 5 3 5 3 3 3 1 3 3 3 3 3 3 1 3 3 2 3 5 3 3 5 5 5 3
## [29445] 3 5 2 3 5 1 1 3 1 3 3 5 4 5 3 3 5 3 3 1 4 3 5 3 5 2 3 1 3 3 3 3 1 5
## [29479] 3 5 5 3 3 5 3 5 4 2 3 3 2 1 3 5 3 4 3 3 3 3 4 3 3 3 3 3 3 5 3 3 3 5
## [29513] 3 3 5 3 5 3 3 2 3 2 1 1 3 3 3 3 3 3 3 3 5 3 3 3 3 5 3 3 3 5 3 3 3 5
## [29547] 3 5 5 5 1 5 3 3 3 4 3 5 5 5 3 2 3 3 3 5 3 3 3 5 5 3 5 5 3 3 5 5 1 3
## [29581] 3 3 3 4 5 5 3 3 5 3 3 5 5 3 5 3 3 5 1 3 3 3 1 5 2 3 3 1 3 3 5 3 5 3
## [29615] 3 3 1 1 3 3 5 3 3 3 3 1 3 3 5 3 3 3 3 1 2 5 4 3 3 5 5 1 5 3 3 1 3 3
## [29649] 5 4 3 5 1 5 4 3 3 5 5 5 3 5 2 3 3 5 3 3 3 5 1 5 5 3 1 3 2 3 3 3 3 3
## [29683] 3 3 1 3 4 4 5 3 3 1 5 5 5 3 2 5 2 3 3 1 5 5 3 3 5 4 3 5 3 3 3 3 3 5
## [29717] 3 3 4 3 3 3 3 3 3 3 3 3 3 5 5 3 3 3 1 3 3 3 5 3 3 3 4 1 3 3 3 5 3 3
## [29751] 3 3 3 3 3 3 3 3 3 5 3 5 3 3 5 3 3 3 3 1 4 3 3 3 3 1 5 3 1 1 3 2 3 5
## [29785] 3 3 5 1 5 5 5 5 3 3 5 3 3 3 3 3 5 1 3 3 5 5 3 1 3 3 1 1 1 2 3 3 5 1
## [29819] 1 1 3 3 3 2 5 5 3 4 4 3 1 3 5 3 3 5 3 3 5 1 3 3 3 3 5 1 3 3 5 3 3 3
## [29853] 3 3 3 3 3 1 3 1 3 4 4 3 3 3 3 5 3 3 2 3 3 3 3 1 3 4 3 3 5 3 1 3 3 3
## [29887] 3 3 5 5 5 2 3 3 3 3 3 3 2 5 3 3 3 3 3 3 5 5 1 3 3 5 3 3 2 1 3 3 1 3
## [29921] 3 3 5 5 1 3 3 3 3 3 3 3 5 3 3 3 2 3 2 3 3 3 3 2 3 5 3 3 3 3 2 3 3 3
## [29955] 3 3 3 3 3 3 1 1 3 3 1 5 5 3 3 3 3 3 5 1 2 3 3 3 1 4 5 3 3 3 5 3 1 3
## [29989] 3 5 3 2 1 3 3 3 3 3 3 1
```

Let's show the coordinates of the cluster centroids for the interest variables.

