

Day Two: Data Cleaning

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Review

Inspecting objects

we'll start by using some data that is already in R

```
data(state)
str(state.x77)
```

Inspecting variables

We should see 50 levels in this division variable

```
state.division
```

```
## [1] East South Central Pacific Mountain
## [4] West South Central Pacific Mountain
## [7] New England South Atlantic South Atlantic
## [10] South Atlantic Pacific Mountain
## [13] East North Central East North Central West North Central
## [16] West North Central East South Central West South Central
## [19] New England South Atlantic New England
## [22] East North Central West North Central East South Central
## [25] West North Central Mountain West North Central
## [28] Mountain New England Middle Atlantic
## [31] Mountain Middle Atlantic South Atlantic
## [34] West North Central East North Central West South Central
## [37] Pacific Middle Atlantic New England
## [40] South Atlantic West North Central East South Central
## [43] West South Central Mountain New England
## [46] South Atlantic Pacific South Atlantic
## [49] East North Central Mountain
## 9 Levels: New England Middle Atlantic ... Pacific
```

```
length(state.division)
```

```
## [1] 50
```

```
levels(state.division)
```

```
## [1] "New England" "Middle Atlantic" "South Atlantic"
## [4] "East South Central" "West South Central" "East North Central"
## [7] "West North Central" "Mountain" "Pacific"
```

Inspecting data frames

recall, a dataframe is a list of vectors, where each vector is one variable with all of its measurements

R expects dataframes to be rectangular

```
state <- state.x77
rm(state.x77)
```

```
## Warning in rm(state.x77): object 'state.x77' not found
```

```
state <- as.data.frame(state)
head(state)
```

```
##           Population Income Illiteracy Life Exp Murder HS Grad Frost
## Alabama           3615   3624         2.1   69.05   15.1   41.3    20
## Alaska             365   6315         1.5   69.31   11.3   66.7   152
## Arizona           2212   4530         1.8   70.55    7.8   58.1    15
## Arkansas           2110   3378         1.9   70.66   10.1   39.9    65
## California        21198   5114         1.1   71.71   10.3   62.6    20
## Colorado          2541   4884         0.7   72.06    6.8   63.9   166
##
##           Area
## Alabama    50708
## Alaska    566432
## Arizona   113417
## Arkansas   51945
## California 156361
## Colorado  103766
```

Introduction

Today's class will be essentially be split into two components: CRUD operations in R and TIDY data. For more on tidiness in data, see [Hadley Wickham's paper](#). We will also touch on missingness - for an accessible introduction, you can read [this very old and no longer state-of-the-art paper](#).

yesterday we saw how to create dataframes in R

```
my.data <- data.frame(n = c(1, 2, 3),
                      c=c('one', 'two', 'three'),
                      b=c(TRUE, TRUE, FALSE),
                      d=c(as.Date("2015-07-27"),
                          as.Date("2015-07-27")+7,
                          as.Date("2015-07-27")-7),
                      really.long.and.complicated.variable.name=999)
```

remember, you can learn about dataframes with

```
str(my.data)
```

```
## 'data.frame':   3 obs. of  5 variables:
## $ n              : num  1 2 3
## $ c              : Factor w/ 3 levels "one","three",...: 1 3 2
```

```
## $ b                                : logi  TRUE TRUE FALSE
## $ d                                : Date, format: "2015-07-27" "2015-08-03" ...
## $ really.long.and.complicated.variable.name: num  999 999 999
```

in practice, you will only rarely create dataframes by hand, because creating tables in a text editor is both boring and prone to error

Readability

we've broken up the previous command across multiple lines to make it easier to read this is a stylistic choice, and one that should be encouraged: however, it won't be obvious to most of the students that it is necessary to either highlight the whole command and run, or hit run for every line, starting from the first one, in order often, students will just run the second line, and be confused when nothing runs correctly in the console anymore - the way to get out of this is by hitting ESC

Reading dataframes from file

why read data from text files?

they are human-readable and highly interoperable

```
read.table("data/mydata.csv", sep=',', header = TRUE)
```

```
##   n     c     b           d really.long.and.complicated.variable.name
## 1 1  one  TRUE 2015-07-27                                     999
## 2 2  two  TRUE 2015-08-03                                     999
## 3 3 three FALSE 2015-07-20                                     999
```

side note - anyone who is 100% new to computing will have a hard time understanding the concept of a working directory, and will try to run this code from their home directory (spoiler alert - it doesn't work)

