Lab 2

Elizabeth McHugh

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More Basic R Skills

- Create a function `my_reverse` which takes as required input a vector and returns the vector in reverse where the first entry is the last entry, etc. No function calls are allowed inside your function otherwise that would defeat the purpose of the exercise! (Yes, there is a base R function that does this called `rev`). Use `head` on `v` and `tail` on `my_reverse(v)` to verify it works.

```
my_reverse = function(v) {
  v_rev = rep(NA, times = length(v))
  for (i in length(v):1) {
    v_rev[length(v) - i + 1] = v[i]
  }
  v_rev
}

v = 1:10
my_reverse(v)
```

```
##  [1] 10  9  8  7  6  5  4  3  2  1
```

- Create a function `flip_matrix` which takes as required input a matrix, an argument `dim_to_rev` that returns the matrix with the rows in reverse order or the columns in reverse order depending on the `dim_to_rev` argument. Let the default be the dimension of the matrix that is greater.

```
flip_matrix = function(X, dim_to_rev = NULL) {
  if(is.null(dim_to_rev)) {
    dim_to_rev = ifelse(nrow(X) >= ncol(X), "rows", "cols")
  }
  if( dim_to_rev == "rows"){
    X[my_reverse(1:nrow(X)), ]
  }else if(dim_to_rev == "cols"){
    X[,my_reverse(1:ncol(X))]
  }else {
  stop ("Illegal arg")
  }
}

X = matrix(rnorm(100), nrow = 25)
X
```

```
##              [,1]        [,2]        [,3]         [,4]
##  [1,] -0.45790570 -0.14879030 -0.99756201 -0.003488411
##  [2,]  0.03777444 -0.04004554  1.01761954 -0.047022091
##  [3,]  0.79322150 -0.24307544 -0.53571186  0.276627526
##  [4,] -1.70394199  0.49783593 -0.08689574  0.490000332
##  [5,] -1.52214618  0.60858879  0.97687508  0.284934142
##  [6,]  0.75179472 -0.30007657  0.81809142  0.915941380
##  [7,]  0.66303295 -2.22314559 -1.89917148 -0.244040825
##  [8,] -0.26997510 -1.19268914  1.67443451 -1.595534476
##  [9,] -0.03855199  0.40409906 -0.13570225 -0.701144175
## [10,] -0.38494959  0.06828407  0.30073685  0.531538747
## [11,]  0.53493403 -0.70008284 -0.33545482  0.061082205
## [12,] -0.92670105  1.12355574 -1.26040153  0.361358870
## [13,] -0.70572227  0.54002846  1.18569272  0.813428537
## [14,] -0.01934126  1.63418497  1.08075465  1.056313456
## [15,]  0.01395542  0.15235446 -0.36305716  1.030089132
## [16,] -0.44760456 -1.30663872 -1.61111227 -0.103075071
## [17,]  0.53137382  1.73059912  1.14050216  1.383900602
## [18,]  0.45194564 -0.91043732 -0.95416359 -1.702056992
## [19,]  0.66987134  1.58355301  2.32742668 -0.141329267
## [20,]  0.32262690 -0.22333635 -0.06770239 -1.100432340
## [21,]  0.10740819  0.55797787 -0.97996409 -0.096867246
## [22,]  1.58677767  0.17966237  0.35555033  0.483453799
## [23,]  1.38244797  0.50779538 -1.95703616 -0.461716930
## [24,] -1.39992198  0.33246691  0.28750103 -1.095527264
## [25,]  0.10411140 -0.48211164  0.77364251 -1.053789542
```

- Create a list named `my_list` with keys "A", "B", … where the entries are arrays of size 1, 2 x 2, 3 x 3 x 3, etc. Fill the array with the numbers 1, 2, 3, etc. Make 8 entries according to this sequence.

```
arrays = list()
new_dim = c()

LETTERS
```

```
##  [1] "A" "B" "C" "D" "E" "F" "G" "H" "I" "J" "K" "L" "M" "N" "O" "P" "Q" "R" "S"
## [20] "T" "U" "V" "W" "X" "Y" "Z"
```

```
for (i in 1:8){
  new_dim = c( rep( i, times = i))
  arrays[[LETTERS[i]]] = array(data = 1:(i^i), dim = new_dim)

}

my_list = arrays

my_list["C"]
```

```
## $C
## , , 1
##
##      [,1] [,2] [,3]
```

```
## [1,]    1    4    7
## [2,]    2    5    8
## [3,]    3    6    9
##
## , , 2
##
##      [,1] [,2] [,3]
## [1,]   10   13   16
## [2,]   11   14   17
## [3,]   12   15   18
##
## , , 3
##
##      [,1] [,2] [,3]
## [1,]   19   22   25
## [2,]   20   23   26
## [3,]   21   24   27
```

Run the following code:

```
lapply(my_list, object.size)
```

```
## $A
## 224 bytes
##
## $B
## 232 bytes
##
## $C
## 352 bytes
##
## $D
## 1248 bytes
##
## $E
## 12744 bytes
##
## $F
## 186864 bytes
##
## $G
## 3294416 bytes
##
## $H
## 67109104 bytes
```

Use `?object.size` to read about what these functions do. Then explain the output you see above. For the later arrays, does it make sense given the dimensions of the arrays?

The output gives the storage size allotted for each matrix in the list. It makes sense that the size should increase greatly with increasing dimensions. (However, I need to think about the exactness of the size for a little bit longer.)

Now cleanup the namespace by deleting all stored objects and functions:

```
rm(list = ls())
```

A little about strings

- Use the `strsplit` function and `sample` to put the sentences in the string `lorem` below in random order. You will also need to manipulate the output of `strsplit` which is a list. You may need to learn basic concepts of regular expressions.

```
lorem = "Lorem ipsum dolor sit amet, consectetur adipiscing elit. Morbi posuere varius volutpat. Morbi

sample( unlist( strsplit( lorem, "[.]") ) )
```

```
##  [1] " Cras suscipit id nibh lacinia elementum"
##  [2] " Donec vehicula sagittis nisi non semper"
##  [3] " Morbi faucibus ligula id massa ultricies viverra"
##  [4] " "
##  [5] " Aenean nulla ante, iaculis sed vehicula ac, finibus vel arcu"
##  [6] " Integer dapibus mi lectus, eu posuere arcu ultricies in"
##  [7] " Mauris at sodales augue"
##  [8] " Curabitur est augue, congue eget quam in, scelerisque semper magna"
##  [9] "Lorem ipsum dolor sit amet, consectetur adipiscing elit"
## [10] " Donec at tempor erat"
## [11] " Morbi posuere varius volutpat"
```

You have a set of names divided by gender (M / F) and generation (Boomer / GenX / Millennial):

- M / Boomer "Theodore, Bernard, Gene, Herbert, Ray, Tom, Lee, Alfred, Leroy, Eddie"
- M / GenX "Marc, Jamie, Greg, Darryl, Tim, Dean, Jon, Chris, Troy, Jeff"
- M / Millennial "Zachary, Dylan, Christian, Wesley, Seth, Austin, Gabriel, Evan, Casey, Luis"
- F / Boomer "Gloria, Joan, Dorothy, Shirley, Betty, Dianne, Kay, Marjorie, Lorraine, Mildred"
- F / GenX "Tracy, Dawn, Tina, Tammy, Melinda, Tamara, Tracey, Colleen, Sherri, Heidi"
- F / Millennial "Samantha, Alexis, Brittany, Lauren, Taylor, Bethany, Latoya, Candice, Brittney, Cheyenne"

Create a list-within-a-list that will intelligently store this data.

```
#Separate original strings into lists of names

Boomer_M_list = strsplit("Theodore, Bernard, Gene, Herbert, Ray, Tom, Lee, Alfred, Leroy, Eddie", "[,]"
GenX_M_list = strsplit("Marc, Jamie, Greg, Darryl, Tim, Dean, Jon, Chris, Troy, Jeff", "[,]")
Millennial_M_list = strsplit("Zachary, Dylan, Christian, Wesley, Seth, Austin, Gabriel, Evan, Casey, Lu

Boomer_F_list = strsplit("Gloria, Joan, Dorothy, Shirley, Betty, Dianne, Kay, Marjorie, Lorraine, Mildr
GenX_F_list = strsplit("Tracy, Dawn, Tina, Tammy, Melinda, Tamara, Tracey, Colleen, Sherri, Heidi", "[,
Millennial_F_list = strsplit("Samantha, Alexis, Brittany, Lauren, Taylor, Bethany, Latoya, Candice, Bri

#Create male sub-list
male = list()

male$Boomer = Boomer_M_list[[1]]
male$GenX = GenX_M_list[[1]]
```

```
male$Millennial = Millennial_M_list[[1]]

#male

#Create female sub-list
female = list()

female$Boomer = Boomer_F_list[[1]]
female$GenX = GenX_F_list[[1]]
female$Millennial = Millennial_F_list[[1]]

#female

#Create combined list
names = list(Male = male, Female = female)
names
```

```
## $Male
## $Male$Boomer
##  [1] "Theodore" " Bernard" " Gene"    " Herbert" " Ray"     " Tom"
##  [7] " Lee"     " Alfred"  " Leroy"   " Eddie"
##
## $Male$GenX
##  [1] "Marc"    " Jamie"  " Greg"   " Darryl" " Tim"    " Dean"   " Jon"
##  [8] " Chris"  " Troy"   " Jeff"
##
## $Male$Millennial
##  [1] "Zachary"    " Dylan"     " Christian" " Wesley"    " Seth"
##  [6] " Austin"    " Gabriel"   " Evan"      " Casey"     " Luis"
##
##
## $Female
## $Female$Boomer
##  [1] "Gloria"    " Joan"     " Dorothy"  " Shirley"  " Betty"    " Dianne"
##  [7] " Kay"      " Marjorie" " Lorraine" " Mildred"
##
## $Female$GenX
##  [1] "Tracy"    " Dawn"    " Tina"    " Tammy"   " Melinda" " Tamara"
##  [7] " Tracey"  " Colleen" " Sherri"  " Heidi"
##
## $Female$Millennial
##  [1] "Samantha"  " Alexis"   " Brittany" " Lauren"   " Taylor"   " Bethany"
##  [7] " Latoya"   " Candice"  " Brittney" " Cheyenne"
```

```
#Just for testing purposes
#names$Female
#names$Male
#names$Male$Millennial
#?c
#?list
```

Dataframe creation

Imagine you are running an experiment with many manipulations. You have 14 levels in the variable "treatment" with levels a, b, c, etc. For each of those manipulations you have 3 submanipulations in a variable named "variation" with levels A, B, C. Then you have "gender" with levels M / F. Then you have "generation" with levels Boomer, GenX, Millennial. Then you will have 6 runs per each of these groups. In each set of 6 you will need to select a name without duplication from the appropriate set of names (from the last question). Create a data frame with columns treatment, variation, gender, generation, name and y that will store all the unique unit information in this experiment. Leave y empty because it will be measured as the experiment is executed.