```
teen_clusters_5$centers
```

```
##   basketball  football    soccer  softball volleyball   swimming
## 1  0.1883302 0.2326850 0.1209677 0.1034156 0.09582543 0.15417457
## 2  0.3185956 0.2964889 0.1462939 0.1579974 0.13524057 0.15669701
## 3  0.1282876 0.1536394 0.0829600 0.0764771 0.08090444 0.09007537
## 4  0.7968952 0.7102199 0.4954722 0.3635188 0.26908150 0.32341527
## 5  0.8191111 0.5928889 0.8868889 0.5388889 0.43088889 0.26266667
##   cheerleading   baseball     tennis     sports      cute        sex
## 1   0.06783681 0.09369070 0.10578748 0.14302657 0.2599620 0.18477230
## 2   0.15734720 0.08972692 0.08777633 0.15149545 0.4785436 0.18985696
## 3   0.06920361 0.07046856 0.06967796 0.08996996 0.1638117 0.08970642
## 4   0.29236740 0.38809832 0.16429495 0.62483829 0.9495472 3.40491591
## 5   0.25155556 0.21733333 0.13111111 0.26066667 0.8915556 0.19488889
##        sexy        hot     kissed     dance      band   marching     music
## 1 0.1425522 0.11835863 0.11480076 0.3394213 1.1892789 0.17314991 2.4305028
## 2 0.2067620 0.20221066 0.09947984 3.1105332 0.3498049 0.03706112 0.9174252
## 3 0.1078902 0.08164233 0.03895009 0.1891635 0.1044115 0.01644442 0.2829284
## 4 0.5148771 0.34152652 1.43596378 1.0944373 0.8576973 0.06597671 2.7024580
## 5 0.1937778 0.26111111 0.13555556 0.4677778 0.1760000 0.01511111 0.6711111
##        rock       god    church     jesus      bible      hair      dress
## 1 0.4295541 0.4070209 0.2277040 0.1159867 0.02371917 0.3275617 0.12286528
## 2 0.3250975 3.0988296 0.7711313 0.5845254 0.12418726 0.5156047 0.24187256
## 3 0.1369841 0.2381279 0.1186423 0.0675697 0.01054130 0.1504243 0.06177199
## 4 1.4100906 0.9456662 0.4036223 0.1461837 0.03492885 4.4773609 0.37645537
## 5 0.2888889 0.4951111 0.6080000 0.1286667 0.02711111 0.9306667 0.21688889
##       blonde      mall  shopping    clothes  hollister abercrombie
## 1 0.06499051 0.2020873 0.3244782 0.15085389 0.04625237  0.03130930
## 2 0.10078023 0.3114434 0.4902471 0.23732120 0.07932380  0.07022107
## 3 0.03868655 0.1360354 0.1999157 0.07452696 0.04095293  0.03025352
## 4 1.28978008 0.7839586 0.6727038 0.84346701 0.28201811  0.24450194
## 5 0.17955556 0.7117778 0.9233333 0.30844444 0.17422222  0.11822222
##         die      death      drunk      drugs
## 1 0.2151328 0.14136622 0.08870968 0.07068311
## 2 0.3582575 0.22041612 0.12288687 0.06306892
## 3 0.1227007 0.07884889 0.05760818 0.02529911
## 4 0.9573092 0.42432083 0.57956016 0.67917206
## 5 0.2215556 0.14844444 0.11888889 0.09177778
```

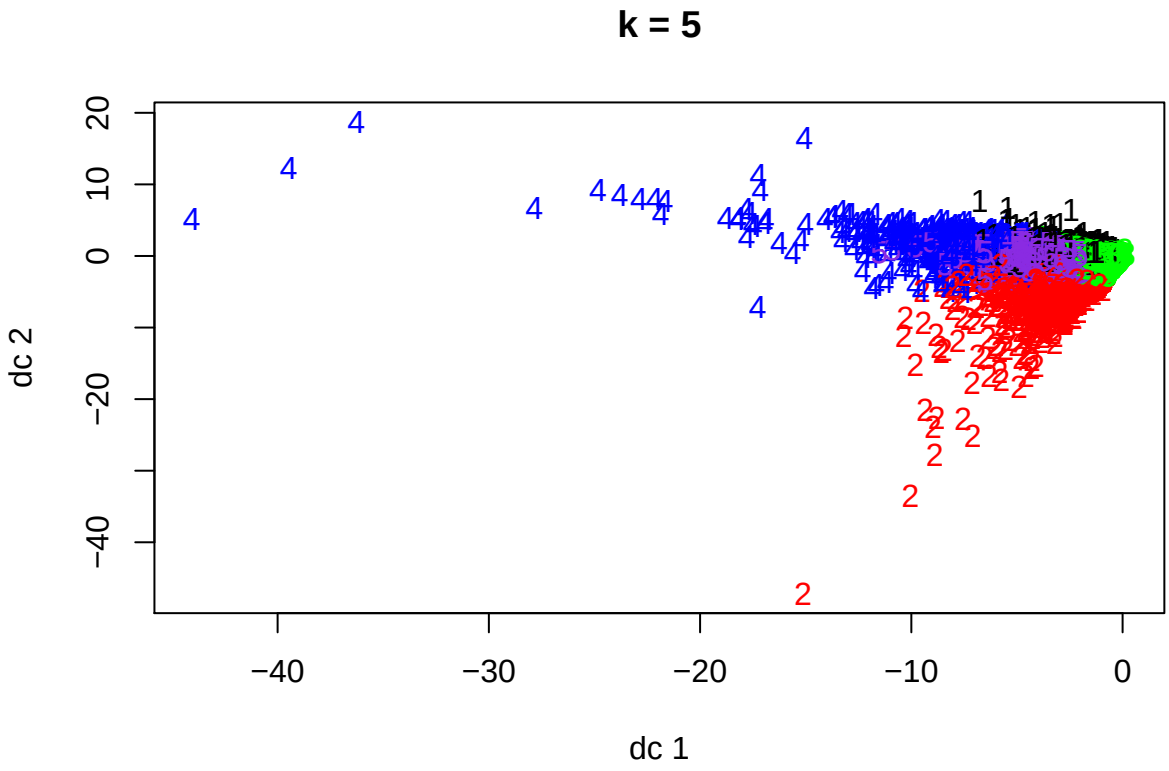
```
t(teen_clusters_5$centers) #transpose for ease of reading purpose
```

