Q&A Material

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What's the Deal with Fall Coding Lab?

Two tracks:

Accelerated: 2 lessons

- 2 lessons covering loops and functions.
- No final project (you already did it).

Not accelerated: 5 lessons.

- 3 lessons review summer camp material.
- 2 lessons covering loops and functions.
- Final project:
  - Find a data set that speaks to you.
  - Try to uncover something interesting. Graph it and tab it.
  - We'll give you feedback.

Logistics for Both Tracks

- Instructors Ari and Terence + wonderful TAs.
- 80 minutes per week: brief review and Q&A, then work in groups.
- Not graded.
- Access to TAs for coding specific problems throughout the quarter.
  - TA office hours 30 minutes before and after lecture time.
- Github website with all material.
  - We'll post solutions (eventually).
- Use Piazza for questions.
  - Rules of engagement: coding questions only, no Stats homework!
  - How to ask a good question?

Poll: How much coding experience do you have?

- First timer.
- Beginner.
- Intermediate.
- Proficient.

Please include your email.

Class 1: Why R? & Vectors

Key Points: R Basics

- Rstudio has a console to access R and a text editor to write code for reproducible projects.
  - Analogy: R is to RStudio as Tony Stark is to Iron Man's suit.
- R extensible through packages.
  - use `install.packages("")` once and then `library()` each session.
- Use `<-` to assign *any* object to a name.
- Functions take inputs and return outputs.
  - Input "understood" based on position or name.
  - Find out more about functions with `?` (e.g. `?filter`).

Questions

- Any questions on this? Feel free to ask on chat.

Key points: Vectors

- Vectors are the fundamental way to store data in R.
- We can operate on vectors element-by-element without loops.
  - `dplyr` verbs rely on this!
- We introduced built-in functions to build vectors and do operations on vectors.
- `NA`s are sticky!

Key points: Data Types and Coercion

- (Atomic) Vectors have a single data type.
  - Most often: `logical`, `integer`, `double`, or `character`.
- Certain operations expect a certain data type and R will try to coerce the data if it can.
- Usually, simpler types can be coerced to more complex types.
  - `logical < integer < double < character`.
  - Example on slides: `paste0(1L, "ing")`.
- Caution! Coercion can lead to unexpected behavior such as making `NA`s.

One More Thing

Logicals are coercible to numeric or character. This is very useful!

Determine the rule for how R treats `TRUE` and `FALSE` in math.

```r
TRUE + 4
```

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

```r
FALSE + 4
```

```
## [1] 4
```

Questions?

- Any questions on this? Feel free to ask on chat.

Warm up & Lab 1

Warm up

- Solve the questions at the beginning of the lab in small (random) groups.

Lab 1

- Two “types” of breakout room:
  - Work along: larger group with more guidance from a TA.
  - Small groups: 4 people, TAs will come in and out to answer questions. Use the help button!
- Add “(work along)” or “(small group)” to your Zoom name so we can sort you.
- Get as far as you can, then finish it up after class.
- Before you leave, fill out the exit poll.

Lab 1: Exit poll

- What does `hist()` return?
  - A histogram plot of the data you give it.
  - A history of the commands you've run.

Class 2: Reading files and ‘dplyr’

Course logistics:

- When should we start working on the final project?
  - Start looking for a dataset now.
  - Write code to read it into R and start investigating with `dplyr` verbs.
    - Ask simple questions that can be addressed with your current tools.

Key points: Reading files

- Tabular data is stored in a lot of different formats.
  - e.g. `.csv`, `.xlsx`, `.dta`
- Read tabular data of a given type with the proper function.
  - e.g. for `csv`s we have `read_csv()`
  - If you get a new type, Google "How to read xxx files into R tidyverse".
- We need to be aware of the file path and can `setwd()`.
- We know there are useful tools built into the `read_xxx()` functions.
  - Though we just scratched the surface.

Key points: Manipulating data with `dplyr()`

- Choose columns with `select()`.
- Choose rows based on a match criteria with `filter()`.
  - We were introduced to comparison operators like == and `%in%`.
- Make new columns with `mutate()`.
- Sort data with `arrange()` and `arrange(desc())` or `arrange(-x)`.
- Create summary statistics with `summarize()`.