???? Either names should be 10 each or n should be 14*3*2*3*6, not 14*3*2*3*10 as provided. ?????

```
n = 14 * 3 * 2 * 3 * 6

X = data.frame(treatment = rep(NA, n), variation = rep(NA, n), gender = rep(NA, n), generation = rep(NA

X$treatment = rep(letters[1:14], each = n/14)
X$variation = rep(LETTERS[1:3], each = n/(14*3))
X$gender = rep(c("F", "M"), each = n/(14*3*2))
X$generation = rep(c("Boomer", "GenX", "Millennial"), each = n/(14*3*2*3))

fb = sample(names$Female$Boomer, 6)
fg = sample(names$Female$GenX, 6)
fm = sample(names$Female$Millennial, 6)
mb= sample(names$Male$Boomer, 6)
mg = sample(names$Male$GenX, 6)
mm = sample(names$Male$Millennial, 6)


X$name = rep(c(fb, fg, fm, mb, mg, mm), n/(14*3*2*3))



#For testing purposes
X
```

```
##      treatment variation gender generation       name  y
## 1            a         A      F     Boomer    Shirley NA
## 2            a         A      F     Boomer     Gloria NA
## 3            a         A      F     Boomer   Marjorie NA
## 4            a         A      F     Boomer     Dianne NA
## 5            a         A      F     Boomer    Mildred NA
## 6            a         A      F     Boomer      Betty NA
## 7            a         A      F       GenX      Tracy NA
## 8            a         A      F       GenX       Tina NA
## 9            a         A      F       GenX      Heidi NA
## 10           a         A      F       GenX     Tamara NA
## 11           a         A      F       GenX       Dawn NA
## 12           a         A      F       GenX    Colleen NA
## 13           a         A      F Millennial     Alexis NA
## 14           a         A      F Millennial    Bethany NA
## 15           a         A      F Millennial   Cheyenne NA
## 16           a         A      F Millennial   Brittany NA
```

```
## 17          a         A      F Millennial    Candice NA
## 18          a         A      F Millennial     Latoya NA
## 19          a         A      M     Boomer        Ray NA
## 20          a         A      M     Boomer        Lee NA
## 21          a         A      M     Boomer        Tom NA
## 22          a         A      M     Boomer      Leroy NA
## 23          a         A      M     Boomer      Eddie NA
## 24          a         A      M     Boomer    Bernard NA
## 25          a         A      M       GenX       Jeff NA
## 26          a         A      M       GenX       Marc NA
## 27          a         A      M       GenX      Chris NA
## 28          a         A      M       GenX      Jamie NA
## 29          a         A      M       GenX        Jon NA
## 30          a         A      M       GenX        Tim NA
## 31          a         A      M Millennial     Austin NA
## 32          a         A      M Millennial       Evan NA
## 33          a         A      M Millennial       Luis NA
## 34          a         A      M Millennial    Zachary NA
## 35          a         A      M Millennial  Christian NA
## 36          a         A      M Millennial     Wesley NA
## 37          a         B      F     Boomer    Shirley NA
## 38          a         B      F     Boomer     Gloria NA
## 39          a         B      F     Boomer   Marjorie NA
## 40          a         B      F     Boomer     Dianne NA
## 41          a         B      F     Boomer    Mildred NA
## 42          a         B      F     Boomer      Betty NA
## 43          a         B      F       GenX      Tracy NA
## 44          a         B      F       GenX       Tina NA
## 45          a         B      F       GenX      Heidi NA
## 46          a         B      F       GenX     Tamara NA
## 47          a         B      F       GenX       Dawn NA
## 48          a         B      F       GenX    Colleen NA
## 49          a         B      F Millennial     Alexis NA
## 50          a         B      F Millennial    Bethany NA
## 51          a         B      F Millennial   Cheyenne NA
## 52          a         B      F Millennial   Brittany NA
## 53          a         B      F Millennial    Candice NA
## 54          a         B      F Millennial     Latoya NA
## 55          a         B      M     Boomer        Ray NA
## 56          a         B      M     Boomer        Lee NA
## 57          a         B      M     Boomer        Tom NA
## 58          a         B      M     Boomer      Leroy NA
## 59          a         B      M     Boomer      Eddie NA
## 60          a         B      M     Boomer    Bernard NA
## 61          a         B      M       GenX       Jeff NA
## 62          a         B      M       GenX       Marc NA
## 63          a         B      M       GenX      Chris NA
## 64          a         B      M       GenX      Jamie NA
## 65          a         B      M       GenX        Jon NA
## 66          a         B      M       GenX        Tim NA
## 67          a         B      M Millennial     Austin NA
## 68          a         B      M Millennial       Evan NA
## 69          a         B      M Millennial       Luis NA
## 70          a         B      M Millennial    Zachary NA
```

```
## 71          a         B      M Millennial  Christian NA
## 72          a         B      M Millennial     Wesley NA
## 73          a         C      F     Boomer    Shirley NA
## 74          a         C      F     Boomer     Gloria NA
## 75          a         C      F     Boomer   Marjorie NA
## 76          a         C      F     Boomer     Dianne NA
## 77          a         C      F     Boomer    Mildred NA
## 78          a         C      F     Boomer      Betty NA
## 79          a         C      F       GenX      Tracy NA
## 80          a         C      F       GenX       Tina NA
## 81          a         C      F       GenX      Heidi NA
## 82          a         C      F       GenX     Tamara NA
## 83          a         C      F       GenX       Dawn NA
## 84          a         C      F       GenX    Colleen NA
## 85          a         C      F Millennial     Alexis NA
## 86          a         C      F Millennial    Bethany NA
## 87          a         C      F Millennial   Cheyenne NA
## 88          a         C      F Millennial   Brittany NA
## 89          a         C      F Millennial    Candice NA
## 90          a         C      F Millennial     Latoya NA
## 91          a         C      M     Boomer        Ray NA
## 92          a         C      M     Boomer        Lee NA
## 93          a         C      M     Boomer        Tom NA
## 94          a         C      M     Boomer      Leroy NA
## 95          a         C      M     Boomer      Eddie NA
## 96          a         C      M     Boomer    Bernard NA
## 97          a         C      M       GenX       Jeff NA
## 98          a         C      M       GenX       Marc NA
## 99          a         C      M       GenX      Chris NA
## 100         a         C      M       GenX      Jamie NA
## 101         a         C      M       GenX        Jon NA
## 102         a         C      M       GenX        Tim NA
## 103         a         C      M Millennial     Austin NA
## 104         a         C      M Millennial       Evan NA
## 105         a         C      M Millennial       Luis NA
## 106         a         C      M Millennial    Zachary NA
## 107         a         C      M Millennial  Christian NA
## 108         a         C      M Millennial     Wesley NA
## 109         b         A      F     Boomer    Shirley NA
## 110         b         A      F     Boomer     Gloria NA
## 111         b         A      F     Boomer   Marjorie NA
## 112         b         A      F     Boomer     Dianne NA
## 113         b         A      F     Boomer    Mildred NA
## 114         b         A      F     Boomer      Betty NA
## 115         b         A      F       GenX      Tracy NA
## 116         b         A      F       GenX       Tina NA
## 117         b         A      F       GenX      Heidi NA
## 118         b         A      F       GenX     Tamara NA
## 119         b         A      F       GenX       Dawn NA
## 120         b         A      F       GenX    Colleen NA
## 121         b         A      F Millennial     Alexis NA
## 122         b         A      F Millennial    Bethany NA
## 123         b         A      F Millennial   Cheyenne NA
## 124         b         A      F Millennial   Brittany NA
```

```
## 125          b         A      F Millennial    Candice NA
## 126          b         A      F Millennial     Latoya NA
## 127          b         A      M     Boomer        Ray NA
## 128          b         A      M     Boomer        Lee NA
## 129          b         A      M     Boomer        Tom NA
## 130          b         A      M     Boomer      Leroy NA
## 131          b         A      M     Boomer      Eddie NA
## 132          b         A      M     Boomer    Bernard NA
## 133          b         A      M       GenX       Jeff NA
## 134          b         A      M       GenX       Marc NA
## 135          b         A      M       GenX      Chris NA
## 136          b         A      M       GenX      Jamie NA
## 137          b         A      M       GenX        Jon NA
## 138          b         A      M       GenX        Tim NA
## 139          b         A      M Millennial     Austin NA
## 140          b         A      M Millennial       Evan NA
## 141          b         A      M Millennial       Luis NA
## 142          b         A      M Millennial    Zachary NA
## 143          b         A      M Millennial  Christian NA
## 144          b         A      M Millennial     Wesley NA
## 145          b         B      F     Boomer    Shirley NA
## 146          b         B      F     Boomer     Gloria NA
## 147          b         B      F     Boomer   Marjorie NA
## 148          b         B      F     Boomer     Dianne NA
## 149          b         B      F     Boomer    Mildred NA
## 150          b         B      F     Boomer      Betty NA
## 151          b         B      F       GenX      Tracy NA
## 152          b         B      F       GenX       Tina NA
## 153          b         B      F       GenX      Heidi NA
## 154          b         B      F       GenX     Tamara NA
## 155          b         B      F       GenX       Dawn NA
## 156          b         B      F       GenX    Colleen NA
## 157          b         B      F Millennial     Alexis NA
## 158          b         B      F Millennial    Bethany NA
## 159          b         B      F Millennial   Cheyenne NA
## 160          b         B      F Millennial   Brittany NA
## 161          b         B      F Millennial    Candice NA
## 162          b         B      F Millennial     Latoya NA
## 163          b         B      M     Boomer        Ray NA
## 164          b         B      M     Boomer        Lee NA
## 165          b         B      M     Boomer        Tom NA
## 166          b         B      M     Boomer      Leroy NA
## 167          b         B      M     Boomer      Eddie NA
## 168          b         B      M     Boomer    Bernard NA
## 169          b         B      M       GenX       Jeff NA
## 170          b         B      M       GenX       Marc NA
## 171          b         B      M       GenX      Chris NA
## 172          b         B      M       GenX      Jamie NA
## 173          b         B      M       GenX        Jon NA
## 174          b         B      M       GenX        Tim NA
## 175          b         B      M Millennial     Austin NA
## 176          b         B      M Millennial       Evan NA
## 177          b         B      M Millennial       Luis NA
## 178          b         B      M Millennial    Zachary NA
```

```
## 179          b         B      M Millennial  Christian NA
## 180          b         B      M Millennial     Wesley NA
## 181          b         C      F     Boomer    Shirley NA
## 182          b         C      F     Boomer     Gloria NA
## 183          b         C      F     Boomer   Marjorie NA
## 184          b         C      F     Boomer     Dianne NA
## 185          b         C      F     Boomer    Mildred NA
## 186          b         C      F     Boomer      Betty NA
## 187          b         C      F       GenX      Tracy NA
## 188          b         C      F       GenX       Tina NA
## 189          b         C      F       GenX      Heidi NA
## 190          b         C      F       GenX     Tamara NA
## 191          b         C      F       GenX       Dawn NA
## 192          b         C      F       GenX    Colleen NA
## 193          b         C      F Millennial     Alexis NA
## 194          b         C      F Millennial    Bethany NA
## 195          b         C      F Millennial   Cheyenne NA
## 196          b         C      F Millennial   Brittany NA
## 197          b         C      F Millennial    Candice NA
## 198          b         C      F Millennial     Latoya NA
## 199          b         C      M     Boomer        Ray NA
## 200          b         C      M     Boomer        Lee NA
## 201          b         C      M     Boomer        Tom NA
## 202          b         C      M     Boomer      Leroy NA
## 203          b         C      M     Boomer      Eddie NA
## 204          b         C      M     Boomer    Bernard NA
## 205          b         C      M       GenX       Jeff NA
## 206          b         C      M       GenX       Marc NA
## 207          b         C      M       GenX      Chris NA
## 208          b         C      M       GenX      Jamie NA
## 209          b         C      M       GenX        Jon NA
## 210          b         C      M       GenX        Tim NA
## 211          b         C      M Millennial     Austin NA
## 212          b         C      M Millennial       Evan NA
## 213          b         C      M Millennial       Luis NA
## 214          b         C      M Millennial    Zachary NA
## 215          b         C      M Millennial  Christian NA
## 216          b         C      M Millennial     Wesley NA
## 217          c         A      F     Boomer    Shirley NA
## 218          c         A      F     Boomer     Gloria NA
## 219          c         A      F     Boomer   Marjorie NA
## 220          c         A      F     Boomer     Dianne NA
## 221          c         A      F     Boomer    Mildred NA
## 222          c         A      F     Boomer      Betty NA
## 223          c         A      F       GenX      Tracy NA
## 224          c         A      F       GenX       Tina NA
## 225          c         A      F       GenX      Heidi NA
## 226          c         A      F       GenX     Tamara NA
## 227          c         A      F       GenX       Dawn NA
## 228          c         A      F       GenX    Colleen NA
## 229          c         A      F Millennial     Alexis NA
## 230          c         A      F Millennial    Bethany NA
## 231          c         A      F Millennial   Cheyenne NA
## 232          c         A      F Millennial   Brittany NA
```

```
## 233          c         A      F Millennial    Candice NA
## 234          c         A      F Millennial     Latoya NA
## 235          c         A      M     Boomer        Ray NA
## 236          c         A      M     Boomer        Lee NA
## 237          c         A      M     Boomer        Tom NA
## 238          c         A      M     Boomer      Leroy NA
## 239          c         A      M     Boomer      Eddie NA
## 240          c         A      M     Boomer    Bernard NA
## 241          c         A      M       GenX       Jeff NA
## 242          c         A      M       GenX       Marc NA
## 243          c         A      M       GenX      Chris NA
## 244          c         A      M       GenX      Jamie NA
## 245          c         A      M       GenX        Jon NA
## 246          c         A      M       GenX        Tim NA
## 247          c         A      M Millennial     Austin NA
## 248          c         A      M Millennial       Evan NA
## 249          c         A      M Millennial       Luis NA
## 250          c         A      M Millennial    Zachary NA
## 251          c         A      M Millennial  Christian NA
## 252          c         A      M Millennial     Wesley NA
## 253          c         B      F     Boomer    Shirley NA
## 254          c         B      F     Boomer     Gloria NA
## 255          c         B      F     Boomer   Marjorie NA
## 256          c         B      F     Boomer     Dianne NA
## 257          c         B      F     Boomer    Mildred NA
## 258          c         B      F     Boomer      Betty NA
## 259          c         B      F       GenX      Tracy NA
## 260          c         B      F       GenX       Tina NA
## 261          c         B      F       GenX      Heidi NA
## 262          c         B      F       GenX     Tamara NA
## 263          c         B      F       GenX       Dawn NA
## 264          c         B      F       GenX    Colleen NA
## 265          c         B      F Millennial     Alexis NA
## 266          c         B      F Millennial    Bethany NA
## 267          c         B      F Millennial   Cheyenne NA
## 268          c         B      F Millennial   Brittany NA
## 269          c         B      F Millennial    Candice NA
## 270          c         B      F Millennial     Latoya NA
## 271          c         B      M     Boomer        Ray NA
## 272          c         B      M     Boomer        Lee NA
## 273          c         B      M     Boomer        Tom NA
## 274          c         B      M     Boomer      Leroy NA
## 275          c         B      M     Boomer      Eddie NA
## 276          c         B      M     Boomer    Bernard NA
## 277          c         B      M       GenX       Jeff NA
## 278          c         B      M       GenX       Marc NA
## 279          c         B      M       GenX      Chris NA
## 280          c         B      M       GenX      Jamie NA
## 281          c         B      M       GenX        Jon NA
## 282          c         B      M       GenX        Tim NA
## 283          c         B      M Millennial     Austin NA
## 284          c         B      M Millennial       Evan NA
## 285          c         B      M Millennial       Luis NA
## 286          c         B      M Millennial    Zachary NA
```

```
## 287          c         B      M Millennial  Christian NA
## 288          c         B      M Millennial     Wesley NA
## 289          c         C      F     Boomer    Shirley NA
## 290          c         C      F     Boomer     Gloria NA
## 291          c         C      F     Boomer   Marjorie NA
## 292          c         C      F     Boomer     Dianne NA
## 293          c         C      F     Boomer    Mildred NA
## 294          c         C      F     Boomer      Betty NA
## 295          c         C      F       GenX      Tracy NA
## 296          c         C      F       GenX       Tina NA
## 297          c         C      F       GenX      Heidi NA
## 298          c         C      F       GenX     Tamara NA
## 299          c         C      F       GenX       Dawn NA
## 300          c         C      F       GenX    Colleen NA
## 301          c         C      F Millennial     Alexis NA
## 302          c         C      F Millennial    Bethany NA
## 303          c         C      F Millennial   Cheyenne NA
## 304          c         C      F Millennial   Brittany NA
## 305          c         C      F Millennial    Candice NA
## 306          c         C      F Millennial     Latoya NA
## 307          c         C      M     Boomer        Ray NA
## 308          c         C      M     Boomer        Lee NA
## 309          c         C      M     Boomer        Tom NA
## 310          c         C      M     Boomer      Leroy NA
## 311          c         C      M     Boomer      Eddie NA
## 312          c         C      M     Boomer    Bernard NA
## 313          c         C      M       GenX       Jeff NA
## 314          c         C      M       GenX       Marc NA
## 315          c         C      M       GenX      Chris NA
## 316          c         C      M       GenX      Jamie NA
## 317          c         C      M       GenX        Jon NA
## 318          c         C      M       GenX        Tim NA
## 319          c         C      M Millennial     Austin NA
## 320          c         C      M Millennial       Evan NA
## 321          c         C      M Millennial       Luis NA
## 322          c         C      M Millennial    Zachary NA
## 323          c         C      M Millennial  Christian NA
## 324          c         C      M Millennial     Wesley NA
## 325          d         A      F     Boomer    Shirley NA
## 326          d         A      F     Boomer     Gloria NA
## 327          d         A      F     Boomer   Marjorie NA
## 328          d         A      F     Boomer     Dianne NA
## 329          d         A      F     Boomer    Mildred NA
## 330          d         A      F     Boomer      Betty NA
## 331          d         A      F       GenX      Tracy NA
## 332          d         A      F       GenX       Tina NA
## 333          d         A      F       GenX      Heidi NA
## 334          d         A      F       GenX     Tamara NA
## 335          d         A      F       GenX       Dawn NA
## 336          d         A      F       GenX    Colleen NA
## 337          d         A      F Millennial     Alexis NA
## 338          d         A      F Millennial    Bethany NA
## 339          d         A      F Millennial   Cheyenne NA
## 340          d         A      F Millennial   Brittany NA
```

```
## 341          d         A      F Millennial    Candice NA
## 342          d         A      F Millennial     Latoya NA
## 343          d         A      M     Boomer        Ray NA
## 344          d         A      M     Boomer        Lee NA
## 345          d         A      M     Boomer        Tom NA
## 346          d         A      M     Boomer      Leroy NA
## 347          d         A      M     Boomer      Eddie NA
## 348          d         A      M     Boomer    Bernard NA
## 349          d         A      M       GenX       Jeff NA
## 350          d         A      M       GenX       Marc NA
## 351          d         A      M       GenX      Chris NA
## 352          d         A      M       GenX      Jamie NA
## 353          d         A      M       GenX        Jon NA
## 354          d         A      M       GenX        Tim NA
## 355          d         A      M Millennial     Austin NA
## 356          d         A      M Millennial       Evan NA
## 357          d         A      M Millennial       Luis NA
## 358          d         A      M Millennial    Zachary NA
## 359          d         A      M Millennial  Christian NA
## 360          d         A      M Millennial     Wesley NA
## 361          d         B      F     Boomer    Shirley NA
## 362          d         B      F     Boomer     Gloria NA
## 363          d         B      F     Boomer   Marjorie NA
## 364          d         B      F     Boomer     Dianne NA
## 365          d         B      F     Boomer    Mildred NA
## 366          d         B      F     Boomer      Betty NA
## 367          d         B      F       GenX      Tracy NA
## 368          d         B      F       GenX       Tina NA
## 369          d         B      F       GenX      Heidi NA
## 370          d         B      F       GenX     Tamara NA
## 371          d         B      F       GenX       Dawn NA
## 372          d         B      F       GenX    Colleen NA
## 373          d         B      F Millennial     Alexis NA
## 374          d         B      F Millennial    Bethany NA
## 375          d         B      F Millennial   Cheyenne NA
## 376          d         B      F Millennial   Brittany NA
## 377          d         B      F Millennial    Candice NA
## 378          d         B      F Millennial     Latoya NA
## 379          d         B      M     Boomer        Ray NA
## 380          d         B      M     Boomer        Lee NA
## 381          d         B      M     Boomer        Tom NA
## 382          d         B      M     Boomer      Leroy NA
## 383          d         B      M     Boomer      Eddie NA
## 384          d         B      M     Boomer    Bernard NA
## 385          d         B      M       GenX       Jeff NA
## 386          d         B      M       GenX       Marc NA
## 387          d         B      M       GenX      Chris NA
## 388          d         B      M       GenX      Jamie NA
## 389          d         B      M       GenX        Jon NA
## 390          d         B      M       GenX        Tim NA
## 391          d         B      M Millennial     Austin NA
## 392          d         B      M Millennial       Evan NA
## 393          d         B      M Millennial       Luis NA
## 394          d         B      M Millennial    Zachary NA
```

```
## 395          d         B      M Millennial  Christian NA
## 396          d         B      M Millennial     Wesley NA
## 397          d         C      F     Boomer    Shirley NA
## 398          d         C      F     Boomer     Gloria NA
## 399          d         C      F     Boomer   Marjorie NA
## 400          d         C      F     Boomer     Dianne NA
## 401          d         C      F     Boomer    Mildred NA
## 402          d         C      F     Boomer      Betty NA
## 403          d         C      F       GenX      Tracy NA
## 404          d         C      F       GenX       Tina NA
## 405          d         C      F       GenX      Heidi NA
## 406          d         C      F       GenX     Tamara NA
## 407          d         C      F       GenX       Dawn NA
## 408          d         C      F       GenX    Colleen NA
## 409          d         C      F Millennial     Alexis NA
## 410          d         C      F Millennial    Bethany NA
## 411          d         C      F Millennial   Cheyenne NA
## 412          d         C      F Millennial   Brittany NA
## 413          d         C      F Millennial    Candice NA
## 414          d         C      F Millennial     Latoya NA
## 415          d         C      M     Boomer        Ray NA
## 416          d         C      M     Boomer        Lee NA
## 417          d         C      M     Boomer        Tom NA
## 418          d         C      M     Boomer      Leroy NA
## 419          d         C      M     Boomer      Eddie NA
## 420          d         C      M     Boomer    Bernard NA
## 421          d         C      M       GenX       Jeff NA
## 422          d         C      M       GenX       Marc NA
## 423          d         C      M       GenX      Chris NA
## 424          d         C      M       GenX      Jamie NA
## 425          d         C      M       GenX        Jon NA
## 426          d         C      M       GenX        Tim NA
## 427          d         C      M Millennial     Austin NA
## 428          d         C      M Millennial       Evan NA
## 429          d         C      M Millennial       Luis NA
## 430          d         C      M Millennial    Zachary NA
## 431          d         C      M Millennial  Christian NA
## 432          d         C      M Millennial     Wesley NA
## 433          e         A      F     Boomer    Shirley NA
## 434          e         A      F     Boomer     Gloria NA
## 435          e         A      F     Boomer   Marjorie NA
## 436          e         A      F     Boomer     Dianne NA
## 437          e         A      F     Boomer    Mildred NA
## 438          e         A      F     Boomer      Betty NA
## 439          e         A      F       GenX      Tracy NA
## 440          e         A      F       GenX       Tina NA
## 441          e         A      F       GenX      Heidi NA
## 442          e         A      F       GenX     Tamara NA
## 443          e         A      F       GenX       Dawn NA
## 444          e         A      F       GenX    Colleen NA
## 445          e         A      F Millennial     Alexis NA
## 446          e         A      F Millennial    Bethany NA
## 447          e         A      F Millennial   Cheyenne NA
## 448          e         A      F Millennial   Brittany NA
```

```
## 449          e         A      F Millennial    Candice NA
## 450          e         A      F Millennial     Latoya NA
## 451          e         A      M     Boomer        Ray NA
## 452          e         A      M     Boomer        Lee NA
## 453          e         A      M     Boomer        Tom NA
## 454          e         A      M     Boomer      Leroy NA
## 455          e         A      M     Boomer      Eddie NA
## 456          e         A      M     Boomer    Bernard NA
## 457          e         A      M       GenX       Jeff NA
## 458          e         A      M       GenX       Marc NA
## 459          e         A      M       GenX      Chris NA
## 460          e         A      M       GenX      Jamie NA
## 461          e         A      M       GenX        Jon NA
## 462          e         A      M       GenX        Tim NA
## 463          e         A      M Millennial     Austin NA
## 464          e         A      M Millennial       Evan NA
## 465          e         A      M Millennial       Luis NA
## 466          e         A      M Millennial    Zachary NA
## 467          e         A      M Millennial  Christian NA
## 468          e         A      M Millennial     Wesley NA
## 469          e         B      F     Boomer    Shirley NA
## 470          e         B      F     Boomer     Gloria NA
## 471          e         B      F     Boomer   Marjorie NA
## 472          e         B      F     Boomer     Dianne NA
## 473          e         B      F     Boomer    Mildred NA
## 474          e         B      F     Boomer      Betty NA
## 475          e         B      F       GenX      Tracy NA
## 476          e         B      F       GenX       Tina NA
## 477          e         B      F       GenX      Heidi NA
## 478          e         B      F       GenX     Tamara NA
## 479          e         B      F       GenX       Dawn NA
## 480          e         B      F       GenX    Colleen NA
## 481          e         B      F Millennial     Alexis NA
## 482          e         B      F Millennial    Bethany NA
## 483          e         B      F Millennial   Cheyenne NA
## 484          e         B      F Millennial   Brittany NA
## 485          e         B      F Millennial    Candice NA
## 486          e         B      F Millennial     Latoya NA
## 487          e         B      M     Boomer        Ray NA
## 488          e         B      M     Boomer        Lee NA
## 489          e         B      M     Boomer        Tom NA
## 490          e         B      M     Boomer      Leroy NA
## 491          e         B      M     Boomer      Eddie NA
## 492          e         B      M     Boomer    Bernard NA
## 493          e         B      M       GenX       Jeff NA
## 494          e         B      M       GenX       Marc NA
## 495          e         B      M       GenX      Chris NA
## 496          e         B      M       GenX      Jamie NA
## 497          e         B      M       GenX        Jon NA
## 498          e         B      M       GenX        Tim NA
## 499          e         B      M Millennial     Austin NA
## 500          e         B      M Millennial       Evan NA
## 501          e         B      M Millennial       Luis NA
## 502          e         B      M Millennial    Zachary NA
```

```
## 503          e         B      M Millennial  Christian NA
## 504          e         B      M Millennial     Wesley NA
## 505          e         C      F     Boomer    Shirley NA
## 506          e         C      F     Boomer     Gloria NA
## 507          e         C      F     Boomer   Marjorie NA
## 508          e         C      F     Boomer     Dianne NA
## 509          e         C      F     Boomer    Mildred NA
## 510          e         C      F     Boomer      Betty NA
## 511          e         C      F       GenX      Tracy NA
## 512          e         C      F       GenX       Tina NA
## 513          e         C      F       GenX      Heidi NA
## 514          e         C      F       GenX     Tamara NA
## 515          e         C      F       GenX       Dawn NA
## 516          e         C      F       GenX    Colleen NA
## 517          e         C      F Millennial     Alexis NA
## 518          e         C      F Millennial    Bethany NA
## 519          e         C      F Millennial   Cheyenne NA
## 520          e         C      F Millennial   Brittany NA
## 521          e         C      F Millennial    Candice NA
## 522          e         C      F Millennial     Latoya NA
## 523          e         C      M     Boomer        Ray NA
## 524          e         C      M     Boomer        Lee NA
## 525          e         C      M     Boomer        Tom NA
## 526          e         C      M     Boomer      Leroy NA
## 527          e         C      M     Boomer      Eddie NA
## 528          e         C      M     Boomer    Bernard NA
## 529          e         C      M       GenX       Jeff NA
## 530          e         C      M       GenX       Marc NA
## 531          e         C      M       GenX      Chris NA
## 532          e         C      M       GenX      Jamie NA
## 533          e         C      M       GenX        Jon NA
## 534          e         C      M       GenX        Tim NA
## 535          e         C      M Millennial     Austin NA
## 536          e         C      M Millennial       Evan NA
## 537          e         C      M Millennial       Luis NA
## 538          e         C      M Millennial    Zachary NA
## 539          e         C      M Millennial  Christian NA
## 540          e         C      M Millennial     Wesley NA
## 541          f         A      F     Boomer    Shirley NA
## 542          f         A      F     Boomer     Gloria NA
## 543          f         A      F     Boomer   Marjorie NA
## 544          f         A      F     Boomer     Dianne NA
## 545          f         A      F     Boomer    Mildred NA
## 546          f         A      F     Boomer      Betty NA
## 547          f         A      F       GenX      Tracy NA
## 548          f         A      F       GenX       Tina NA
## 549          f         A      F       GenX      Heidi NA
## 550          f         A      F       GenX     Tamara NA
## 551          f         A      F       GenX       Dawn NA
## 552          f         A      F       GenX    Colleen NA
## 553          f         A      F Millennial     Alexis NA
## 554          f         A      F Millennial    Bethany NA
## 555          f         A      F Millennial   Cheyenne NA
## 556          f         A      F Millennial   Brittany NA
```

```
## 557          f          A       F Millennial    Candice NA
## 558          f          A       F Millennial     Latoya NA
## 559          f          A       M     Boomer        Ray NA
## 560          f          A       M     Boomer        Lee NA
## 561          f          A       M     Boomer        Tom NA
## 562          f          A       M     Boomer      Leroy NA
## 563          f          A       M     Boomer      Eddie NA
## 564          f          A       M     Boomer    Bernard NA
## 565          f          A       M       GenX       Jeff NA
## 566          f          A       M       GenX       Marc NA
## 567          f          A       M       GenX      Chris NA
## 568          f          A       M       GenX      Jamie NA
## 569          f          A       M       GenX        Jon NA
## 570          f          A       M       GenX        Tim NA
## 571          f          A       M Millennial     Austin NA
## 572          f          A       M Millennial       Evan NA
## 573          f          A       M Millennial       Luis NA
## 574          f          A       M Millennial    Zachary NA
## 575          f          A       M Millennial  Christian NA
## 576          f          A       M Millennial     Wesley NA
## 577          f          B       F     Boomer    Shirley NA
## 578          f          B       F     Boomer     Gloria NA
## 579          f          B       F     Boomer   Marjorie NA
## 580          f          B       F     Boomer     Dianne NA
## 581          f          B       F     Boomer    Mildred NA
## 582          f          B       F     Boomer      Betty NA
## 583          f          B       F       GenX      Tracy NA
## 584          f          B       F       GenX       Tina NA
## 585          f          B       F       GenX      Heidi NA
## 586          f          B       F       GenX     Tamara NA
## 587          f          B       F       GenX       Dawn NA
## 588          f          B       F       GenX    Colleen NA
## 589          f          B       F Millennial     Alexis NA
## 590          f          B       F Millennial    Bethany NA
## 591          f          B       F Millennial   Cheyenne NA
## 592          f          B       F Millennial   Brittany NA
## 593          f          B       F Millennial    Candice NA
## 594          f          B       F Millennial     Latoya NA
## 595          f          B       M     Boomer        Ray NA
## 596          f          B       M     Boomer        Lee NA
## 597          f          B       M     Boomer        Tom NA
## 598          f          B       M     Boomer      Leroy NA
## 599          f          B       M     Boomer      Eddie NA
## 600          f          B       M     Boomer    Bernard NA
## 601          f          B       M       GenX       Jeff NA
## 602          f          B       M       GenX       Marc NA
## 603          f          B       M       GenX      Chris NA
## 604          f          B       M       GenX      Jamie NA
## 605          f          B       M       GenX        Jon NA
## 606          f          B       M       GenX        Tim NA
## 607          f          B       M Millennial     Austin NA
## 608          f          B       M Millennial       Evan NA
## 609          f          B       M Millennial       Luis NA
## 610          f          B       M Millennial    Zachary NA
```

