Intermediate R Programming

POS6933: Computational Social Science

Jake S. Truscott, Ph.D

University of Florida

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Overview

- **Today's Goal**: Improve Effectiveness w/ R Programming
- Random Number Generation in R
- Loops and Iteration
- Visualizing Data and Relationships Using `ggplot::()`

Coin Flips

What is the probability that any independent coin flip will land on heads?

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Does this change if I flip 50 times?

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What about 100 times?

Coin Flips

What is the probability that any independent coin flip will land on heads?

Does this change if I flip 50 times?

What about 100 times?

What about 1000 times?

Coin Flips

What is the probability that any independent coin flip will land on heads?

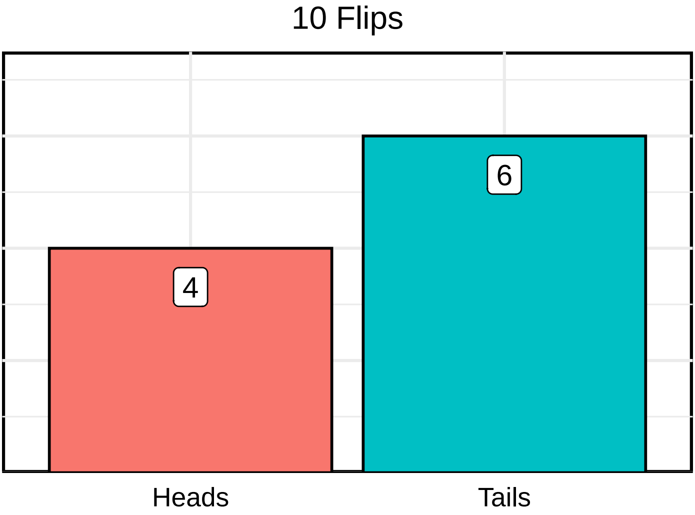
Does this change if I flip 50 times?

What about 100 times?

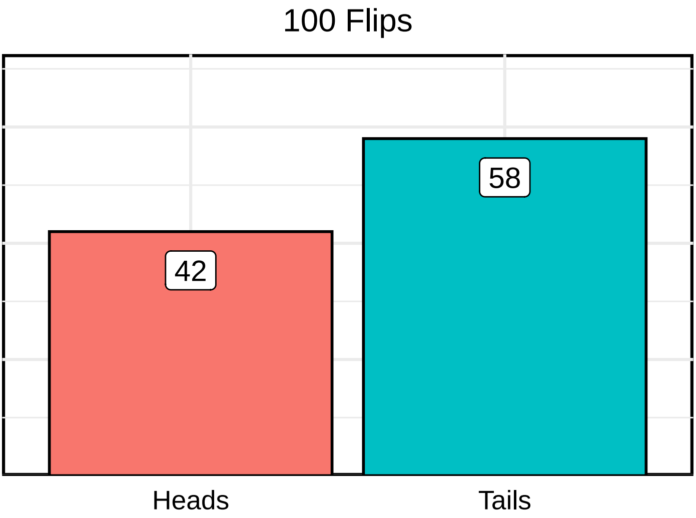
What about 1000 times?

What about 10000 times?

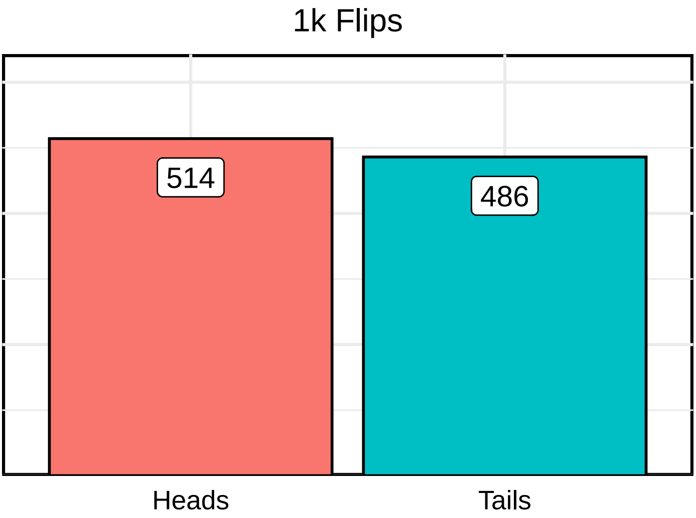
Coin Flips (Cont.)