```
##                       1          2          3          4          5
## basketball   0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## football     0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## soccer       0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## softball     0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## volleyball   0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## swimming     0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## baseball     0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
## tennis       0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## sports       0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
```

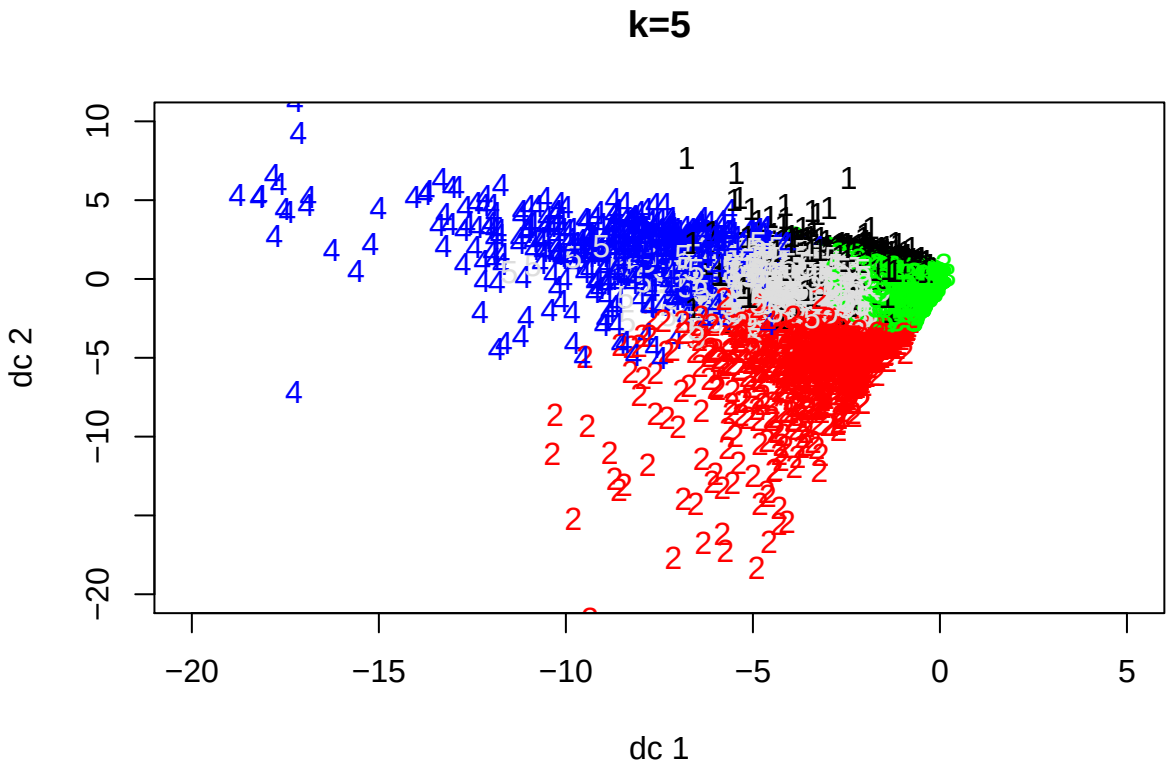
```
## cute         0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## sex          0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## sexy         0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## hot          0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## kissed       0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## dance        0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## band         1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
## marching     0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
## music        2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## rock         0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## god          0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## church       0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## jesus        0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## bible        0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
## hair         0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## dress        0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## blonde       0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## mall         0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## shopping     0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## clothes      0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## hollister    0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## abercrombie  0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## die          0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## death        0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## drunk        0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## drugs        0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
```

### Visualizing the Clusters