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## 611          f         B      M Millennial  Christian NA
## 612          f         B      M Millennial     Wesley NA
## 613          f         C      F     Boomer    Shirley NA
## 614          f         C      F     Boomer     Gloria NA
## 615          f         C      F     Boomer   Marjorie NA
## 616          f         C      F     Boomer     Dianne NA
## 617          f         C      F     Boomer    Mildred NA
## 618          f         C      F     Boomer      Betty NA
## 619          f         C      F       GenX      Tracy NA
## 620          f         C      F       GenX       Tina NA
## 621          f         C      F       GenX      Heidi NA
## 622          f         C      F       GenX     Tamara NA
## 623          f         C      F       GenX       Dawn NA
## 624          f         C      F       GenX    Colleen NA
## 625          f         C      F Millennial     Alexis NA
## 626          f         C      F Millennial    Bethany NA
## 627          f         C      F Millennial   Cheyenne NA
## 628          f         C      F Millennial   Brittany NA
## 629          f         C      F Millennial    Candice NA
## 630          f         C      F Millennial     Latoya NA
## 631          f         C      M     Boomer        Ray NA
## 632          f         C      M     Boomer        Lee NA
## 633          f         C      M     Boomer        Tom NA
## 634          f         C      M     Boomer      Leroy NA
## 635          f         C      M     Boomer      Eddie NA
## 636          f         C      M     Boomer    Bernard NA
## 637          f         C      M       GenX       Jeff NA
## 638          f         C      M       GenX       Marc NA
## 639          f         C      M       GenX      Chris NA
## 640          f         C      M       GenX      Jamie NA
## 641          f         C      M       GenX        Jon NA
## 642          f         C      M       GenX        Tim NA
## 643          f         C      M Millennial     Austin NA
## 644          f         C      M Millennial       Evan NA
## 645          f         C      M Millennial       Luis NA
## 646          f         C      M Millennial    Zachary NA
## 647          f         C      M Millennial  Christian NA
## 648          f         C      M Millennial     Wesley NA
## 649          g         A      F     Boomer    Shirley NA
## 650          g         A      F     Boomer     Gloria NA
## 651          g         A      F     Boomer   Marjorie NA
## 652          g         A      F     Boomer     Dianne NA
## 653          g         A      F     Boomer    Mildred NA
## 654          g         A      F     Boomer      Betty NA
## 655          g         A      F       GenX      Tracy NA
## 656          g         A      F       GenX       Tina NA
## 657          g         A      F       GenX      Heidi NA
## 658          g         A      F       GenX     Tamara NA
## 659          g         A      F       GenX       Dawn NA
## 660          g         A      F       GenX    Colleen NA
## 661          g         A      F Millennial     Alexis NA
## 662          g         A      F Millennial    Bethany NA
## 663          g         A      F Millennial   Cheyenne NA
## 664          g         A      F Millennial   Brittany NA
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```
## 665          g         A      F Millennial    Candice NA
## 666          g         A      F Millennial     Latoya NA
## 667          g         A      M     Boomer        Ray NA
## 668          g         A      M     Boomer        Lee NA
## 669          g         A      M     Boomer        Tom NA
## 670          g         A      M     Boomer      Leroy NA
## 671          g         A      M     Boomer      Eddie NA
## 672          g         A      M     Boomer    Bernard NA
## 673          g         A      M       GenX       Jeff NA
## 674          g         A      M       GenX       Marc NA
## 675          g         A      M       GenX      Chris NA
## 676          g         A      M       GenX      Jamie NA
## 677          g         A      M       GenX        Jon NA
## 678          g         A      M       GenX        Tim NA
## 679          g         A      M Millennial     Austin NA
## 680          g         A      M Millennial       Evan NA
## 681          g         A      M Millennial       Luis NA
## 682          g         A      M Millennial    Zachary NA
## 683          g         A      M Millennial  Christian NA
## 684          g         A      M Millennial     Wesley NA
## 685          g         B      F     Boomer    Shirley NA
## 686          g         B      F     Boomer     Gloria NA
## 687          g         B      F     Boomer   Marjorie NA
## 688          g         B      F     Boomer     Dianne NA
## 689          g         B      F     Boomer    Mildred NA
## 690          g         B      F     Boomer      Betty NA
## 691          g         B      F       GenX      Tracy NA
## 692          g         B      F       GenX       Tina NA
## 693          g         B      F       GenX      Heidi NA
## 694          g         B      F       GenX     Tamara NA
## 695          g         B      F       GenX       Dawn NA
## 696          g         B      F       GenX    Colleen NA
## 697          g         B      F Millennial     Alexis NA
## 698          g         B      F Millennial    Bethany NA
## 699          g         B      F Millennial   Cheyenne NA
## 700          g         B      F Millennial   Brittany NA
## 701          g         B      F Millennial    Candice NA
## 702          g         B      F Millennial     Latoya NA
## 703          g         B      M     Boomer        Ray NA
## 704          g         B      M     Boomer        Lee NA
## 705          g         B      M     Boomer        Tom NA
## 706          g         B      M     Boomer      Leroy NA
## 707          g         B      M     Boomer      Eddie NA
## 708          g         B      M     Boomer    Bernard NA
## 709          g         B      M       GenX       Jeff NA
## 710          g         B      M       GenX       Marc NA
## 711          g         B      M       GenX      Chris NA
## 712          g         B      M       GenX      Jamie NA
## 713          g         B      M       GenX        Jon NA
## 714          g         B      M       GenX        Tim NA
## 715          g         B      M Millennial     Austin NA
## 716          g         B      M Millennial       Evan NA
## 717          g         B      M Millennial       Luis NA
## 718          g         B      M Millennial    Zachary NA
```