Key points: Grouped analysis with `group_by()`

- *Groups* are a set of rows that belong together.
  - `group_by()` adds information about groups without changing the "data".
- Use `group_by()` with `summarize()` to create summary data at group-level.
  - Use with functions that *reduce* data from a vector to a single value per group.
  - Expected output: a table with one row per group and one column per summary statistic and one column per grouping column.
- We can also use `group_by` to do grouped analysis with:
  - `mutate` with window functions or to add a summary stat as column for further analysis.
  - It also can impact `arrange` and `filter`.

Warm up & Lab 2

Warm up & Lab 2

- Solve the questions at the beginning of the lab in small (random) groups.
- After: add "(small group)" in front of your name if you want to work in one, if you want to work along just stay in the main room.
- Exit poll:

1. What `dplyr` command allows you to create or modify variables?
2. What `dplyr` command allows you to sort your data?

Class 3: Control Flow

Key points: control flow with `if ()` and `ifelse ()`

- Review how logical operators (i.e. `!`, `|`, `&`) and comparison operators work.
  - If this all still seems confusing a refresher in propositional logic will seriously pay off!
- Use `if ()`, `else`, and `else if ()` to control when and how an action is completed.
  - Can use shorthand for conditions: `if (thing_thats_true)` is equivalent to `if (thing_thats_true == TRUE)`.
- `ifelse()` as a vectorized, `NA` friendly alternative.
- Use `ifelse()` with `mutate()` to create new columns contingently.

Two more things (1/2): `case_when()`

- `case_when()` allows you to chain many conditions and outputs:

```
case_when(condition_1 ~ value_1,
          condition_2 ~ value_2,
          condition_3 ~ value_3,
          TRUE ~ value_4)
```

Somewhat equivalent to:

```
ifelse(condition_1, value_1,
       ifelse(condition_2, value_2,
              ifelse(condition_3, value_3, value_4)))
```

Two more things (2/2): NA

- How to think about logicals and NA? If the answer is ambiguous → NA. If the answer isn't → not NA.

```
TRUE | NA
```

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

```
FALSE & NA
```

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

Warm up & Lab 3

Warm up & Lab 3

- This warm up is a little longer. Aim to get up to the "Vectorized booleans" part!
- After: add "(small group)" in front of your name if you want to work in one.
- Exit poll:

1. What is `FALSE | NA`?
2. What is `TRUE & NA`?

Acc Class 1 / Class 4: Functions

Functions

What are some of the key take aways you learned about functions from the video?

```
do_monte_carlo <- function(N, true_mean, B, alpha){
  sample_statistics <- monte_carlo_samples(N, true_mean, B)
  z_scores <- get_zscores(sample_statistics$mean,
                          true_mean,
                          sample_statistics$sd,
                          N)
  test_significance(z_scores, alpha) %>% mean()
}
```

Key points: Functions

- Write functions when you want o use a set of operations repeatedly
  - Don't Repeat Yourself (DRY)
- Functions consist of arguments and a body and are usually assigned to a name.
  - The arguments are things that you want to change in the code
  - The body is what you would be repeating if you wrote sloppy code
- Functions are for humans
  - pick names for the function and arguments that are clear and consistent
- Debug your code as much as you can as you write it.
  - if you want to use your code with `mutate()` test the code with vectors

Warm up

- Solve the questions at the beginning of the lab in small (random) groups.