```
library(fpc) #load this

plotcluster(interests, teen_clusters_5$cluster, main="k = 5") #creates a visualization of the K=5 clust
```



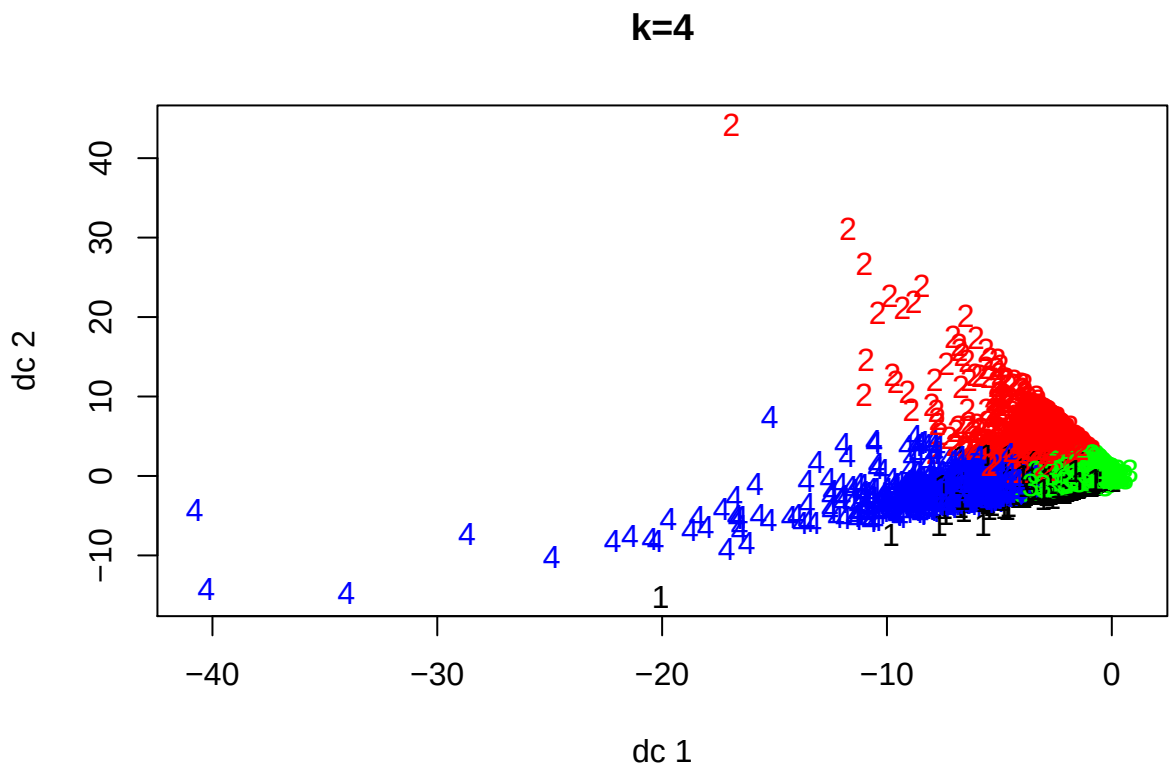