R has convenience wrappers for reading in tables

```
read.csv("data/mydata.csv")
```

```
##   n     c     b           d really.long.and.complicated.variable.name
## 1 1  one  TRUE 2015-07-27                                     999
## 2 2  two  TRUE 2015-08-03                                     999
## 3 3 three FALSE 2015-07-20                                     999
```

note that we are only reading the files by doing this

R lets you read in part of a table

you'll sometimes find that you want to work with a smaller part of a dataset - maybe because the data is too large to fit into memory, or maybe because you want to test out some code on a small piece of the data so it runs faster

```
read.csv("data/mydata.csv", nrows=2)
```

```
##   n   c   b           d really.long.and.complicated.variable.name
## 1 1 one TRUE 2015-07-27                                     999
## 2 2 two TRUE 2015-08-03                                     999
```

note that `nrows` is **not** equal to the number of lines in the file, because it does not include the file header

R also has its own kind of data file

```
load("data/mydata.Rda")
```

the `load` function does actually put the file into memory, and with the name you originally gave it when you saved it

this is typically a bad thing, and there is currently no easy workaround

to read in tables from excel, use the `xlsx` package

if you are exporting data from excel, be sure to export datetimes as strings, as excel does not store dates internally the same way Unix does

```
# WARNING! xlsx package install crashed current version of RStudio
install.packages("xlsx")
library(xlsx)
read.xlsx("data/cpds_excel_new.xlsx")
```

But it may be better to save your `.xlsx` file as a `csv.` format in Excel first, and then read the `csv` file into R.

you can also use R to read in data from proprietary software

```
# examples of these?
install.packages("foreign")
library(foreign)
read.dta("data/cpds_stata.dta")
read.spss()
read.octave()
```

Cleaning data

there are two major steps to data cleaning, which we will call ‘sanitizing’ and ‘tidying’

in sanitizing, our goal is to take each variable and force its values to be honest representations of its levels

in tidying, we are arranging our data structurally such that each row contains exactly one observation, and each column contains exactly one kind of data about that observation (this is sometimes expressed in SQL terms as “An attribute must tell something about the key, the whole key, and nothing but the key, so help me Codd”)

exporting data from other software can do weird things to numbers and factors

```
dirty <- read.csv('data/dirty.csv')
str(dirty)
```

```
## 'data.frame':    5 obs. of  5 variables:
## $ Timestamp      : Factor w/  5 levels "7/25/2015 10:08:41",...: 1 2 3 4 5
## $ How.tall.are.you. : Factor w/  5 levels "156","2.1","5'9",...: 5 4 3 2 1
## $ What.department.are.you.in.: Factor w/  5 levels " geology","999",...: 4 2 1 5 3
## $ Are.you.currently.enrolled.: Factor w/  3 levels "999","No","Yes": 3 3 1 2 1
## $ What.is.your.birth.order.  : Factor w/  3 levels "1","2","9,000": 1 1 2 3 2
```

it’s usually better to DISABLE R’s intuition about data types

unless you already know the data is clean and has no non-factor strings in it (i.e. you are the one who created it)

```
dirty <- read.csv('data/dirty.csv',stringsAsFactors = FALSE)
str(dirty)
```

```
## 'data.frame':    5 obs. of  5 variables:
## $ Timestamp      : chr  "7/25/2015 10:08:41" "7/25/2015 10:10:56" "7/25/2015 10:11:20"
## $ How.tall.are.you. : chr  "very" "70" "5'9" "2.1" ...
## $ What.department.are.you.in.: chr  "Geology " "999" " geology" "goelogy" ...
## $ Are.you.currently.enrolled.: chr  "Yes" "Yes" "999" "No" ...
## $ What.is.your.birth.order.  : chr  "1" "1" "2" "9,000" ...
```