```
## 719          g         B      M Millennial  Christian NA
## 720          g         B      M Millennial     Wesley NA
## 721          g         C      F     Boomer    Shirley NA
## 722          g         C      F     Boomer     Gloria NA
## 723          g         C      F     Boomer   Marjorie NA
## 724          g         C      F     Boomer     Dianne NA
## 725          g         C      F     Boomer    Mildred NA
## 726          g         C      F     Boomer      Betty NA
## 727          g         C      F       GenX      Tracy NA
## 728          g         C      F       GenX       Tina NA
## 729          g         C      F       GenX      Heidi NA
## 730          g         C      F       GenX     Tamara NA
## 731          g         C      F       GenX       Dawn NA
## 732          g         C      F       GenX    Colleen NA
## 733          g         C      F Millennial     Alexis NA
## 734          g         C      F Millennial    Bethany NA
## 735          g         C      F Millennial   Cheyenne NA
## 736          g         C      F Millennial   Brittany NA
## 737          g         C      F Millennial    Candice NA
## 738          g         C      F Millennial     Latoya NA
## 739          g         C      M     Boomer        Ray NA
## 740          g         C      M     Boomer        Lee NA
## 741          g         C      M     Boomer        Tom NA
## 742          g         C      M     Boomer      Leroy NA
## 743          g         C      M     Boomer      Eddie NA
## 744          g         C      M     Boomer    Bernard NA
## 745          g         C      M       GenX       Jeff NA
## 746          g         C      M       GenX       Marc NA
## 747          g         C      M       GenX      Chris NA
## 748          g         C      M       GenX      Jamie NA
## 749          g         C      M       GenX        Jon NA
## 750          g         C      M       GenX        Tim NA
## 751          g         C      M Millennial     Austin NA
## 752          g         C      M Millennial       Evan NA
## 753          g         C      M Millennial       Luis NA
## 754          g         C      M Millennial    Zachary NA
## 755          g         C      M Millennial  Christian NA
## 756          g         C      M Millennial     Wesley NA
## 757          h         A      F     Boomer    Shirley NA
## 758          h         A      F     Boomer     Gloria NA
## 759          h         A      F     Boomer   Marjorie NA
## 760          h         A      F     Boomer     Dianne NA
## 761          h         A      F     Boomer    Mildred NA
## 762          h         A      F     Boomer      Betty NA
## 763          h         A      F       GenX      Tracy NA
## 764          h         A      F       GenX       Tina NA
## 765          h         A      F       GenX      Heidi NA
## 766          h         A      F       GenX     Tamara NA
## 767          h         A      F       GenX       Dawn NA
## 768          h         A      F       GenX    Colleen NA
## 769          h         A      F Millennial     Alexis NA
## 770          h         A      F Millennial    Bethany NA
## 771          h         A      F Millennial   Cheyenne NA
## 772          h         A      F Millennial   Brittany NA
```

```
## 773          h         A      F Millennial    Candice NA
## 774          h         A      F Millennial     Latoya NA
## 775          h         A      M     Boomer        Ray NA
## 776          h         A      M     Boomer        Lee NA
## 777          h         A      M     Boomer        Tom NA
## 778          h         A      M     Boomer      Leroy NA
## 779          h         A      M     Boomer      Eddie NA
## 780          h         A      M     Boomer    Bernard NA
## 781          h         A      M       GenX       Jeff NA
## 782          h         A      M       GenX       Marc NA
## 783          h         A      M       GenX      Chris NA
## 784          h         A      M       GenX      Jamie NA
## 785          h         A      M       GenX        Jon NA
## 786          h         A      M       GenX        Tim NA
## 787          h         A      M Millennial     Austin NA
## 788          h         A      M Millennial       Evan NA
## 789          h         A      M Millennial       Luis NA
## 790          h         A      M Millennial    Zachary NA
## 791          h         A      M Millennial  Christian NA
## 792          h         A      M Millennial     Wesley NA
## 793          h         B      F     Boomer    Shirley NA
## 794          h         B      F     Boomer     Gloria NA
## 795          h         B      F     Boomer   Marjorie NA
## 796          h         B      F     Boomer     Dianne NA
## 797          h         B      F     Boomer    Mildred NA
## 798          h         B      F     Boomer      Betty NA
## 799          h         B      F       GenX      Tracy NA
## 800          h         B      F       GenX       Tina NA
## 801          h         B      F       GenX      Heidi NA
## 802          h         B      F       GenX     Tamara NA
## 803          h         B      F       GenX       Dawn NA
## 804          h         B      F       GenX    Colleen NA
## 805          h         B      F Millennial     Alexis NA
## 806          h         B      F Millennial    Bethany NA
## 807          h         B      F Millennial   Cheyenne NA
## 808          h         B      F Millennial   Brittany NA
## 809          h         B      F Millennial    Candice NA
## 810          h         B      F Millennial     Latoya NA
## 811          h         B      M     Boomer        Ray NA
## 812          h         B      M     Boomer        Lee NA
## 813          h         B      M     Boomer        Tom NA
## 814          h         B      M     Boomer      Leroy NA
## 815          h         B      M     Boomer      Eddie NA
## 816          h         B      M     Boomer    Bernard NA
## 817          h         B      M       GenX       Jeff NA
## 818          h         B      M       GenX       Marc NA
## 819          h         B      M       GenX      Chris NA
## 820          h         B      M       GenX      Jamie NA
## 821          h         B      M       GenX        Jon NA
## 822          h         B      M       GenX        Tim NA
## 823          h         B      M Millennial     Austin NA
## 824          h         B      M Millennial       Evan NA
## 825          h         B      M Millennial       Luis NA
## 826          h         B      M Millennial    Zachary NA
```

```
## 827          h         B      M Millennial  Christian NA
## 828          h         B      M Millennial     Wesley NA
## 829          h         C      F     Boomer    Shirley NA
## 830          h         C      F     Boomer     Gloria NA
## 831          h         C      F     Boomer   Marjorie NA
## 832          h         C      F     Boomer     Dianne NA
## 833          h         C      F     Boomer    Mildred NA
## 834          h         C      F     Boomer      Betty NA
## 835          h         C      F       GenX      Tracy NA
## 836          h         C      F       GenX       Tina NA
## 837          h         C      F       GenX      Heidi NA
## 838          h         C      F       GenX     Tamara NA
## 839          h         C      F       GenX       Dawn NA
## 840          h         C      F       GenX    Colleen NA
## 841          h         C      F Millennial     Alexis NA
## 842          h         C      F Millennial    Bethany NA
## 843          h         C      F Millennial   Cheyenne NA
## 844          h         C      F Millennial   Brittany NA
## 845          h         C      F Millennial    Candice NA
## 846          h         C      F Millennial     Latoya NA
## 847          h         C      M     Boomer        Ray NA
## 848          h         C      M     Boomer        Lee NA
## 849          h         C      M     Boomer        Tom NA
## 850          h         C      M     Boomer      Leroy NA
## 851          h         C      M     Boomer      Eddie NA
## 852          h         C      M     Boomer    Bernard NA
## 853          h         C      M       GenX       Jeff NA
## 854          h         C      M       GenX       Marc NA
## 855          h         C      M       GenX      Chris NA
## 856          h         C      M       GenX      Jamie NA
## 857          h         C      M       GenX        Jon NA
## 858          h         C      M       GenX        Tim NA
## 859          h         C      M Millennial     Austin NA
## 860          h         C      M Millennial       Evan NA
## 861          h         C      M Millennial       Luis NA
## 862          h         C      M Millennial    Zachary NA
## 863          h         C      M Millennial  Christian NA
## 864          h         C      M Millennial     Wesley NA
## 865          i         A      F     Boomer    Shirley NA
## 866          i         A      F     Boomer     Gloria NA
## 867          i         A      F     Boomer   Marjorie NA
## 868          i         A      F     Boomer     Dianne NA
## 869          i         A      F     Boomer    Mildred NA
## 870          i         A      F     Boomer      Betty NA
## 871          i         A      F       GenX      Tracy NA
## 872          i         A      F       GenX       Tina NA
## 873          i         A      F       GenX      Heidi NA
## 874          i         A      F       GenX     Tamara NA
## 875          i         A      F       GenX       Dawn NA
## 876          i         A      F       GenX    Colleen NA
## 877          i         A      F Millennial     Alexis NA
## 878          i         A      F Millennial    Bethany NA
## 879          i         A      F Millennial   Cheyenne NA
## 880          i         A      F Millennial   Brittany NA
```