Background for the lab

Concepts: `r/q/p/d` functions

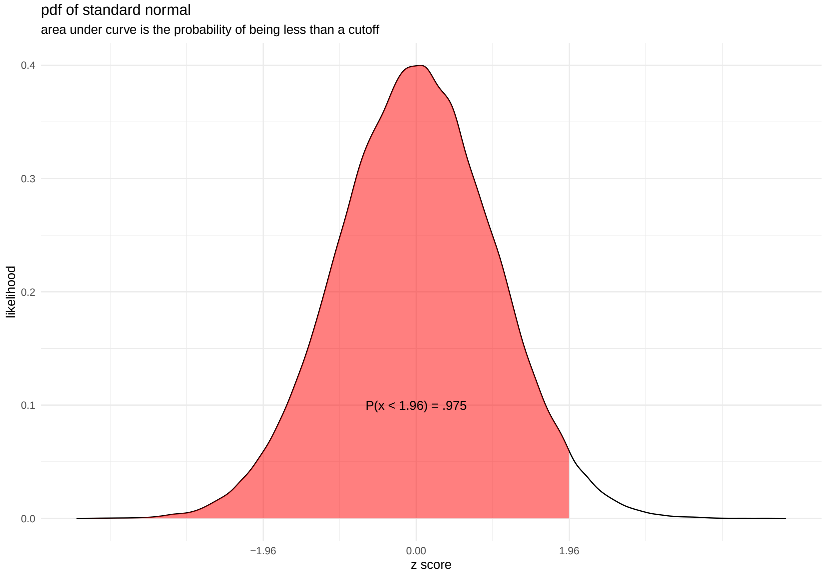
R has built-in functions for working with distributions.

	example	what it does?
r	`rnorm(n)`	generates a random sample of size n
p	`pnorm(q)`	returns CDF value at q
q	`qnorm(p)`	returns inverse CDF (the quantile) for a given probability
d	`dnorm(x)`	returns pdf value at x

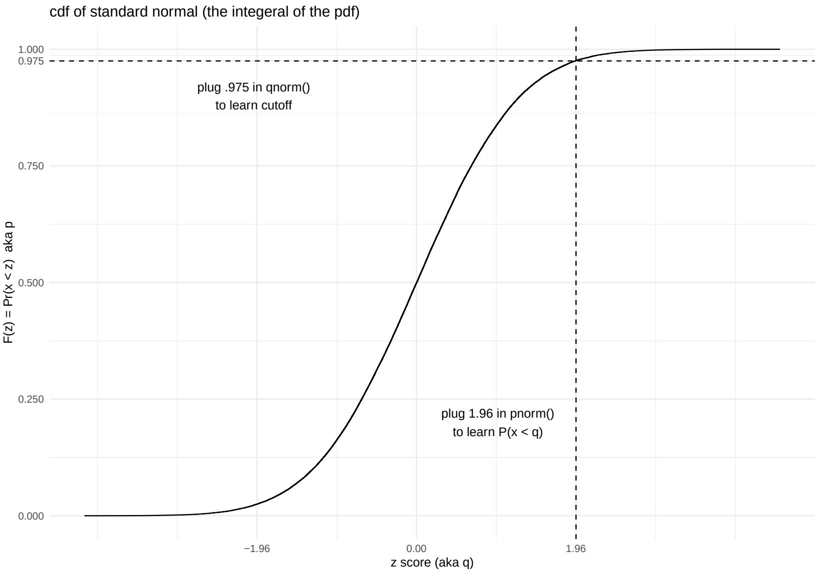
We should already be familiar with `r` functions like `rnorm()` and `runif()`.

- These concepts will be taught in stats. We don't expect you to learn them here. We can help you reason through the material enough to do the coding.

What are p and q?



What are p and q?



What are p and q?

pnorm returns the probability we observe a value less than or equal to some value q.

```
pnorm(1.96)
```

```
## [1] 0.9750021
```

```
pnorm(0)
```

```
## [1] 0.5
```

qnorm returns the inverse of `pnorm`. Plug in the probability and get the cutoff.

```
qnorm(.975)
```

```
## [1] 1.959964
```

```
qnorm(.5)
```

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

Monte Carlo experiments

Monte Carlo is a world gambling hub.

- Gamblers know that roulette wheels are not made perfectly.
- If you watch the wheel long enough and take notes you can figure out the emprical probability

Monte Carlo experiments

Statisticians use the same idea.

- If we're not sure how to calculate something exactly, we can simulate it and get the result.
- Often used for difficult to compute integrals.