let’s start by removing the empty rows and columns

```
tail(dirty)
```

```
##           Timestamp How.tall.are.you. What.department.are.you.in.
## 1 7/25/2015 10:08:41          very          Geology
## 2 7/25/2015 10:10:56           70           999
## 3 7/25/2015 10:11:20          5'9          geology
## 4 7/25/2015 10:11:25           2.1          goelogy
## 5 7/25/2015 10:11:29          156          anthro
```

```
## Are.you.currently.enrolled. What.is.your.birth.order.
## 1 Yes 1
## 2 Yes 1
## 3 999 2
## 4 No 9,000
## 5 999 2
```

```
dirty <- dirty[1:5,-6]
dim(dirty)
```

```
## [1] 5 5
```

you can replace variable names

and you should, if they are uninformative or long

```
names(dirty)
```

```
## [1] "Timestamp" "How.tall.are.you."
## [3] "What.department.are.you.in." "Are.you.currently.enrolled."
## [5] "What.is.your.birth.order."
```

```
names(dirty) <- c("time", "height", "dept", "enroll", "birth.order")
```

it's common for hand-coded data to have a signifier for subject-missingness

(to help differentiate it from your hand-coder forgetting to do something)

```
dirty$enroll
```

```
## [1] "Yes" "Yes" "999" "No" "999"
```

you should replace all of these values in your dataframe with R's missingness signifier, NA

```
table(dirty$enroll)
```

```
##
## 999 No Yes
## 2 1 2
```

```
dirty$enroll[dirty$enroll=="999"] <- NA
table(dirty$enroll, useNA = "ifany")
```

```
##
## No Yes <NA>
## 1 2 2
```

side note - `read.table()` has an option to specify field values as NA as soon as you import the data, but this is a BAAAAAD idea because R automatically encodes blank fields as missing too, and thus you lose the ability to distinguish between user-missing and experimenter-missing

the height variable is in four different units

we can fix this with a somewhat complicated loop (since R started as a functional language, there are not easy ways to conditionally modify structures in place)

OR

we can do the same task line-by-line, since the number of observations is small

```
class(dirty$height)
```

```
## [1] "character"
```

```
as.numeric(dirty$height)
```

```
## Warning: NAs introduced by coercion
```

```
## [1] NA 70.0 NA 2.1 156.0
```

because there are apostrophes and quotation marks, R thinks these are strings

```
dirty$height[grep("'", dirty$height, perl=TRUE)] <- 5*30.48 + 9*2.54
dirty$height[2] <- 70*2.54
dirty$height[3] <- 2.1*100
```

let's fix some of those department spellings

first, let's make this all lowercase

```
dirty$dept
```

```
## [1] "Geology" "999" "geology" "goelogy" "anthro"
```

```
dirty$dept <- tolower(dirty$dept)
dirty$dept <- gsub(' ', '', dirty$dept) # what did we just do?
dirty$dept[4] <- "geology"
dirty[dirty == "999"] <- NA
```

then, you can coerce the data into the types they should be

```
dirty$time <- as.Date(dirty$time, '%m/%d/%Y')
dirty$height <- as.numeric(dirty$height)
```

```
## Warning: NAs introduced by coercion
```

```
dirty$dept <- as.factor(dirty$dept)
dirty$enroll <- as.factor(dirty$enroll)
dirty$birth.order <- as.numeric(dirty$birth.order)
```

```
## Warning: NAs introduced by coercion
```

```
str(dirty)
```

```
## 'data.frame':   5 obs. of  5 variables:
## $ time       : Date, format: "2015-07-25" "2015-07-25" ...
## $ height     : num  NA 177.8 210 2.1 156
## $ dept       : Factor w/ 2 levels "anthro","geology": 2 NA 2 2 1
## $ enroll     : Factor w/ 2 levels "No","Yes": 2 2 NA 1 NA
## $ birth.order: num  1 1 2 NA 2
```

Missingness

there are many reasons why you might have missing data

AS LONG AS MISSINGNESS IS NOT CAUSED BY YOUR INDEPENDENT VARIABLE this is fine

deleting those observations is wasteful, but easy (listwise deletion)

ignoring the individual missing data points is typical (casewise deletion)

imputing mean values for missing data is possibly the worst thing you can do

imputing via MI + error is currently the best option

listwise deletion is wasteful

```
na.omit(dirty)
```

```
## [1] time      height      dept      enroll      birth.order
## <0 rows> (or 0-length row.names)
```

casewise deletion is what R does internally

```
nrow(dirty)
```

```
## [1] 5
```

```
sum(is.na(dirty$height))
```