```
## 881          i         A      F Millennial    Candice NA
## 882          i         A      F Millennial     Latoya NA
## 883          i         A      M     Boomer        Ray NA
## 884          i         A      M     Boomer        Lee NA
## 885          i         A      M     Boomer        Tom NA
## 886          i         A      M     Boomer      Leroy NA
## 887          i         A      M     Boomer      Eddie NA
## 888          i         A      M     Boomer    Bernard NA
## 889          i         A      M       GenX       Jeff NA
## 890          i         A      M       GenX       Marc NA
## 891          i         A      M       GenX      Chris NA
## 892          i         A      M       GenX      Jamie NA
## 893          i         A      M       GenX        Jon NA
## 894          i         A      M       GenX        Tim NA
## 895          i         A      M Millennial     Austin NA
## 896          i         A      M Millennial       Evan NA
## 897          i         A      M Millennial       Luis NA
## 898          i         A      M Millennial    Zachary NA
## 899          i         A      M Millennial  Christian NA
## 900          i         A      M Millennial     Wesley NA
## 901          i         B      F     Boomer    Shirley NA
## 902          i         B      F     Boomer     Gloria NA
## 903          i         B      F     Boomer   Marjorie NA
## 904          i         B      F     Boomer     Dianne NA
## 905          i         B      F     Boomer    Mildred NA
## 906          i         B      F     Boomer      Betty NA
## 907          i         B      F       GenX      Tracy NA
## 908          i         B      F       GenX       Tina NA
## 909          i         B      F       GenX      Heidi NA
## 910          i         B      F       GenX     Tamara NA
## 911          i         B      F       GenX       Dawn NA
## 912          i         B      F       GenX    Colleen NA
## 913          i         B      F Millennial     Alexis NA
## 914          i         B      F Millennial    Bethany NA
## 915          i         B      F Millennial   Cheyenne NA
## 916          i         B      F Millennial   Brittany NA
## 917          i         B      F Millennial    Candice NA
## 918          i         B      F Millennial     Latoya NA
## 919          i         B      M     Boomer        Ray NA
## 920          i         B      M     Boomer        Lee NA
## 921          i         B      M     Boomer        Tom NA
## 922          i         B      M     Boomer      Leroy NA
## 923          i         B      M     Boomer      Eddie NA
## 924          i         B      M     Boomer    Bernard NA
## 925          i         B      M       GenX       Jeff NA
## 926          i         B      M       GenX       Marc NA
## 927          i         B      M       GenX      Chris NA
## 928          i         B      M       GenX      Jamie NA
## 929          i         B      M       GenX        Jon NA
## 930          i         B      M       GenX        Tim NA
## 931          i         B      M Millennial     Austin NA
## 932          i         B      M Millennial       Evan NA
## 933          i         B      M Millennial       Luis NA
## 934          i         B      M Millennial    Zachary NA
```

```
## 935          i         B      M Millennial  Christian NA
## 936          i         B      M Millennial     Wesley NA
## 937          i         C      F     Boomer    Shirley NA
## 938          i         C      F     Boomer     Gloria NA
## 939          i         C      F     Boomer   Marjorie NA
## 940          i         C      F     Boomer     Dianne NA
## 941          i         C      F     Boomer    Mildred NA
## 942          i         C      F     Boomer      Betty NA
## 943          i         C      F       GenX      Tracy NA
## 944          i         C      F       GenX       Tina NA
## 945          i         C      F       GenX      Heidi NA
## 946          i         C      F       GenX     Tamara NA
## 947          i         C      F       GenX       Dawn NA
## 948          i         C      F       GenX    Colleen NA
## 949          i         C      F Millennial     Alexis NA
## 950          i         C      F Millennial    Bethany NA
## 951          i         C      F Millennial   Cheyenne NA
## 952          i         C      F Millennial   Brittany NA
## 953          i         C      F Millennial    Candice NA
## 954          i         C      F Millennial     Latoya NA
## 955          i         C      M     Boomer        Ray NA
## 956          i         C      M     Boomer        Lee NA
## 957          i         C      M     Boomer        Tom NA
## 958          i         C      M     Boomer      Leroy NA
## 959          i         C      M     Boomer      Eddie NA
## 960          i         C      M     Boomer    Bernard NA
## 961          i         C      M       GenX       Jeff NA
## 962          i         C      M       GenX       Marc NA
## 963          i         C      M       GenX      Chris NA
## 964          i         C      M       GenX      Jamie NA
## 965          i         C      M       GenX        Jon NA
## 966          i         C      M       GenX        Tim NA
## 967          i         C      M Millennial     Austin NA
## 968          i         C      M Millennial       Evan NA
## 969          i         C      M Millennial       Luis NA
## 970          i         C      M Millennial    Zachary NA
## 971          i         C      M Millennial  Christian NA
## 972          i         C      M Millennial     Wesley NA
## 973          j         A      F     Boomer    Shirley NA
## 974          j         A      F     Boomer     Gloria NA
## 975          j         A      F     Boomer   Marjorie NA
## 976          j         A      F     Boomer     Dianne NA
## 977          j         A      F     Boomer    Mildred NA
## 978          j         A      F     Boomer      Betty NA
## 979          j         A      F       GenX      Tracy NA
## 980          j         A      F       GenX       Tina NA
## 981          j         A      F       GenX      Heidi NA
## 982          j         A      F       GenX     Tamara NA
## 983          j         A      F       GenX       Dawn NA
## 984          j         A      F       GenX    Colleen NA
## 985          j         A      F Millennial     Alexis NA
## 986          j         A      F Millennial    Bethany NA
## 987          j         A      F Millennial   Cheyenne NA
## 988          j         A      F Millennial   Brittany NA
```

```
## 989          j         A      F Millennial    Candice NA
## 990          j         A      F Millennial     Latoya NA
## 991          j         A      M     Boomer        Ray NA
## 992          j         A      M     Boomer        Lee NA
## 993          j         A      M     Boomer        Tom NA
## 994          j         A      M     Boomer      Leroy NA
## 995          j         A      M     Boomer      Eddie NA
## 996          j         A      M     Boomer    Bernard NA
## 997          j         A      M       GenX       Jeff NA
## 998          j         A      M       GenX       Marc NA
## 999          j         A      M       GenX      Chris NA
## 1000         j         A      M       GenX      Jamie NA
## 1001         j         A      M       GenX        Jon NA
## 1002         j         A      M       GenX        Tim NA
## 1003         j         A      M Millennial     Austin NA
## 1004         j         A      M Millennial       Evan NA
## 1005         j         A      M Millennial       Luis NA
## 1006         j         A      M Millennial    Zachary NA
## 1007         j         A      M Millennial  Christian NA
## 1008         j         A      M Millennial     Wesley NA
## 1009         j         B      F     Boomer    Shirley NA
## 1010         j         B      F     Boomer     Gloria NA
## 1011         j         B      F     Boomer   Marjorie NA
## 1012         j         B      F     Boomer     Dianne NA
## 1013         j         B      F     Boomer    Mildred NA
## 1014         j         B      F     Boomer      Betty NA
## 1015         j         B      F       GenX      Tracy NA
## 1016         j         B      F       GenX       Tina NA
## 1017         j         B      F       GenX      Heidi NA
## 1018         j         B      F       GenX     Tamara NA
## 1019         j         B      F       GenX       Dawn NA
## 1020         j         B      F       GenX    Colleen NA
## 1021         j         B      F Millennial     Alexis NA
## 1022         j         B      F Millennial    Bethany NA
## 1023         j         B      F Millennial   Cheyenne NA
## 1024         j         B      F Millennial   Brittany NA
## 1025         j         B      F Millennial    Candice NA
## 1026         j         B      F Millennial     Latoya NA
## 1027         j         B      M     Boomer        Ray NA
## 1028         j         B      M     Boomer        Lee NA
## 1029         j         B      M     Boomer        Tom NA
## 1030         j         B      M     Boomer      Leroy NA
## 1031         j         B      M     Boomer      Eddie NA
## 1032         j         B      M     Boomer    Bernard NA
## 1033         j         B      M       GenX       Jeff NA
## 1034         j         B      M       GenX       Marc NA
## 1035         j         B      M       GenX      Chris NA
## 1036         j         B      M       GenX      Jamie NA
## 1037         j         B      M       GenX        Jon NA
## 1038         j         B      M       GenX        Tim NA
## 1039         j         B      M Millennial     Austin NA
## 1040         j         B      M Millennial       Evan NA
## 1041         j         B      M Millennial       Luis NA
## 1042         j         B      M Millennial    Zachary NA
```

```
## 1043        j         B      M Millennial  Christian NA
## 1044        j         B      M Millennial     Wesley NA
## 1045        j         C      F     Boomer    Shirley NA
## 1046        j         C      F     Boomer     Gloria NA
## 1047        j         C      F     Boomer   Marjorie NA
## 1048        j         C      F     Boomer     Dianne NA
## 1049        j         C      F     Boomer    Mildred NA
## 1050        j         C      F     Boomer      Betty NA
## 1051        j         C      F       GenX      Tracy NA
## 1052        j         C      F       GenX       Tina NA
## 1053        j         C      F       GenX      Heidi NA
## 1054        j         C      F       GenX     Tamara NA
## 1055        j         C      F       GenX       Dawn NA
## 1056        j         C      F       GenX    Colleen NA
## 1057        j         C      F Millennial     Alexis NA
## 1058        j         C      F Millennial    Bethany NA
## 1059        j         C      F Millennial   Cheyenne NA
## 1060        j         C      F Millennial   Brittany NA
## 1061        j         C      F Millennial    Candice NA
## 1062        j         C      F Millennial     Latoya NA
## 1063        j         C      M     Boomer        Ray NA
## 1064        j         C      M     Boomer        Lee NA
## 1065        j         C      M     Boomer        Tom NA
## 1066        j         C      M     Boomer      Leroy NA
## 1067        j         C      M     Boomer      Eddie NA
## 1068        j         C      M     Boomer    Bernard NA
## 1069        j         C      M       GenX       Jeff NA
## 1070        j         C      M       GenX       Marc NA
## 1071        j         C      M       GenX      Chris NA
## 1072        j         C      M       GenX      Jamie NA
## 1073        j         C      M       GenX        Jon NA
## 1074        j         C      M       GenX        Tim NA
## 1075        j         C      M Millennial     Austin NA
## 1076        j         C      M Millennial       Evan NA
## 1077        j         C      M Millennial       Luis NA
## 1078        j         C      M Millennial    Zachary NA
## 1079        j         C      M Millennial  Christian NA
## 1080        j         C      M Millennial     Wesley NA
## 1081        k         A      F     Boomer    Shirley NA
## 1082        k         A      F     Boomer     Gloria NA
## 1083        k         A      F     Boomer   Marjorie NA
## 1084        k         A      F     Boomer     Dianne NA
## 1085        k         A      F     Boomer    Mildred NA
## 1086        k         A      F     Boomer      Betty NA
## 1087        k         A      F       GenX      Tracy NA
## 1088        k         A      F       GenX       Tina NA
## 1089        k         A      F       GenX      Heidi NA
## 1090        k         A      F       GenX     Tamara NA
## 1091        k         A      F       GenX       Dawn NA
## 1092        k         A      F       GenX    Colleen NA
## 1093        k         A      F Millennial     Alexis NA
## 1094        k         A      F Millennial    Bethany NA
## 1095        k         A      F Millennial   Cheyenne NA
## 1096        k         A      F Millennial   Brittany NA
```

```
## 1097        k         A      F Millennial    Candice NA
## 1098        k         A      F Millennial     Latoya NA
## 1099        k         A      M     Boomer        Ray NA
## 1100        k         A      M     Boomer        Lee NA
## 1101        k         A      M     Boomer        Tom NA
## 1102        k         A      M     Boomer      Leroy NA
## 1103        k         A      M     Boomer      Eddie NA
## 1104        k         A      M     Boomer    Bernard NA
## 1105        k         A      M       GenX       Jeff NA
## 1106        k         A      M       GenX       Marc NA
## 1107        k         A      M       GenX      Chris NA
## 1108        k         A      M       GenX      Jamie NA
## 1109        k         A      M       GenX        Jon NA
## 1110        k         A      M       GenX        Tim NA
## 1111        k         A      M Millennial     Austin NA
## 1112        k         A      M Millennial       Evan NA
## 1113        k         A      M Millennial       Luis NA
## 1114        k         A      M Millennial    Zachary NA
## 1115        k         A      M Millennial  Christian NA
## 1116        k         A      M Millennial     Wesley NA
## 1117        k         B      F     Boomer    Shirley NA
## 1118        k         B      F     Boomer     Gloria NA
## 1119        k         B      F     Boomer   Marjorie NA
## 1120        k         B      F     Boomer     Dianne NA
## 1121        k         B      F     Boomer    Mildred NA
## 1122        k         B      F     Boomer      Betty NA
## 1123        k         B      F       GenX      Tracy NA
## 1124        k         B      F       GenX       Tina NA
## 1125        k         B      F       GenX      Heidi NA
## 1126        k         B      F       GenX     Tamara NA
## 1127        k         B      F       GenX       Dawn NA
## 1128        k         B      F       GenX    Colleen NA
## 1129        k         B      F Millennial     Alexis NA
## 1130        k         B      F Millennial    Bethany NA
## 1131        k         B      F Millennial   Cheyenne NA
## 1132        k         B      F Millennial   Brittany NA
## 1133        k         B      F Millennial    Candice NA
## 1134        k         B      F Millennial     Latoya NA
## 1135        k         B      M     Boomer        Ray NA
## 1136        k         B      M     Boomer        Lee NA
## 1137        k         B      M     Boomer        Tom NA
## 1138        k         B      M     Boomer      Leroy NA
## 1139        k         B      M     Boomer      Eddie NA
## 1140        k         B      M     Boomer    Bernard NA
## 1141        k         B      M       GenX       Jeff NA
## 1142        k         B      M       GenX       Marc NA
## 1143        k         B      M       GenX      Chris NA
## 1144        k         B      M       GenX      Jamie NA
## 1145        k         B      M       GenX        Jon NA
## 1146        k         B      M       GenX        Tim NA
## 1147        k         B      M Millennial     Austin NA
## 1148        k         B      M Millennial       Evan NA
## 1149        k         B      M Millennial       Luis NA
## 1150        k         B      M Millennial    Zachary NA
```