An example

In real life experiements we usually have one sample.

```r
# Setting a seed ensures replicability
set.seed(4)

# we set our parameters
true_mean <- 0.5
N <- 30

# We simulate and observe outcomes
simulated_data <- rnorm(N, mean = true_mean)
obs_mean <- mean(simulated_data)
obs_mean
```

```
## [1] 0.9871873
```

Put that number in perspective with a z score

```r
obs_sd <- sd(simulated_data)
zscore <- (obs_mean - true_mean) / (obs_sd / sqrt(N))
zscore
```

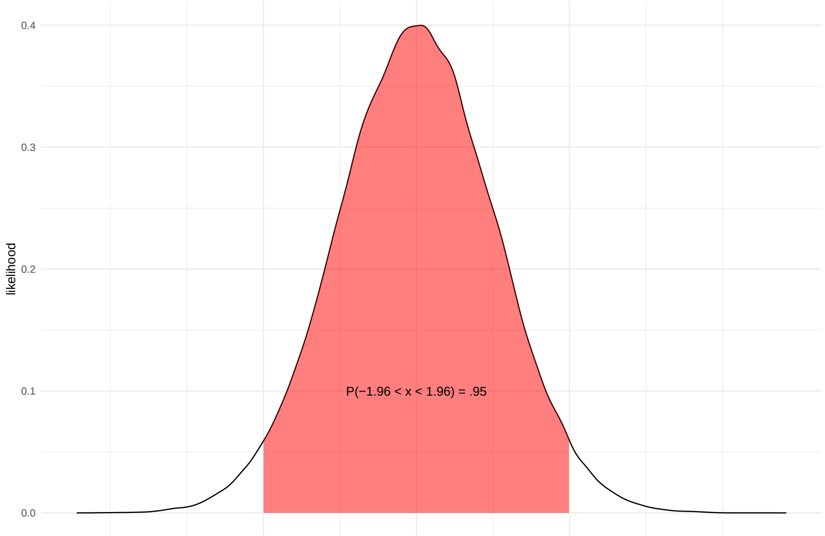
```
## [1] 3.303849
```

```r
1 - pnorm(zscore)
```

```
## [1] 0.000476836
```

Our monte carlo experiment

Show that the sample mean from a sample drawn from a normal distribution falls outside the 95 percent confidence region 5 percent of the time.



How to do a Monte Carlo Simulation

1. Generate random samples of data using a known process (e.g. `rnorm()`).
2. Make calculations based on the random sample.
3. Aggregate the results.

```
do_monte_carlo <- function(N, true_mean, B, alpha){
  sample_statistics <- make_mc_samples(N, true_mean, B)
  z_scores <- get_zscores(sample_statistics$mean, true_mean
  test_significance(z_scores, alpha) %>% mean()
}
```

Lab 4

- Two “types” of breakout room:
  - Work along: larger group with more guidance from a TA.
  - Small groups: 4 people, TAs will come in and out to answer questions. Use the help button!
- Add “(work along)” or “(small group)” to your Zoom name so we can sort you.
- Get as far as you can, then finish it up after class.
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Acc Class 2

For loops

What are some of the key take aways you learned about for-loops from the video?

```
x <- -10:10
y <- integer(length = length(x))

for (z in seq_along(x)) {

  y[z] <- x[z] ^ 2 + x[z] + 1

}
```

Key points: for-loops

- Iteration is useful when we are repeatedly calling the same block of code or function while changing one (or two) inputs.
- If you can, use vectorized operations.
- Otherwise, for loops work for iteration
  - Clearly define what you will iterate over (values or indicies)
  - Preallocate space for your output (if you can)
  - The body of the for-loop has parametrized code based on thing your iterating over
  - Debug as you code by testing your understanding of what the for-loop should be doing (e.g. using `print()`)

For loops

Compare and contrast the two code blocks

```
x <- -10:10
y <- integer(length = length(x))

for (z in seq_along(x)) {
  y[z] <- x[z]^2 + x[z] + 1
}
```

and

```
x <- -10:10
y <- c()

for (item in x) {
  y <- c(y, item^2 + item + 1)
}
```

Is there a better way to write this code?

Warm-up & Lab 5

Warm-up

- Solve the questions at the beginning of the lab in small (random) groups.
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if you want to work along just stay in the main room.

lab 5

In this lab you'll simulate the law of large numbers in action. Afterwards, you should be able to explain what this graph is telling you!