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

```
sum(is.na(dirty$birth.order))
```

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

```
length(lm(height ~ birth.order, data=dirty)$fitted.values)
```

```
## [1] 3
```

this is usually the default strategy

remember how we talked about the extensibility of R?

amelia is a package that makes a complicated MI approach work without you knowing anything about its implementation

```
library(Amelia)
```

let's use this large dataset as an example

```
large <- read.csv('data/large.csv')
summary(large)
```

```
##           a           b           c
##  Min.      :-33.98426  Min.      :-13.4   Min.      :-249998.64
##  1st Qu.: -6.71903    1st Qu.:128.6   1st Qu.: -141005.65
##  Median :  0.41681    Median :256.9   Median : -63498.56
##  Mean   :  0.00176    Mean   :252.2   Mean   : -83954.09
##  3rd Qu.:  7.00630    3rd Qu.:377.5   3rd Qu.: -15748.98
##  Max.    : 35.33306    Max.    :513.3   Max.     :   11.77
##  NA's    :45          NA's     :45     NA's     :45
```

```
nrow(na.omit(large))
```

```
## [1] 871
```

for it to work you need low missingness and large N

```
a <- amelia(large,m = 1)
```

```
## -- Imputation 1 --
##
##  1  2  3
```

```
print(a)
```

```
##
## Amelia output with 1 imputed datasets.
## Return code: 1
## Message: Normal EM convergence.
##
## Chain Lengths:
## -----
## Imputation 1: 3
```

amelia returns a list, where the first item is a list of your imputations

we only did one, so here it is

```
large.imputed <- a[[1]][[1]]
summary(large.imputed)
```

```
##           a           b           c
## Min.      :-33.98426  Min.      :-13.4   Min.      :-249999
## 1st Qu.:  -6.56630   1st Qu.:126.5   1st Qu.: -140641
## Median :   0.46497   Median :252.0   Median :  -63010
## Mean      :  0.02079   Mean      :249.9   Mean      : -83310
## 3rd Qu.:   6.99412   3rd Qu.:375.2   3rd Qu.: -15626
## Max.      : 35.33306   Max.      :568.8   Max.      : 41249
```

if you give it a tiny dataset, it will fuss at you

```
a <- amelia(large[990:1000,],m = 1)
```

```
## Warning in amelia.prep(x = x, m = m, idvars = idvars, empri = empri, ts =
## ts, : You have a small number of observations, relative to the number, of
## variables in the imputation model. Consider removing some variables, or
## reducing the order of time polynomials to reduce the number of parameters.
```

```
## -- Imputation 1 --
##
## No missing data in bootstrapped sample: EM chain unnecessary
```

```
print(a)
```

```
##
## Amelia output with 1 imputed datasets.
## Return code: 1
## Message: Normal EM convergence.
##
## Chain Lengths:
## -----
## Imputation 1:
```

Reshaping

now that our data is clean, it's time to put it in a tidy format. this is a way of storing data that makes it easy to:

1. make graphs
2. run tests
3. summarize
4. transform into other formats

we are basically trying to organize ourselves such that:

1. any grouping is made on rows
2. any testing is done between columns

an aside on testing

in R, you use double symbols for testing

```
1 == 2
```

```
## [1] FALSE
```

```
1 != 1
```

```
## [1] FALSE
```

```
1 >= 1
```

```
## [1] TRUE
```

(you've already seen a couple of these)

tests return boolean vectors

```
1 >= c(0,1,2)
```

```
## [1] TRUE TRUE FALSE
```

recall that boolean vectors need to be the same length or a divisor

if your vectors are not multiples of each other, R will fuss at you

```
c(1,2) >= c(1,2,3)
```

```
## Warning in c(1, 2) >= c(1, 2, 3): longer object length is not a multiple of  
## shorter object length
```

```
## [1] TRUE TRUE FALSE
```

```
c(1,2) >= c(1,2,3,4) # why no warning this time? R recycles!
```

```
## [1] TRUE TRUE FALSE FALSE
```

the combination of the length requirement, the lack of support in R for proper indexing, and missingness in your data will cause many headaches later on

subsetting data frames

subsetting your data is where you will use this regularly

```
my.data$numeric == 2
```

```
## logical(0)
```

```
my.data[my.data$numeric == 2,]
```

```
## [1] n  
## [2] c  
## [3] b  
## [4] d  
## [5] really.long.and.complicated.variable.name  
## <0 rows> (or 0-length row.names)
```