```
## 1151        k        B      M Millennial  Christian NA
## 1152        k        B      M Millennial     Wesley NA
## 1153        k        C      F     Boomer    Shirley NA
## 1154        k        C      F     Boomer     Gloria NA
## 1155        k        C      F     Boomer   Marjorie NA
## 1156        k        C      F     Boomer     Dianne NA
## 1157        k        C      F     Boomer    Mildred NA
## 1158        k        C      F     Boomer      Betty NA
## 1159        k        C      F       GenX      Tracy NA
## 1160        k        C      F       GenX       Tina NA
## 1161        k        C      F       GenX      Heidi NA
## 1162        k        C      F       GenX     Tamara NA
## 1163        k        C      F       GenX       Dawn NA
## 1164        k        C      F       GenX    Colleen NA
## 1165        k        C      F Millennial     Alexis NA
## 1166        k        C      F Millennial    Bethany NA
## 1167        k        C      F Millennial   Cheyenne NA
## 1168        k        C      F Millennial   Brittany NA
## 1169        k        C      F Millennial    Candice NA
## 1170        k        C      F Millennial     Latoya NA
## 1171        k        C      M     Boomer        Ray NA
## 1172        k        C      M     Boomer        Lee NA
## 1173        k        C      M     Boomer        Tom NA
## 1174        k        C      M     Boomer      Leroy NA
## 1175        k        C      M     Boomer      Eddie NA
## 1176        k        C      M     Boomer    Bernard NA
## 1177        k        C      M       GenX       Jeff NA
## 1178        k        C      M       GenX       Marc NA
## 1179        k        C      M       GenX      Chris NA
## 1180        k        C      M       GenX      Jamie NA
## 1181        k        C      M       GenX        Jon NA
## 1182        k        C      M       GenX        Tim NA
## 1183        k        C      M Millennial     Austin NA
## 1184        k        C      M Millennial       Evan NA
## 1185        k        C      M Millennial       Luis NA
## 1186        k        C      M Millennial    Zachary NA
## 1187        k        C      M Millennial  Christian NA
## 1188        k        C      M Millennial     Wesley NA
## 1189        l        A      F     Boomer    Shirley NA
## 1190        l        A      F     Boomer     Gloria NA
## 1191        l        A      F     Boomer   Marjorie NA
## 1192        l        A      F     Boomer     Dianne NA
## 1193        l        A      F     Boomer    Mildred NA
## 1194        l        A      F     Boomer      Betty NA
## 1195        l        A      F       GenX      Tracy NA
## 1196        l        A      F       GenX       Tina NA
## 1197        l        A      F       GenX      Heidi NA
## 1198        l        A      F       GenX     Tamara NA
## 1199        l        A      F       GenX       Dawn NA
## 1200        l        A      F       GenX    Colleen NA
## 1201        l        A      F Millennial     Alexis NA
## 1202        l        A      F Millennial    Bethany NA
## 1203        l        A      F Millennial   Cheyenne NA
## 1204        l        A      F Millennial   Brittany NA
```

```
## 1205         1         A      F Millennial    Candice NA
## 1206         1         A      F Millennial     Latoya NA
## 1207         1         A      M     Boomer        Ray NA
## 1208         1         A      M     Boomer        Lee NA
## 1209         1         A      M     Boomer        Tom NA
## 1210         1         A      M     Boomer      Leroy NA
## 1211         1         A      M     Boomer      Eddie NA
## 1212         1         A      M     Boomer    Bernard NA
## 1213         1         A      M       GenX       Jeff NA
## 1214         1         A      M       GenX       Marc NA
## 1215         1         A      M       GenX      Chris NA
## 1216         1         A      M       GenX      Jamie NA
## 1217         1         A      M       GenX        Jon NA
## 1218         1         A      M       GenX        Tim NA
## 1219         1         A      M Millennial     Austin NA
## 1220         1         A      M Millennial       Evan NA
## 1221         1         A      M Millennial       Luis NA
## 1222         1         A      M Millennial    Zachary NA
## 1223         1         A      M Millennial  Christian NA
## 1224         1         A      M Millennial     Wesley NA
## 1225         1         B      F     Boomer    Shirley NA
## 1226         1         B      F     Boomer     Gloria NA
## 1227         1         B      F     Boomer   Marjorie NA
## 1228         1         B      F     Boomer     Dianne NA
## 1229         1         B      F     Boomer    Mildred NA
## 1230         1         B      F     Boomer      Betty NA
## 1231         1         B      F       GenX      Tracy NA
## 1232         1         B      F       GenX       Tina NA
## 1233         1         B      F       GenX      Heidi NA
## 1234         1         B      F       GenX     Tamara NA
## 1235         1         B      F       GenX       Dawn NA
## 1236         1         B      F       GenX    Colleen NA
## 1237         1         B      F Millennial     Alexis NA
## 1238         1         B      F Millennial    Bethany NA
## 1239         1         B      F Millennial   Cheyenne NA
## 1240         1         B      F Millennial   Brittany NA
## 1241         1         B      F Millennial    Candice NA
## 1242         1         B      F Millennial     Latoya NA
## 1243         1         B      M     Boomer        Ray NA
## 1244         1         B      M     Boomer        Lee NA
## 1245         1         B      M     Boomer        Tom NA
## 1246         1         B      M     Boomer      Leroy NA
## 1247         1         B      M     Boomer      Eddie NA
## 1248         1         B      M     Boomer    Bernard NA
## 1249         1         B      M       GenX       Jeff NA
## 1250         1         B      M       GenX       Marc NA
## 1251         1         B      M       GenX      Chris NA
## 1252         1         B      M       GenX      Jamie NA
## 1253         1         B      M       GenX        Jon NA
## 1254         1         B      M       GenX        Tim NA
## 1255         1         B      M Millennial     Austin NA
## 1256         1         B      M Millennial       Evan NA
## 1257         1         B      M Millennial       Luis NA
## 1258         1         B      M Millennial    Zachary NA
```

```
## 1259         l         B      M Millennial  Christian NA
## 1260         l         B      M Millennial     Wesley NA
## 1261         l         C      F     Boomer    Shirley NA
## 1262         l         C      F     Boomer     Gloria NA
## 1263         l         C      F     Boomer   Marjorie NA
## 1264         l         C      F     Boomer     Dianne NA
## 1265         l         C      F     Boomer    Mildred NA
## 1266         l         C      F     Boomer      Betty NA
## 1267         l         C      F       GenX      Tracy NA
## 1268         l         C      F       GenX       Tina NA
## 1269         l         C      F       GenX      Heidi NA
## 1270         l         C      F       GenX     Tamara NA
## 1271         l         C      F       GenX       Dawn NA
## 1272         l         C      F       GenX    Colleen NA
## 1273         l         C      F Millennial     Alexis NA
## 1274         l         C      F Millennial    Bethany NA
## 1275         l         C      F Millennial   Cheyenne NA
## 1276         l         C      F Millennial   Brittany NA
## 1277         l         C      F Millennial    Candice NA
## 1278         l         C      F Millennial     Latoya NA
## 1279         l         C      M     Boomer        Ray NA
## 1280         l         C      M     Boomer        Lee NA
## 1281         l         C      M     Boomer        Tom NA
## 1282         l         C      M     Boomer      Leroy NA
## 1283         l         C      M     Boomer      Eddie NA
## 1284         l         C      M     Boomer    Bernard NA
## 1285         l         C      M       GenX       Jeff NA
## 1286         l         C      M       GenX       Marc NA
## 1287         l         C      M       GenX      Chris NA
## 1288         l         C      M       GenX      Jamie NA
## 1289         l         C      M       GenX        Jon NA
## 1290         l         C      M       GenX        Tim NA
## 1291         l         C      M Millennial     Austin NA
## 1292         l         C      M Millennial       Evan NA
## 1293         l         C      M Millennial       Luis NA
## 1294         l         C      M Millennial    Zachary NA
## 1295         l         C      M Millennial  Christian NA
## 1296         l         C      M Millennial     Wesley NA
## 1297         m         A      F     Boomer    Shirley NA
## 1298         m         A      F     Boomer     Gloria NA
## 1299         m         A      F     Boomer   Marjorie NA
## 1300         m         A      F     Boomer     Dianne NA
## 1301         m         A      F     Boomer    Mildred NA
## 1302         m         A      F     Boomer      Betty NA
## 1303         m         A      F       GenX      Tracy NA
## 1304         m         A      F       GenX       Tina NA
## 1305         m         A      F       GenX      Heidi NA
## 1306         m         A      F       GenX     Tamara NA
## 1307         m         A      F       GenX       Dawn NA
## 1308         m         A      F       GenX    Colleen NA
## 1309         m         A      F Millennial     Alexis NA
## 1310         m         A      F Millennial    Bethany NA
## 1311         m         A      F Millennial   Cheyenne NA
## 1312         m         A      F Millennial   Brittany NA
```

```
## 1313         m         A      F Millennial    Candice NA
## 1314         m         A      F Millennial     Latoya NA
## 1315         m         A      M     Boomer        Ray NA
## 1316         m         A      M     Boomer        Lee NA
## 1317         m         A      M     Boomer        Tom NA
## 1318         m         A      M     Boomer      Leroy NA
## 1319         m         A      M     Boomer      Eddie NA
## 1320         m         A      M     Boomer    Bernard NA
## 1321         m         A      M       GenX       Jeff NA
## 1322         m         A      M       GenX       Marc NA
## 1323         m         A      M       GenX      Chris NA
## 1324         m         A      M       GenX      Jamie NA
## 1325         m         A      M       GenX        Jon NA
## 1326         m         A      M       GenX        Tim NA
## 1327         m         A      M Millennial     Austin NA
## 1328         m         A      M Millennial       Evan NA
## 1329         m         A      M Millennial       Luis NA
## 1330         m         A      M Millennial    Zachary NA
## 1331         m         A      M Millennial  Christian NA
## 1332         m         A      M Millennial     Wesley NA
## 1333         m         B      F     Boomer    Shirley NA
## 1334         m         B      F     Boomer     Gloria NA
## 1335         m         B      F     Boomer   Marjorie NA
## 1336         m         B      F     Boomer     Dianne NA
## 1337         m         B      F     Boomer    Mildred NA
## 1338         m         B      F     Boomer      Betty NA
## 1339         m         B      F       GenX      Tracy NA
## 1340         m         B      F       GenX       Tina NA
## 1341         m         B      F       GenX      Heidi NA
## 1342         m         B      F       GenX     Tamara NA
## 1343         m         B      F       GenX       Dawn NA
## 1344         m         B      F       GenX    Colleen NA
## 1345         m         B      F Millennial     Alexis NA
## 1346         m         B      F Millennial    Bethany NA
## 1347         m         B      F Millennial   Cheyenne NA
## 1348         m         B      F Millennial   Brittany NA
## 1349         m         B      F Millennial    Candice NA
## 1350         m         B      F Millennial     Latoya NA
## 1351         m         B      M     Boomer        Ray NA
## 1352         m         B      M     Boomer        Lee NA
## 1353         m         B      M     Boomer        Tom NA
## 1354         m         B      M     Boomer      Leroy NA
## 1355         m         B      M     Boomer      Eddie NA
## 1356         m         B      M     Boomer    Bernard NA
## 1357         m         B      M       GenX       Jeff NA
## 1358         m         B      M       GenX       Marc NA
## 1359         m         B      M       GenX      Chris NA
## 1360         m         B      M       GenX      Jamie NA
## 1361         m         B      M       GenX        Jon NA
## 1362         m         B      M       GenX        Tim NA
## 1363         m         B      M Millennial     Austin NA
## 1364         m         B      M Millennial       Evan NA
## 1365         m         B      M Millennial       Luis NA
## 1366         m         B      M Millennial    Zachary NA
```

```
## 1367         m         B      M Millennial  Christian NA
## 1368         m         B      M Millennial     Wesley NA
## 1369         m         C      F     Boomer    Shirley NA
## 1370         m         C      F     Boomer     Gloria NA
## 1371         m         C      F     Boomer   Marjorie NA
## 1372         m         C      F     Boomer     Dianne NA
## 1373         m         C      F     Boomer    Mildred NA
## 1374         m         C      F     Boomer      Betty NA
## 1375         m         C      F       GenX      Tracy NA
## 1376         m         C      F       GenX       Tina NA
## 1377         m         C      F       GenX      Heidi NA
## 1378         m         C      F       GenX     Tamara NA
## 1379         m         C      F       GenX       Dawn NA
## 1380         m         C      F       GenX    Colleen NA
## 1381         m         C      F Millennial     Alexis NA
## 1382         m         C      F Millennial    Bethany NA
## 1383         m         C      F Millennial   Cheyenne NA
## 1384         m         C      F Millennial   Brittany NA
## 1385         m         C      F Millennial    Candice NA
## 1386         m         C      F Millennial     Latoya NA
## 1387         m         C      M     Boomer        Ray NA
## 1388         m         C      M     Boomer        Lee NA
## 1389         m         C      M     Boomer        Tom NA
## 1390         m         C      M     Boomer      Leroy NA
## 1391         m         C      M     Boomer      Eddie NA
## 1392         m         C      M     Boomer    Bernard NA
## 1393         m         C      M       GenX       Jeff NA
## 1394         m         C      M       GenX       Marc NA
## 1395         m         C      M       GenX      Chris NA
## 1396         m         C      M       GenX      Jamie NA
## 1397         m         C      M       GenX        Jon NA
## 1398         m         C      M       GenX        Tim NA
## 1399         m         C      M Millennial     Austin NA
## 1400         m         C      M Millennial       Evan NA
## 1401         m         C      M Millennial       Luis NA
## 1402         m         C      M Millennial    Zachary NA
## 1403         m         C      M Millennial  Christian NA
## 1404         m         C      M Millennial     Wesley NA
## 1405         n         A      F     Boomer    Shirley NA
## 1406         n         A      F     Boomer     Gloria NA
## 1407         n         A      F     Boomer   Marjorie NA
## 1408         n         A      F     Boomer     Dianne NA
## 1409         n         A      F     Boomer    Mildred NA
## 1410         n         A      F     Boomer      Betty NA
## 1411         n         A      F       GenX      Tracy NA
## 1412         n         A      F       GenX       Tina NA
## 1413         n         A      F       GenX      Heidi NA
## 1414         n         A      F       GenX     Tamara NA
## 1415         n         A      F       GenX       Dawn NA
## 1416         n         A      F       GenX    Colleen NA
## 1417         n         A      F Millennial     Alexis NA
## 1418         n         A      F Millennial    Bethany NA
## 1419         n         A      F Millennial   Cheyenne NA
## 1420         n         A      F Millennial   Brittany NA
```