```
#If all your data ends up in a corner and hard to read- change the lim for y and x:
#sometime you need to run it first with out the lims and then add them in and run again.
plotcluster(interests, teen_clusters_5$cluster, main="k=5", xlim=c(-20,5), ylim=c(-20,10))
```




The plot you see here is two dimensional whereas your dataset has 36 dimensions (because of the 36 "interest" variables). In another word, it is a simplified version. The coordinates on the x and y axes are called "usual discriminant coordinates." Here's more on the topic: see here and see here

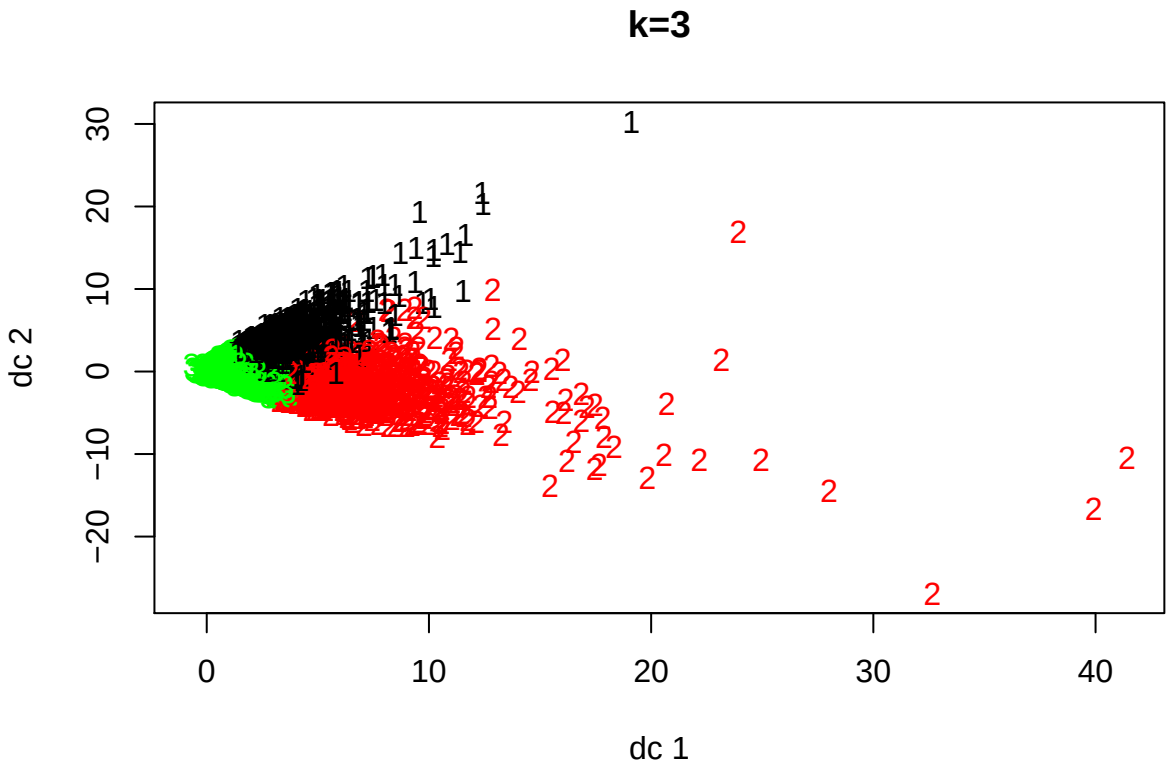
**What about k=4?**

```
set.seed(123)
teen_clusters_4 <- kmeans(interests, centers=4)
plotcluster(interests, teen_clusters_4$cluster, main="k=4")
```




**What about k=3?**

```
set.seed(123)
teen_clusters_3 <- kmeans(interests, centers=3)
plotcluster(interests, teen_clusters_3$cluster, main="k=3")
```




**Picking Among the K's**

**A Digression on Sum of Squares**

**Within Sum of Squares (withinss)**

We want our clusters to be "unique." In another word, we want the sum of squares within each cluster to be small because it means the cluster is cohesive. As we stated earlier, the default algorithm in kmeans is Hartigan & Wong, which minimizes the withinss. What are the withinss for each cluster? Look at Clusters 3, 5, and 1 in particular. Which cluster has the largest withinss?

```
teen_clusters_5$withinss
```

```
## [1]  78835.33  80153.80 102071.44 179006.65 128069.21
```

**Between Sum of Squares (betweenss)**

We want each cluster to be different from its neighboring clusters. The betweenss is the most useful when we want to compare among multiple kmeans models.

```
teen_clusters_5$betweenss
```

```
## [1] 92856.37
```

### Total Sum of Squares (totss)

totss = betweenss + withinss

```
teen_clusters_5$totss
```

```
## [1] 660992.8
```

### Method 1: Use the visualizations

Look at your cluster plots. Can you make a determination this way?

### Method 2: Examine the betweenss and withinss ratios!

We want the clusters to demonstrate both cohesion and separation. Cohesion is measured by minimizing the ratio of withinss/totalss. Separation is measured by maximizing the ratio of betweenss/totalss.

### Cluster Separation