boolean variables can act as filters right out of the box

```
my.data[my.data$b,]
```

```
##   n   c   b           d really.long.and.complicated.variable.name  
## 1 1 one TRUE 2015-07-27                                     999  
## 2 2 two TRUE 2015-08-03                                     999
```

you see the empty space after the comma? that tells R to grab all the columns

you can also select columns

```
my.data[, 'd']
```

```
## [1] "2015-07-27" "2015-08-03" "2015-07-20"
```

that empty space **before** the comma? that tells R to grab all the rows

you can also match elements from a vector

```
good.things <- c("three", "four", "five")  
my.data[my.data$character %in% good.things, ]
```

```
## [1] n  
## [2] c  
## [3] b  
## [4] d  
## [5] really.long.and.complicated.variable.name  
## <0 rows> (or 0-length row.names)
```

most subsetting operations on dataframes also return a dataframe

```
str(my.data[!(my.data$character %in% good.things), ])
```

```
## 'data.frame': 0 obs. of 5 variables:
## $ n : num
## $ c : Factor w/ 3 levels "one","three",...:
## $ b : logi
## $ d :Class 'Date' num(0)
## $ really.long.and.complicated.variable.name: num
```

subsets that are a single column return a vector

```
str(my.data$numeric)
```

```
## NULL
```

most tidying can be done with two R packages

(plus a wrapper around the base string functions)

```
install.packages('tidyr')
install.packages('stringr')
install.packages('dplyr')
```

```
library(tidyr)
library(stringr)
library(dplyr)
```

reshaping

our goal here is to arrange our data such that each table is about one kind of thing: whether it is everything about a measurement, everything about a person, or everything about a group of people

```
abnormal <- data.frame(name = c('Alice','Bob','Eve'),
                       time1 = c(90,90,150),
                       time2 = c(100,95,100))
```

this table is not tidy - why not?

the table is about measurements, but each measurement does not have its own row, and each type of measurement value is represented by more than one column

```
normal <- gather(abnormal, "time", "score", time1, time2)
normal
```

```
##   name  time score
## 1 Alice time1    90
## 2  Bob time1    90
```

```
## 3   Eve time1    150
## 4 Alice time2    100
## 5   Bob time2     95
## 6   Eve time2    100
```

we can gather the two columns with time data into a column representing just time, and another representing just scores

now that each row is a unique observation, we can clean up the dataframe a bit

```
normal$id <- seq(1:nrow(normal))
normal$time <- str_replace(normal$time, 'time', '')
normal$time <- as.numeric(normal$time)
```

now that we are in a tidy format, see how easy it is to subset

```
normal[normal$time == 1,]
```

```
##   name time score id
## 1 Alice    1    90  1
## 2  Bob    1    90  2
## 3  Eve    1   150  3
```

```
normal[normal$name == 'Alice',]
```

```
##   name time score id
## 1 Alice    1    90  1
## 4 Alice    2   100  4
```

and test

side note - don't worry about how this works yet - we'll talk about it tomorrow

```
t.test(score ~ time, data=normal)
```

```
##
## Welch Two Sample t-test
##
## data:  score by time
## t = 0.58132, df = 2.0278, p-value = 0.6191
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -73.56101  96.89434
## sample estimates:
## mean in group 1 mean in group 2
##      110.00000      98.33333
```

it's easy to combine tidy tables to compare different levels of information simultaneously

Merging data frames

flexibly join dataframes with merge

imagine you have two datasets that you want to merge

```
data.1 <- read.csv('data/merge_practice_1.csv')
data.2 <- read.csv('data/merge_practice_2.csv')
```

```
## Warning in read.table(file = file, header = header, sep = sep, quote
## = quote, : incomplete final line found by readTableHeader on 'data/
## merge_practice_2.csv'
```

```
str(data.1)
```

```
## 'data.frame': 5 obs. of 4 variables:
## $ id : int 1 2 3 4 5
## $ name : Factor w/ 5 levels "Alice","Bob",...: 1 2 3 4 5
## $ job : Factor w/ 3 levels "communications",...: 1 1 2 1 3
## $ location: Factor w/ 3 levels "Berkeley","Cambridge",...: 3 2 3 1 2
```

```
str(data.2)
```

```
## 'data.frame': 4 obs. of 4 variables:
## $ id : int 1 4 5 6
## $ name : Factor w/ 4 levels "Alice","Dave",...: 1 2 3 4
## $ job : Factor w/ 3 levels "hacker","handler",...: 1 3 2 1
## $ location: Factor w/ 4 levels "berkeley","cambridge",...: 2 4 3 1
```