```
## 1421         n         A      F Millennial    Candice NA
## 1422         n         A      F Millennial     Latoya NA
## 1423         n         A      M     Boomer        Ray NA
## 1424         n         A      M     Boomer        Lee NA
## 1425         n         A      M     Boomer        Tom NA
## 1426         n         A      M     Boomer      Leroy NA
## 1427         n         A      M     Boomer      Eddie NA
## 1428         n         A      M     Boomer    Bernard NA
## 1429         n         A      M       GenX       Jeff NA
## 1430         n         A      M       GenX       Marc NA
## 1431         n         A      M       GenX      Chris NA
## 1432         n         A      M       GenX      Jamie NA
## 1433         n         A      M       GenX        Jon NA
## 1434         n         A      M       GenX        Tim NA
## 1435         n         A      M Millennial     Austin NA
## 1436         n         A      M Millennial       Evan NA
## 1437         n         A      M Millennial       Luis NA
## 1438         n         A      M Millennial    Zachary NA
## 1439         n         A      M Millennial  Christian NA
## 1440         n         A      M Millennial     Wesley NA
## 1441         n         B      F     Boomer    Shirley NA
## 1442         n         B      F     Boomer     Gloria NA
## 1443         n         B      F     Boomer   Marjorie NA
## 1444         n         B      F     Boomer     Dianne NA
## 1445         n         B      F     Boomer    Mildred NA
## 1446         n         B      F     Boomer      Betty NA
## 1447         n         B      F       GenX      Tracy NA
## 1448         n         B      F       GenX       Tina NA
## 1449         n         B      F       GenX      Heidi NA
## 1450         n         B      F       GenX     Tamara NA
## 1451         n         B      F       GenX       Dawn NA
## 1452         n         B      F       GenX    Colleen NA
## 1453         n         B      F Millennial     Alexis NA
## 1454         n         B      F Millennial    Bethany NA
## 1455         n         B      F Millennial   Cheyenne NA
## 1456         n         B      F Millennial   Brittany NA
## 1457         n         B      F Millennial    Candice NA
## 1458         n         B      F Millennial     Latoya NA
## 1459         n         B      M     Boomer        Ray NA
## 1460         n         B      M     Boomer        Lee NA
## 1461         n         B      M     Boomer        Tom NA
## 1462         n         B      M     Boomer      Leroy NA
## 1463         n         B      M     Boomer      Eddie NA
## 1464         n         B      M     Boomer    Bernard NA
## 1465         n         B      M       GenX       Jeff NA
## 1466         n         B      M       GenX       Marc NA
## 1467         n         B      M       GenX      Chris NA
## 1468         n         B      M       GenX      Jamie NA
## 1469         n         B      M       GenX        Jon NA
## 1470         n         B      M       GenX        Tim NA
## 1471         n         B      M Millennial     Austin NA
## 1472         n         B      M Millennial       Evan NA
## 1473         n         B      M Millennial       Luis NA
## 1474         n         B      M Millennial    Zachary NA
```

```
## 1475         n         B      M Millennial  Christian NA
## 1476         n         B      M Millennial     Wesley NA
## 1477         n         C      F     Boomer    Shirley NA
## 1478         n         C      F     Boomer     Gloria NA
## 1479         n         C      F     Boomer   Marjorie NA
## 1480         n         C      F     Boomer     Dianne NA
## 1481         n         C      F     Boomer    Mildred NA
## 1482         n         C      F     Boomer      Betty NA
## 1483         n         C      F       GenX      Tracy NA
## 1484         n         C      F       GenX       Tina NA
## 1485         n         C      F       GenX      Heidi NA
## 1486         n         C      F       GenX     Tamara NA
## 1487         n         C      F       GenX       Dawn NA
## 1488         n         C      F       GenX    Colleen NA
## 1489         n         C      F Millennial     Alexis NA
## 1490         n         C      F Millennial    Bethany NA
## 1491         n         C      F Millennial   Cheyenne NA
## 1492         n         C      F Millennial   Brittany NA
## 1493         n         C      F Millennial    Candice NA
## 1494         n         C      F Millennial     Latoya NA
## 1495         n         C      M     Boomer        Ray NA
## 1496         n         C      M     Boomer        Lee NA
## 1497         n         C      M     Boomer        Tom NA
## 1498         n         C      M     Boomer      Leroy NA
## 1499         n         C      M     Boomer      Eddie NA
## 1500         n         C      M     Boomer    Bernard NA
## 1501         n         C      M       GenX       Jeff NA
## 1502         n         C      M       GenX       Marc NA
## 1503         n         C      M       GenX      Chris NA
## 1504         n         C      M       GenX      Jamie NA
## 1505         n         C      M       GenX        Jon NA
## 1506         n         C      M       GenX        Tim NA
## 1507         n         C      M Millennial     Austin NA
## 1508         n         C      M Millennial       Evan NA
## 1509         n         C      M Millennial       Luis NA
## 1510         n         C      M Millennial    Zachary NA
## 1511         n         C      M Millennial  Christian NA
## 1512         n         C      M Millennial     Wesley NA
```

```
X[1,]
```

```
##   treatment variation gender generation     name  y
## 1         a         A      F     Boomer  Shirley NA
```

```
X[2,]
```

```
##   treatment variation gender generation   name  y
## 2         a         A      F     Boomer Gloria NA
```

```
X[1199, ]
```

```
##      treatment variation gender generation  name  y
## 1199         l         A      F       GenX  Dawn NA
```

```
X[1200, ]
```

```
##      treatment variation gender generation     name  y
## 1200         l         A      F       GenX  Colleen NA
```

```
X[1201, ]
```

```
##      treatment variation gender generation    name  y
## 1201         l         A      F Millennial  Alexis NA
```

```
X[2519, ]
```

```
##    treatment variation gender generation name  y
## NA      <NA>      <NA>   <NA>       <NA> <NA> NA
```

```
X[2520, ]
```

```
##    treatment variation gender generation name  y
## NA      <NA>      <NA>   <NA>       <NA> <NA> NA
```

```
#?rep
```

Packages

Install the package `pacman` using regular base R.

```
install.packages("pacman")
```

First, install the package `testthat` (a widely accepted testing suite for R) from https://github.com/r-lib/testthat using `pacman`. If you are using Windows, this will be a long install, but you have to go through it for some of the stuff we are doing in class. LINUX (or MAC) is preferred for coding. If you can't get it to work, install this package from CRAN (still using `pacman`), but this is not recommended long term.

```
pacman::p_load(testthat)
```

- Create vector `v` consisting of all numbers from -100 to 100 and test using the second line of code su

```
v= seq(-100, 100)
expect_equal(v, -100 : 100)
```

If there are any errors, the `expect_equal` function will tell you about them. If there are no errors, then it will be silent.

Test the `my_reverse` function from lab2 using the following code:

```
v = 1:100

expect_equal(my_reverse(v), rev(v))
expect_equal(my_reverse(c("A", "B", "C")), c("C", "B", "A"))
```

Multinomial Classification using KNN

Write a $k = 1$ nearest neighbor algorithm using the Euclidean distance function. This is standard "Roxygen" format for documentation. Hopefully, we will get to packages at some point and we will go over this again. It is your job also to fill in this documentation.

```
#' Nearest Neighbor Classifier (Euclidean Distance)
#'
#' Classify an observation based on the label of the closest observation in a set of training observati
#
#' @param Xinput      TO-DO: Training data observations as a matrix
#' @param y_binary    TO-DO: The vector of training data labels
#' @param xtest       TO-DO: A test observation as a row vector
#' @return            TO-DO: Predicted label for test observation

nn_algorithm_predict = function(Xinput, y_binary, xtest){
  n = nrow(Xinput)
  distances = array(NA, n)
  for(i in 1:n){
    distances[i] = sum((Xinput[i, ] - xtest)^2)
  }

  which.min(distances)
  y_binary[which.min(distances)]

}
```

Write a few tests to ensure it actually works:

```
iris_measures = iris[ ,1:4]
iris_labels = iris[,5]
iris_test_1 = c(4.5, 3.2, 1.1, 0.2)
iris_test_2 = c(5.3, 3.1, 3.5, 1.1)
iris_test_3 = c(6.7, 2, 5.8, 1)

nn_algorithm_predict(iris_measures, iris_labels, iris_test_1)
```

```
## [1] setosa
## Levels: setosa versicolor virginica
```

```
nn_algorithm_predict(iris_measures, iris_labels, iris_test_2)
```

```
## [1] versicolor
## Levels: setosa versicolor virginica
```

```
nn_algorithm_predict(iris_measures, iris_labels, iris_test_3)
```

```
## [1] virginica
## Levels: setosa versicolor virginica
```

We now add an argument `d` representing any legal distance function to the `nn_algorithm_predict` function. Update the implementation so it performs NN using that distance function. Set the default function to be the Euclidean distance in the original function. Also, alter the documentation in the appropriate places.

```
#' Nearest Neighbor Classifier (Any Distance Function)
#'
#' Classify an observation based on the label of the closest observation in a set of training observati
#
#' @param Xinput      Training data observations as a matrix
#' @param y_binary    The vector of training data labels
#' @param xtest       A test observation as a row vector
#' @param d           A distance function which takes as input two row vectors
#' @return            Predicted label for test observation

nn_algorithm_predict = function(Xinput, y_binary, xtest, d = function(v1, v2){sum((v1 - v2)^2)}){
  n = nrow(Xinput)
  distances = array(NA, n)

  for(i in 1:n){
    distances[i] = d(Xinput[i,], xtest)     # Find test observation closest to desired observation
  }

  y_binary[which.min(distances)]            # Call label of test value whose x-value is closest to the

}
```

For extra credit (unless you're a masters student), add an argument `k` to the `nn_algorithm_predict` function and update the implementation so it performs KNN. In the case of a tie, choose $\hat{y}$ randomly. Set the default `k` to be the square root of the size of $\mathcal{D}$ which is an empirical rule-of-thumb popularized by the "Pattern Classification" book by Duda, Hart and Stork (2007). Also, alter the documentation in the appropriate places.

```
#' K-Nearest Neighbor Classifier (Any Distance Function)
#'
#' Classify an observation based on the mode of the k closest observations in a set of training observa
#
#' @param Xinput      Training data observations as a matrix
#' @param y_binary    The vector of training data labels
#' @param xtest       A test observation as a row vector
#' @param d           A distance function which takes as input two row vectors
#' @param k           The number of neighbors to compare
#' @return            Predicted label for test observation

knn_algorithm_predict = function(Xinput, y_binary, xtest, d = function(v1, v2){sum((v1 - v2)^2)}, k = NU

  n = nrow(Xinput)
  distances = array(NA, n)

  for(i in 1:n){
    distances[i] = d(Xinput[i,], xtest)
  }

  ordered_distances = sort(distances)

  k_nearest_distances = array(NA, dim = k)
  k_nearest_distances = ordered_distances[1:k]
```

```
  #Find mode of LABEL of nearest distances

  }

# Finish the rest and come back later....
# Add argument k, etc
# Return mode of nearest neighbors, but if there is a tie randomly choose which label to return.
# HARD
## SUPER HARD??
```

Basic Binary Classification Modeling

- Load the famous `iris` data frame into the namespace. Provide a summary of the columns using the `skim` function in package `skimr` and write a few descriptive sentences about the distributions using the code below in English.

```
data(iris)
pacman::p_load(skimr)
skim(iris)
```

Table 1: Data summary

Name	iris
Number of rows	150
Number of columns	5
Column type frequency:	
factor	1
numeric	4
Group variables	None

Variable type: factor

skim_variable	n_missing	complete_rate	ordered	n_unique	top_counts
Species	0	1	FALSE	3	set: 50, ver: 50, vir: 50

Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
Sepal.Length	0	1	5.84	0.83	4.3	5.1	5.80	6.4	7.9	
Sepal.Width	0	1	3.06	0.44	2.0	2.8	3.00	3.3	4.4	
Petal.Length	0	1	3.76	1.77	1.0	1.6	4.35	5.1	6.9	
Petal.Width	0	1	1.20	0.76	0.1	0.3	1.30	1.8	2.5	

The sepal length is fairly evenly distributed on the lower end, and sparsely distributed on the higher end of the range. Sepal width is mostly distributed at and slightly below the mean. Petal length and petal width both have very similar distributions, with a heavy distribution on the low end and at and just above the

mean, but almost none distributed at the highest point and between the low end and the mean.

The outcome / label / response is `Species`. This is what we will be trying to predict. However, we only care about binary classification between "setosa" and "versicolor" for the purposes of this exercise. Thus the first order of business is to drop one class. Let's drop the data for the level "virginica" from the data frame.

```
iris = iris[iris$Species != "virginica", ]
```

Now create a vector `y` that is length the number of remaining rows in the data frame whose entries are 0 if "setosa" and 1 if "versicolor".