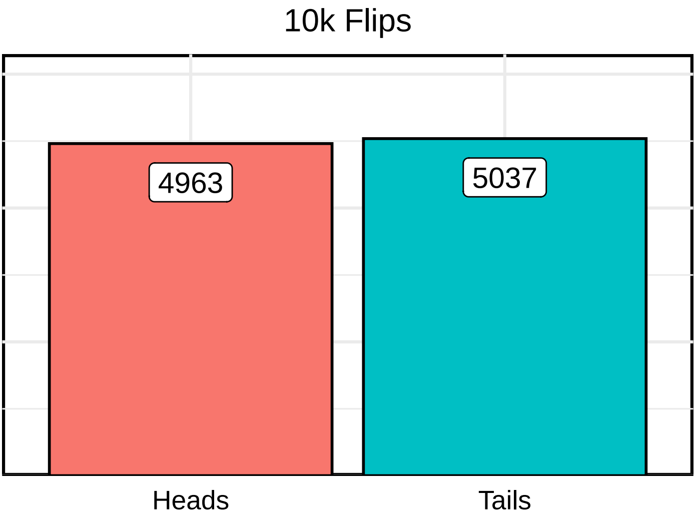
Coin Flips (Cont.)



Coin Flips (Cont.)



Coin Flips (Cont.)



Coin Flips (Cont.)

- We can use `sample()` to randomly select elements from a vector
- In this case, a coin flip where $p(heads) = p(tails) = 0.5$

```
sides <- c("Heads", "Tails")  # Flip Options
single_flip <- sample(sides, size = 1)  # Single Draw
print(single_flip)
```

```
[1] "Tails"
```

6-Sided Die

- We can use the same approach to “roll” a six-sided die.

```
sides <- c(1:6)  # 1, 2, 3, 4, 5, 6
single_roll <- sample(sides, size = 1)  # Single Roll
message("Result of Single Roll: ", single_roll)
```

```
Result of Single Roll: 2
```

Poker Hands

- We can even use it to do more complex operations like simulate a random draw from 5-card Poker

```
cards <- as.character(c(2:10, "J", "Q", "K", "A"))
# All Card Values
suits <- c("Hearts", "Diamonds", "Spades", "Clubs")
# Suits

deck <- expand.grid(value = cards, suit = suits) %>%
    mutate(card = paste(value, "of", suit)) %>%
    pull(card)  # Create a Full Deck

random_draw <- sample(deck, size = 5, replace = F)
# Random 5-Card Draw w/out Replacement
```

Poker Hands (Cont.)

```
Hand:
3 of Diamonds
5 of Hearts
10 of Diamonds
2 of Diamonds
Q of Diamonds
```

Generating Distributions

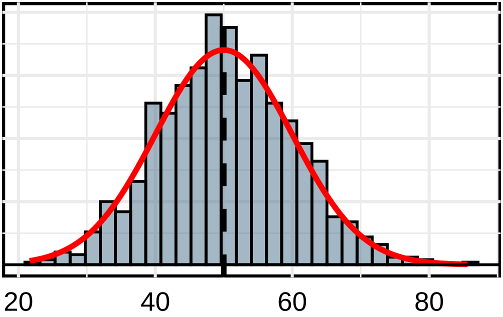
- What if we wanted to move beyond random selection where each draw or iteration exists with equal probability or within a uniform distribution?

- R is very flexible and capable of illustrating sampling distributions against expected outcomes

Generating Distributions (Standard Normal)

- Let's start with 1000 samples from a standard normal distribution where $\mu = 50$ and $\sigma = 10$

```r
normal <- rnorm(1000, mean = 50, sd = 10)
```

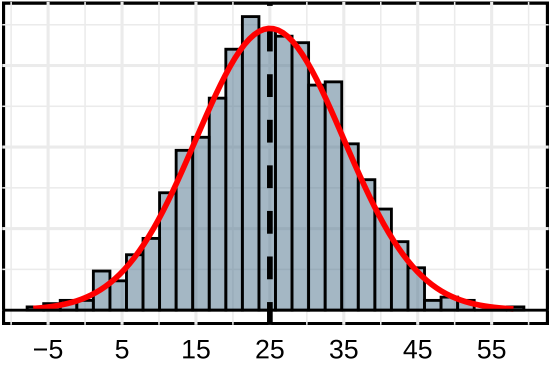


Generating Distributions (Standard Normal)

- **Your Turn**: Generate 1000 draws from a standard normal distribution where $\mu = 25$ and $\sigma = 10$.