```
clusters3<- teen_clusters_3$betweenss/teen_clusters_3$totss
clusters4<- teen_clusters_4$betweenss/teen_clusters_4$totss
clusters5<- teen_clusters_5$betweenss/teen_clusters_5$totss

betweenss.metric <- c(clusters3, clusters4, clusters5)
print(betweenss.metric) #Look for a ratio that is closer to 1.
```

```
## [1] 0.09368819 0.12094187 0.14048016
```

k=5 has the most separation.

### Cluster Cohesion

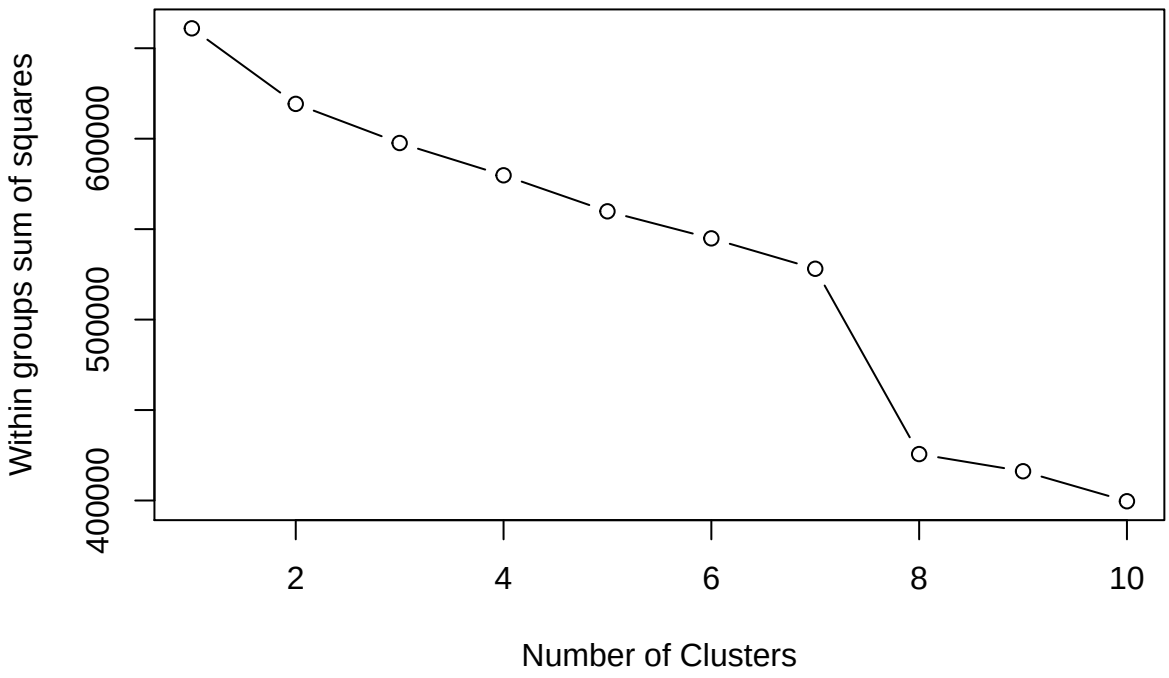
```
clusters3<- teen_clusters_3$tot.withinss/teen_clusters_3$totss
clusters4<- teen_clusters_4$tot.withinss/teen_clusters_4$totss
clusters5<- teen_clusters_5$tot.withinss/teen_clusters_5$totss

totwithinss.metric <- c(clusters3, clusters4, clusters5)
print(totwithinss.metric) #Looking for a ratio that is closer to 0.
```

```
## [1] 0.9063118 0.8790581 0.8595198
```

k=5 also has the most cluster cohesion.

### Method 3: Using the "Elbow Method"

```
wss <- (nrow(interests)-1)*sum(apply(interests,2,var))
for (i in 2:10) wss[i] <- sum(kmeans(interests,
                                     centers=i)$withinss)
plot(1:10, wss, type="b", xlab="Number of Clusters",
     ylab="Within groups sum of squares")
```




Source: The above code chunk is from here

**Method 4: Use Your Business Knowledge!**

What is actionable? What is not? what do you know about your customers? Your data?

**A Side Note: Trying an Automatic Pick**

```
#library(fpc) #Requires this
#teen_clusters_optimal<-kmeansruns(interests, krange=2:10) #finds the "best"" K between 2 and 10
#teen_clusters_optimal$bestk
```

**Creating an Aggregate Profile for Our Clusters**

To create "meaning" for our clusters, we need to give each cluster an "identity."