sometimes the same people have different jobs in different locations

you can do an *inner* join using merge

```
merge(data.1, data.2, by = 'id')
```

```
##   id name.x      job.x location.x name.y  job.y location.y
## 1  1 Alice communications New York Alice hacker  cambridge
## 2  4 Dave communications Berkeley Dave tree palo alto
## 3  5 Eve spy Cambridge Eve handler new york
```

that's no good - we lost half of our people!

inner joins are mostly used when you **only** want records that appear in both tables

if you want the union, you can use an outer join

```
merge(data.1, data.2, by = 'id', all = TRUE)
```

```
##   id name.x      job.x location.x name.y  job.y location.y
## 1  1 Alice communications New York Alice hacker  cambridge
## 2  2 Bob communications Cambridge <NA> <NA> <NA>
## 3  3 Chuck hacker New York <NA> <NA> <NA>
## 4  4 Dave communications Berkeley Dave tree palo alto
## 5  5 Eve spy Cambridge Eve handler new york
## 6  6 <NA> <NA> <NA> Faith hacker berkeley
```

this works basically the same as join in SQL

running merges is particularly useful when:

- a. your data is tidy; and,
- b. you want to add information with a lookup table

in this case, you can store your lookup table as a dataframe, then merge it

```
lookup <- read.csv('data/merge_practice_3.csv')
str(lookup)
```

```
## 'data.frame':  5 obs. of  2 variables:
## $ location  : Factor w/ 5 levels "Berkeley","Cambridge",...: 2 3 1 4 5
## $ population: int  107289 8406000 116768 66642 233294
```

this lookup table gives us the population for each location

we can add this to our people table with

```
merge(data.1, lookup, by = "location")
```

```
##   location id  name      job population
## 1 Berkeley  4  Dave communications    116768
## 2 Cambridge 2   Bob communications    107289
## 3 Cambridge 5   Eve             spy      107289
## 4 New York  1 Alice communications    8406000
## 5 New York  3 Chuck             hacker    8406000
```

note that Reno was in our lookup table

```
lookup[lookup$location == 'Reno', ]
```

```
##   location population
## 5      Reno      233294
```

but doesn't show up when we merge - why do you think this is?

Transforming data

introduction

because R started out as a functional language, it can be hard to modify data, especially in place

in practice, if you want 100% control over how your frames are being modified, you'll be writing lots of `for` loops, which is messy

luckily, there is a package that handles the common tasks for you


```
library(dplyr)
```

sort data with arrange

base R syntax for sorting is a bit of a pain in that you have to create a sorting vector based on the values in a column, then subset the same dataframe and apply the sorting vector to the rows slice

to demonstrate this, let's have another look at our 'normal' data frame

```
normal
```

```
##   name time score id
## 1 Alice   1    90  1
## 2  Bob    1    90  2
## 3  Eve    1   150  3
## 4 Alice   2   100  4
## 5  Bob    2    95  5
## 6  Eve    2   100  6
```

```
arrange(normal, score)
```

```
##   name time score id
## 1 Alice   1    90  1
## 2  Bob    1    90  2
## 3  Bob    2    95  5
## 4 Alice   2   100  4
## 5  Eve    2   100  6
## 6  Eve    1   150  3
```

apply summary functions with summarise

dplyr includes most of the base R summary statistics, along with:

- `n()`
- `n_distinct()`
- `first()`
- `last()`

if we want to get the mean and sd for the scores, we can do

```
summarise(normal, mean(score), sd(score))
```

```
##   mean(score) sd(score)
## 1    104.1667  22.89469
```

dplyr allows you to apply functions to groups

so far, these have taken base R functions and made them faster (with C++ calls behind the scenes), easier to use, or both

dplyr's real utility is in its grouped dataframes, which apply dplyr functions groupwise

let's say that we want to know the rank at each time – we can **groupby** time and then do some variable transformation

```
group_by(normal, time)
```

```
## Source: local data frame [6 x 4]
## Groups: time [2]
##
##   name  time score   id
##   (fctr) (dbl) (dbl) (int)
## 1  Alice     1    90     1
## 2   Bob     1    90     2
## 3   Eve     1   150     3
## 4  Alice     2   100     4
## 5   Bob     2    95     5
## 6   Eve     2   100     6
```

```
summarize(group_by(normal, time), mean(score))
```

```
## Source: local data frame [2 x 2]
##
##   time mean(score)
##   (dbl)      (dbl)
## 1     1   110.00000
## 2     2    98.33333
```

```
mutate(group_by(normal, time), diff=score-mean(score))
```

```
## Source: local data frame [6 x 5]
## Groups: time [2]
##
##   name  time score   id    diff
##   (fctr) (dbl) (dbl) (int)  (dbl)
## 1  Alice     1    90     1 -20.000000
## 2   Bob     1    90     2 -20.000000
## 3   Eve     1   150     3  40.000000
## 4  Alice     2   100     4   1.666667
## 5   Bob     2    95     5  -3.333333
## 6   Eve     2   100     6   1.666667
```

```
ungroup(mutate(group_by(normal, time), diff=score-mean(score)))
```

```
## Source: local data frame [6 x 5]
##
##   name  time score   id    diff
```

```
##      (fctr) (dbl) (dbl) (int)      (dbl)
## 1  Alice      1    90      1 -20.000000
## 2   Bob       1    90      2 -20.000000
## 3   Eve       1   150      3  40.000000
## 4  Alice      2   100      4   1.666667
## 5   Bob       2    95      5  -3.333333
## 6   Eve       2   100      6   1.666667
```

you can add as many functions as you want inbetween, but wrapping function call around function call can be hard to read (and write!)

you can pipe functions with the %>% operator

pipes take the output of one function and give it as an input to the next function, without deep nesting of functions nor saving all of the intermediate steps

this makes code a lot easier to read, and to understand

```
normal %>% group_by(time) %>% mutate(diff=score-mean(score)) %>% ungroup() -> super
```

Practice

Grab some data from Pew

and sanitize/tidy it

this will be hard

```
library(foreign)
pew <- as.data.frame(read.spss("data/pew.sav"))
```

```
## re-encoding from CP1252
```

```
## Warning in `levels<-`(`*tmp*`, value = if (nl == nL) as.character(labels)
## else paste0(labels, : duplicated levels in factors are deprecated
```

```
religion <- pew[c("q16", "reltrad", "income")]
rm(pew)
```

we'll start by cleaning up the factor variables

```
religion$reltrad <- as.character(religion$reltrad)
religion$reltrad <- str_replace(religion$reltrad, " Churches", "")
religion$reltrad <- str_replace(religion$reltrad, " Protestant", " Prot")
religion$reltrad[religion$q16 == " Atheist (do not believe in God) "] <- "Atheist"
religion$reltrad[religion$q16 == " Agnostic (not sure if there is a God) "] <- "Agnostic"
religion$reltrad <- str_trim(religion$reltrad)
religion$reltrad <- str_replace_all(religion$reltrad, " \\(.*?\\)", "")
```

```

religion$income <- c("Less than $10,000" = "<$10k",
  "10 to under $20,000" = "$10-20k",
  "20 to under $30,000" = "$20-30k",
  "30 to under $40,000" = "$30-40k",
  "40 to under $50,000" = "$40-50k",
  "50 to under $75,000" = "$50-75k",
  "75 to under $100,000" = "$75-100k",
  "100 to under $150,000" = "$100-150k",
  "$150,000 or more" = ">150k",
  "Don't know/Refused (VOL)" = "Don't know/refused")[religion$income]

religion$income <- factor(religion$income, levels = c("<$10k", "$10-20k", "$20-30k", "$30-40k", "$40-50k",
  "$50-75k", "$75-100k", "$100-150k", ">150k", "Don't know/refused"))

```

now we can reduce this down to three columns for three variables

```

religion <- count(religion, reltrad, income)
names(religion)[1] <- "religion"

```

Acknowledgements

Materials taken from:

[Chris Krogslund](#) [Hadley Wickham](#)