Generating Distributions (Standard Normal – Ex)

```r
normal <- rnorm(1000, mean = 25, sd = 10)
```

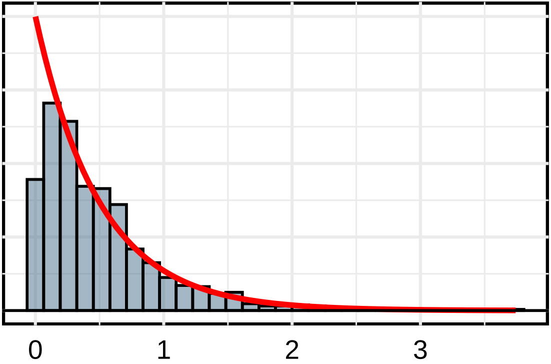


Generating Distributions (Exponential – Ex)

- **Your Turn**: Generate 1000 draws from an exponential distribution where `rate` $= 2$

Generating Distributions (Exponential – Ex)

```
exp <- rexp(1000, rate = 2)
```



Functions (Basics)

- Functions are reusable blocks of code that perform a specific task when called, helping avoid repetition.
- They can take arguments (inputs) and return values (outputs), making them flexible and generalizable.
- They can also be combined, nested, and used within other functions to build complex workflows in a clear, organized way.

Functions (Basic Syntax)

```
function_name <- function(input_1, input_2) {

    # Code to Assume Input_1 and Input_2

    # return(Return Output Value or Object)

}
```

Functions (Example)

```r
add_numbers <- function(x, y) {
    result <- x + y
    return(result)
}

add_numbers(5, 3)
```

Functions (Basics, Cont.)

- Take some time to try your own!
- Try:
    - Random Number Generation
    - Easy Task Completion (e.g., addition, subtraction, etc.)

Loops (Basics)

- In R, a for loop is a control structure used to repeat a block of code a fixed number of times, iterating over a sequence of values. The basic syntax is:

```
for (variable in sequence) {
    # Repeating Code Routine return(Result Value
    # or Object)
}
```

Loops (Basics, Cont.)

- For example, we can complete basics rolls of six-sided dice:

```
rolls <- c()

for (i in 1:10) {

    temp_roll <- sample(1:6, 1, replace = TRUE, prob = rep(1/6,
        6))

    rolls <- c(rolls, temp_roll)
}

rolls  # Print
```

```
 [1] 4 6 3 1 2 2 3 2 5 5
```

Loops (Basics, Cont.)

- We can also conditionally iterate through different values from the `functions` example

```
add_numbers <- function(x, y) {
    result <- x + y
    return(result)
}

available_values <- c(1:10)
sums <- c()

for (pair in seq(1:10)) {
    temp_pair <- sample(available_values, 2)
    sums <- c(sums, add_numbers(temp_pair[1], temp_pair[2]))
}

sums
```

```
 [1]  9  7  9  9 12 15 19 15  8 13
```

Loops (Basics, Cont.)

- I can also deal 5 hands from a standard 52-card deck for a game of Texas Hold 'Em
- Here's the setup – What's Next?

```r
set.seed(1234)  # Seed
cards <- as.character(c(2:10, "J", "Q", "K", "A"))
suits <- c("Hearts", "Diamonds", "Spades", "Clubs")
deck <- expand.grid(value = cards, suit = suits) |>
    mutate(card = paste(value, "of", suit)) |>
    pull(card)  # Create a Full Deck

hands <- lapply(1:5, function(x) x)
```