```
teen_clusters_5$size #Get the size of each cluster
```

```
## [1]  4216  1538 18973   773  4500
```

```
Clusters_5<-data.frame(teen_clusters_5$centers) #Put the cluster centroids into a data frame
Clusters_5<-data.frame(t(teen_clusters_5$centers)) #Transpose for easier reading
```

We can sort the centroids for each cluster to see what the teens were writing on their profiles.

```
Clusters_5[order(-Clusters_5$X1), ]
```

```
##                    X1         X2         X3         X4         X5
## music        2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## band         1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
## rock         0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## god          0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## dance        0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## hair         0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## shopping     0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## cute         0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## football     0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## church       0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## die          0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## mall         0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## basketball   0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## sex          0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## marching     0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
## swimming     0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## clothes      0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## sports       0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
## sexy         0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## death        0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## dress        0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## soccer       0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## hot          0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## jesus        0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## kissed       0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## tennis       0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## softball     0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## volleyball   0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## baseball     0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
## drunk        0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## drugs        0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## blonde       0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## hollister    0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## abercrombie  0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## bible        0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
```

```
Clusters_5[order(-Clusters_5$X2), ]
```

```
##                    X1         X2         X3         X4         X5
## dance        0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## god          0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## music        2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## church       0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## jesus        0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## hair         0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## shopping     0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## cute         0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## die          0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## band         1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
```

```
## rock         0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## basketball   0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## mall         0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## football     0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## dress        0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## clothes      0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## death        0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## sexy         0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## hot          0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## sex          0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## softball     0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## swimming     0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## sports       0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
## soccer       0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## volleyball   0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## bible        0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
## drunk        0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## blonde       0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## kissed       0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## baseball     0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
## tennis       0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## hollister    0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## abercrombie  0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## drugs        0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
## marching     0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
```

```
Clusters_5[order(-Clusters_5$X3), ]
```

```
##                    X1         X2         X3         X4         X5
## music        2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## god          0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## shopping     0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## dance        0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## cute         0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## football     0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## hair         0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## rock         0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## mall         0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## basketball   0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## die          0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## church       0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## sexy         0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## band         1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
## swimming     0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## sports       0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
## sex          0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## soccer       0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## hot          0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## volleyball   0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## death        0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## softball     0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## clothes      0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## baseball     0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
```

```
## tennis       0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## jesus        0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## dress        0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## drunk        0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## hollister    0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## kissed       0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## blonde       0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## abercrombie  0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## drugs        0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
## marching     0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
## bible        0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
```

```
Clusters_5[order(-Clusters_5$X4), ]
```

```
##                    X1         X2         X3         X4         X5
## hair         0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## sex          0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## music        2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## kissed       0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## rock         0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## blonde       0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## dance        0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## die          0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## cute         0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## god          0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## band         1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
## clothes      0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## basketball   0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## mall         0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## football     0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## drugs        0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
## shopping     0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## sports       0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
## drunk        0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## sexy         0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## soccer       0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## death        0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## church       0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## baseball     0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
## dress        0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## softball     0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## hot          0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## swimming     0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## hollister    0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## volleyball   0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## abercrombie  0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## tennis       0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## jesus        0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## marching     0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
## bible        0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
```