```
y = as.integer(iris$Species == "versicolor")
y
```

```
##   [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##  [38] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [75] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

- Write a function `mode` returning the sample mode.

```
mode = function(v){
  names(sort(table(v), decreasing = TRUE[1]))
}

mode(y)
```

```
## [1] "0" "1"
```

- Fit a threshold model to `y` using the feature `Sepal.Length`. Write your own code to do this. What is the estimated value of the threshold parameter? Save the threshold value as `threshold`.

```
Xy = cbind(iris$Sepal.Length, y)

n = length(y)

num_errors_par = matrix(NA, nrow = n, ncol = 2)

colnames(num_errors_par) = c("threshold_param", "num_errors")

y_logical = iris$Species == "versicolor"

for (i in 1 : n){
  threshold = iris$Sepal.Length[i]

  num_errors = sum((iris$Sepal.Length > threshold) != y_logical)
  num_errors_par[i, ] = c(threshold, num_errors)
}

#num_errors

num_errors_par[order(num_errors_par[ ,"num_errors"]), ]
```

```
##        threshold_param num_errors
##   [1,]             5.4         11
##   [2,]             5.4         11
##   [3,]             5.4         11
##   [4,]             5.4         11
##   [5,]             5.4         11
##   [6,]             5.4         11
##   [7,]             5.5         14
##   [8,]             5.5         14
##   [9,]             5.5         14
##  [10,]             5.5         14
##  [11,]             5.5         14
##  [12,]             5.5         14
##  [13,]             5.5         14
##  [14,]             5.3         15
##  [15,]             5.2         16
##  [16,]             5.2         16
##  [17,]             5.2         16
##  [18,]             5.2         16
##  [19,]             5.1         18
##  [20,]             5.1         18
##  [21,]             5.1         18
##  [22,]             5.1         18
##  [23,]             5.1         18
##  [24,]             5.1         18
##  [25,]             5.1         18
##  [26,]             5.1         18
##  [27,]             5.1         18
##  [28,]             5.6         19
##  [29,]             5.6         19
##  [30,]             5.6         19
##  [31,]             5.6         19
##  [32,]             5.6         19
##  [33,]             5.7         22
##  [34,]             5.7         22
##  [35,]             5.7         22
##  [36,]             5.7         22
##  [37,]             5.7         22
##  [38,]             5.7         22
##  [39,]             5.7         22
##  [40,]             5.8         24
##  [41,]             5.8         24
##  [42,]             5.8         24
##  [43,]             5.8         24
##  [44,]             5.0         25
##  [45,]             5.0         25
##  [46,]             5.0         25
##  [47,]             5.0         25
##  [48,]             5.0         25
##  [49,]             5.0         25
##  [50,]             5.0         25
##  [51,]             5.0         25
##  [52,]             5.0         25
##  [53,]             5.0         25
```

```
##  [54,]             5.9         26
##  [55,]             5.9         26
##  [56,]             6.0         30
##  [57,]             6.0         30
##  [58,]             6.0         30
##  [59,]             6.0         30
##  [60,]             4.9         31
##  [61,]             4.9         31
##  [62,]             4.9         31
##  [63,]             4.9         31
##  [64,]             4.9         31
##  [65,]             4.8         34
##  [66,]             4.8         34
##  [67,]             4.8         34
##  [68,]             4.8         34
##  [69,]             4.8         34
##  [70,]             6.1         34
##  [71,]             6.1         34
##  [72,]             6.1         34
##  [73,]             6.1         34
##  [74,]             6.2         36
##  [75,]             6.2         36
##  [76,]             4.7         39
##  [77,]             4.7         39
##  [78,]             6.3         39
##  [79,]             6.3         39
##  [80,]             6.3         39
##  [81,]             4.6         41
##  [82,]             4.6         41
##  [83,]             4.6         41
##  [84,]             4.6         41
##  [85,]             6.4         41
##  [86,]             6.4         41
##  [87,]             6.5         42
##  [88,]             6.6         44
##  [89,]             6.6         44
##  [90,]             4.5         45
##  [91,]             4.4         46
##  [92,]             4.4         46
##  [93,]             4.4         46
##  [94,]             6.7         47
##  [95,]             6.7         47
##  [96,]             6.7         47
##  [97,]             6.8         48
##  [98,]             4.3         49
##  [99,]             6.9         49
## [100,]             7.0         50
```

```
best_row = order(num_errors_par[, "num_errors"])[1]
x_star = c(num_errors_par[best_row, "threshold_param"], use.names = FALSE)

threshold = x_star

print('Threshold:')
```

```
## [1] "Threshold:"
```

```
x_star
```

```
## [1] 5.4
```

What is the total number of errors this model makes?

```
num_errors_par[best_row, 2]
```

```
## num_errors
##         11
```

Does the threshold model's performance make sense given the following summaries:

```
threshold
```

```
## [1] 5.4
```

```
summary(iris[iris$Species == "setosa", "Sepal.Length"])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   4.300   4.800   5.000   5.006   5.200   5.800
```

```
summary(iris[iris$Species == "versicolor", "Sepal.Length"])
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   4.900   5.600   5.900   5.936   6.300   7.000
```

Yes, this threshold makes sense in light of the given summaries. Half of the observations are setosa and half are versicolor, so it would be expected to find a threshold between the max of setosa (5.8) and the min of versicolor (4.9). A threshold of 5.4 fits this criteria and seems to reasonably fit with the data summary

Create the function `g` explicitly that can predict `y` from `x` being a new `Sepal.Length`.

```
g = function(x){
  ifelse (x > threshold, "versicolor", "setosa")
}
```

Perceptron

You will code the "perceptron learning algorithm" for arbitrary number of features p. Take a look at the comments above the function. Respect the spec below:

COMPLETE ME, PLEASE!!!!

```
#' Perceptron Learning Algorithm for p Features
#'
#' TO-DO:
#'
#' @param Xinput      A matrix of training data
#' @param y_binary    A vector of training data labels
#' @param MAX_ITER    The maximum number of iterations (or updates to W) which the algorithm will attem
#' @param w           A vector of length p+1 containing the weights for the line of best fit.  ????
#'
#' @return            The computed final parameter (weight) as a vector of length p + 1

perceptron_learning_algorithm = function(Xinput, y_binary, MAX_ITER = 1000, w = array(NA, (length(y_bina

    for (i in 1:(length(y_binary)))


  #TO-DO
}



# y_bin = c(1,2,3,4)      Just using to test out pieces. Please, please delete me later.
```

To understand what the algorithm is doing - linear "discrimination" between two response categories, we can draw a picture. First let's make up some very simple training data $\mathbb{D}$.

```
Xy_simple = data.frame(
 response = factor(c(0, 0, 0, 1, 1, 1)), #nominal
 first_feature = c(1, 1, 2, 3, 3, 4),    #continuous
 second_feature = c(1, 2, 1, 3, 4, 3)    #continuous
)
```

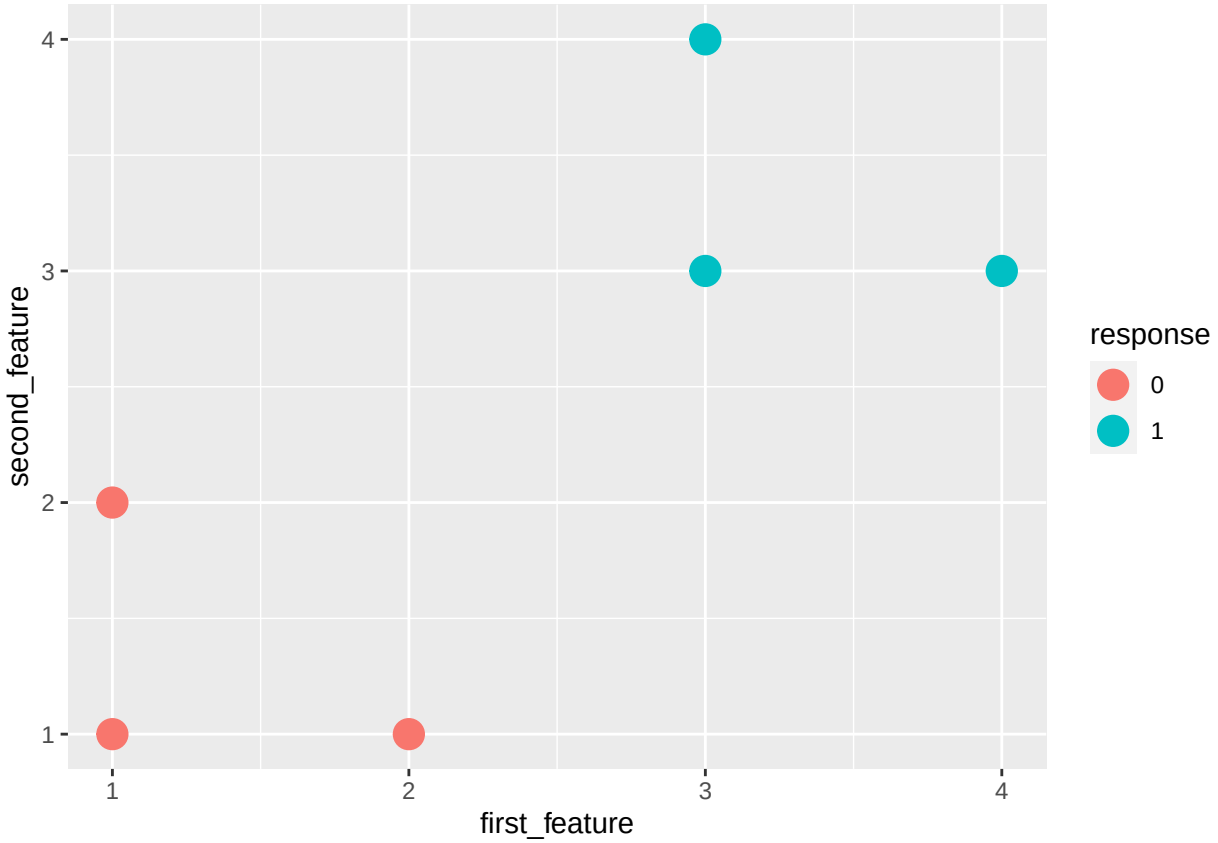
We haven't spoken about visualization yet, but it is important we do some of it now. Thus, I will write this code for you and you will just run it. First we load the visualization library we're going to use:

```
pacman::p_load(ggplot2)
```

We are going to just get some plots and not talk about the code to generate them as we will have a whole unit on visualization using `ggplot2` in the future.

Let's first plot y by the two features so the coordinate plane will be the two features and we use different colors to represent the third dimension, y.

```
simple_viz_obj = ggplot(Xy_simple, aes(x = first_feature, y = second_feature, color = response)) +
  geom_point(size = 5)
simple_viz_obj
```



This picture is a plot showing the linear separability of the given data into two categories (red/0 and blue?/1) based on two features.

Now, let us run the algorithm and see what happens:

```
w_vec_simple_per = perceptron_learning_algorithm(
  cbind(Xy_simple$first_feature, Xy_simple$second_feature),
  as.numeric(Xy_simple$response == 1))
w_vec_simple_per
```

Explain this output. What do the numbers mean? What is the intercept of this line and the slope? You will have to do some algebra.

TO-DO

```
simple_perceptron_line = geom_abline(
    intercept = -w_vec_simple_per[1] / w_vec_simple_per[3],
    slope = -w_vec_simple_per[2] / w_vec_simple_per[3],
    color = "orange")
simple_viz_obj + simple_perceptron_line
```

Explain this picture. Why is this line of separation not "satisfying" to you?

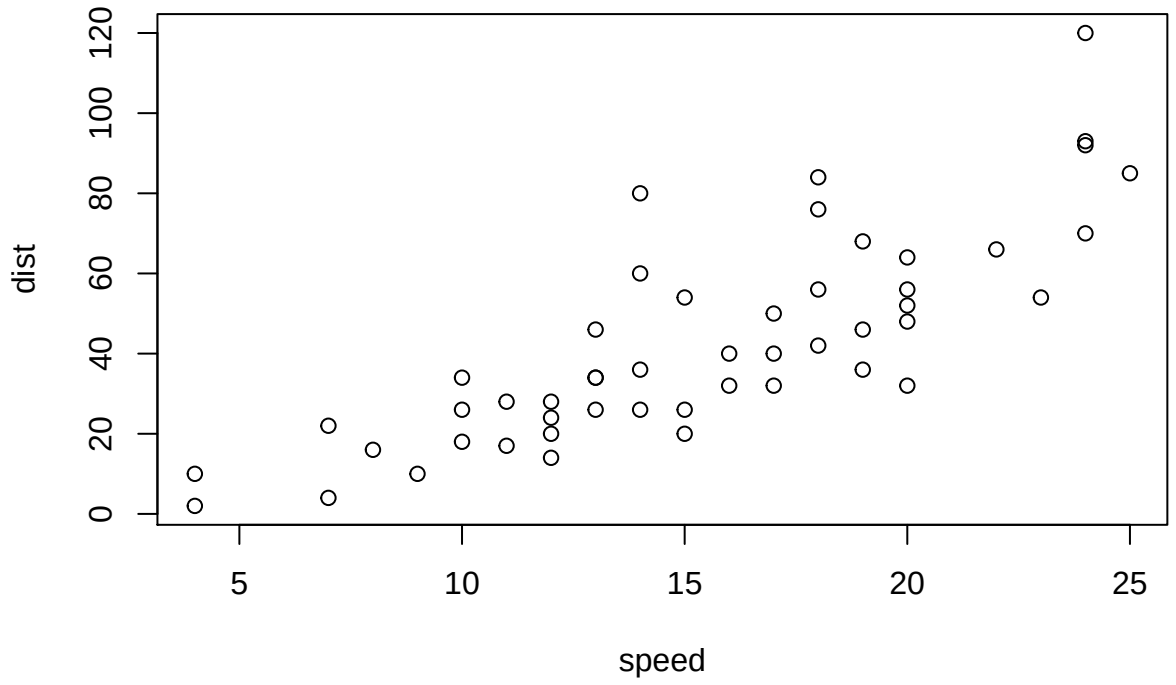
TO-DO

For extra credit, program the maximum-margin hyperplane perceptron that provides the best linear discrimination model for linearly separable data. Make sure you provide ROxygen documentation for this function.

```
#TO-DO
```

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Ctrl+Shift+Enter*.

```
plot(cars)
```



Add a new chunk by clicking the *Insert Chunk* button on the toolbar or by pressing *Ctrl+Alt+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Ctrl+Shift+K* to preview the HTML file).

The preview shows you a rendered HTML copy of the contents of the editor. Consequently, unlike *Knit*, *Preview* does not run any R code chunks. Instead, the output of the chunk when it was last run in the editor is displayed.