```
Clusters_5[order(-Clusters_5$X5), ]
```

```
##                      X1         X2         X3         X4         X5
## hair          0.32756167 0.51560468 0.15042429 4.47736093 0.93066667
## shopping      0.32447818 0.49024707 0.19991567 0.67270375 0.92333333
## cute          0.25996205 0.47854356 0.16381173 0.94954722 0.89155556
## soccer        0.12096774 0.14629389 0.08296000 0.49547219 0.88688889
## basketball    0.18833017 0.31859558 0.12828757 0.79689521 0.81911111
## mall          0.20208729 0.31144343 0.13603542 0.78395860 0.71177778
## music         2.43050285 0.91742523 0.28292837 2.70245796 0.67111111
## church        0.22770398 0.77113134 0.11864228 0.40362225 0.60800000
## football      0.23268501 0.29648895 0.15363938 0.71021992 0.59288889
## softball      0.10341556 0.15799740 0.07647710 0.36351876 0.53888889
## god           0.40702087 3.09882965 0.23812787 0.94566624 0.49511111
## dance         0.33942125 3.11053316 0.18916355 1.09443726 0.46777778
## volleyball    0.09582543 0.13524057 0.08090444 0.26908150 0.43088889
## clothes       0.15085389 0.23732120 0.07452696 0.84346701 0.30844444
## rock          0.42955408 0.32509753 0.13698414 1.41009056 0.28888889
## swimming      0.15417457 0.15669701 0.09007537 0.32341527 0.26266667
## hot           0.11835863 0.20221066 0.08164233 0.34152652 0.26111111
## sports        0.14302657 0.15149545 0.08996996 0.62483829 0.26066667
## cheerleading 0.06783681 0.15734720 0.06920361 0.29236740 0.25155556
## die           0.21513283 0.35825748 0.12270068 0.95730918 0.22155556
## baseball      0.09369070 0.08972692 0.07046856 0.38809832 0.21733333
## dress         0.12286528 0.24187256 0.06177199 0.37645537 0.21688889
## sex           0.18477230 0.18985696 0.08970642 3.40491591 0.19488889
## sexy          0.14255218 0.20676203 0.10789016 0.51487710 0.19377778
## blonde        0.06499051 0.10078023 0.03868655 1.28978008 0.17955556
## band          1.18927894 0.34980494 0.10441153 0.85769728 0.17600000
## hollister     0.04625237 0.07932380 0.04095293 0.28201811 0.17422222
## death         0.14136622 0.22041612 0.07884889 0.42432083 0.14844444
## kissed        0.11480076 0.09947984 0.03895009 1.43596378 0.13555556
## tennis        0.10578748 0.08777633 0.06967796 0.16429495 0.13111111
## jesus         0.11598672 0.58452536 0.06756970 0.14618370 0.12866667
## drunk         0.08870968 0.12288687 0.05760818 0.57956016 0.11888889
## abercrombie   0.03130930 0.07022107 0.03025352 0.24450194 0.11822222
## drugs         0.07068311 0.06306892 0.02529911 0.67917206 0.09177778
## bible         0.02371917 0.12418726 0.01054130 0.03492885 0.02711111
## marching      0.17314991 0.03706112 0.01644442 0.06597671 0.01511111
```

**Cluster 1** (4,216 teens): music, band. Other words with smaller centroids: rock, god, dance, hair, shopping, cute, football, church.

Are these the "band kids"?

**Cluster 2** (1,538 teens): dance, god. Other words with smaller centroids: music, church, jesus, hair, shopping, cute, die, band.

Are these the "religious/church" kids?

**Cluster 3** (18,973 teens): All very low centroid values: music, god, shopping, dance, cute, football, hair, rock, mall, basketball

Who are these "kids"? The "basket cases"?

**Cluster 4** (773 teens): hair, sex, music, kissed, rock, blonde. Other words with smaller centroids: dance, die, cute, god

Are these "princesses"?

**Cluster 5** (4,500 teens): Moderate centroid values: hair, shopping, cute, soccer, basketball, mall, music, church, football, softball

Who are these "kids"? Another "basket cases"?

Let's add back the demographic information.

```
# apply the cluster IDs to the original data frame
teens$cluster <- teen_clusters_5$cluster #adds the cluster number to each recond

# mean age by cluster
aggregate(data = teens, age ~ cluster, mean)
```

```
##   cluster      age
## 1       1 17.27793
## 2       2 17.20026
## 3       3 17.29521
## 4       4 17.04603
## 5       5 17.00078
```

```
# proportion of females by cluster
aggregate(data = teens, female ~ cluster, mean)
```

```
##   cluster    female
## 1       1 0.7352941
## 2       2 0.8146944
## 3       3 0.6954093
## 4       4 0.8680466
## 5       5 0.8524444
```

```
# mean number of friends by cluster
aggregate(data = teens, friends ~ cluster, mean)
```

```
##   cluster  friends
## 1       1 30.74763
## 2       2 35.92133
## 3       3 27.57076
## 4       4 30.31824
## 5       5 38.65978
```

## K-Medoid Clustering

The problem with k-means is that it is sensitive to outliers. A workaround to this issue is k-medoids clustering. Instead of finding centroids, we find medoids. What is a medoid? Medoid is just basically the most "central" data point in a cluster. Instead of finding the mean point in a cluster, we just choose one of the existing data points in each cluster to make it the "center."