Loops (Basics, Cont.)

```
for (card in 1:2) {
    for (player in 1:5) {
        temp_player_card <- sample(deck, 1, replace = F)
        deck <- deck[!deck %in% temp_player_card]
        hands[[player]][card] <- temp_player_card
    }  # For All 5 Players
}  # For Both Cards

do.call(cbind, hands)
```

```
     [,1]          [,2]            [,3]
[1,] "3 of Spades" "4 of Diamonds" "J of Diamonds"
[2,] "A of Clubs"  "10 of Hearts"  "6 of Hearts"
     [,4]         [,5]
[1,] "2 of Clubs" "10 of Clubs"
[2,] "6 of Clubs" "7 of Diamonds"
```

Games of Chance: Blackjack

What are the basic rules of Blackjack?

Rules of Blackjack:

- Objective: Beat the dealer by getting closer to 21 without going over
- Card values:
  - Number Cards = Face Value
  - Face Cards = 10 (Aces = 1 *or* 11)
- Dealer Rules: Dealer reveals cards after players act and must hit until *at least* 17
- Gameplay:
  - Go Over 21 = **BUST** (Loss)
  - Tie w/ Dealer = Push (No Win/Loss)
  - Standard Win = **1:1** (Win Bet x2)
  - Blackjack (Ace + 10-Value Card = **3:2**

Blackjack Exercise

Write an R routine to play a round of Blackjack. I will do the same.

- *Hint*: Sample from all 52 cards without replacement...

Blackjack Exercise (Cont.)

1. What if we play with a four-deck shoe?

Blackjack Exercise (Cont.)

1. What if we play with a four-deck shoe?
2. What if I wanted to repeat this process 1,000 times?

Hint: Use a loop!

Blackjack Exercise (Cont.)

1. Assume I begin with $1000 every day and bet $100 each game (though I'll only play 10 hands. . .). Over 100 days, approximately how much money am I left with? *Note*: If I run out of money on a given day, I'm done – also, each day restarts with $1000 but previous day's leftover sum is added to aggregate winnings.
2. What if I start with $1000 but don't replace the money every day. . . How much will I have after 10 days? 50 days?
3. Take some time then play around with blackjack_simulation.R

Roulette Exercise

- Head over to Course GitHub (Intermediate Programming in `R`)
- Bottom of `Number Generation & Loops`

Data Visualization

- `ggplot()` is an incredibly flexible visualization tool
- There's a balance between professional & *noisy* visualizations
- Some journals & reviewers are more critical than others
- **Goal**: *Publication-ready* visualizations capable of relaying inferential value on its own

My Default ggplot() Aesthetics

```
default_ggplot_theme  <- theme_minimal(base_size = 12) +
  theme(
    plot.title = element_text(hjust = 0.5, size = 12),

    axis.title = element_text(size = 12, colour = 'black'),

    axis.text = element_text(size = 10, colour = 'black'),

    panel.background = element_rect(linewidth = 1, colour = 'black', fill = NA),

    legend.position = 'bottom',

    legend.background = element_rect(linewidth = 1, colour = 'black', fill = NA),
  )
```

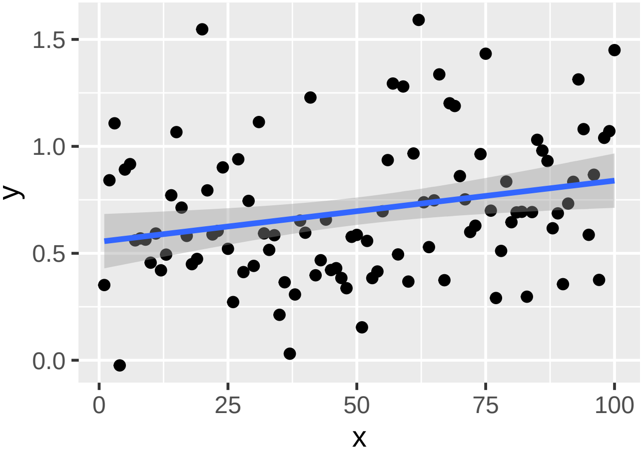
My Default ggplot() Aesthetics

```r
set.seed(1234)

sample_data <- tibble(x = c(1:100), y = rnorm(100,
    mean = 0.75, sd = 0.33))

summary(sample_data)
```

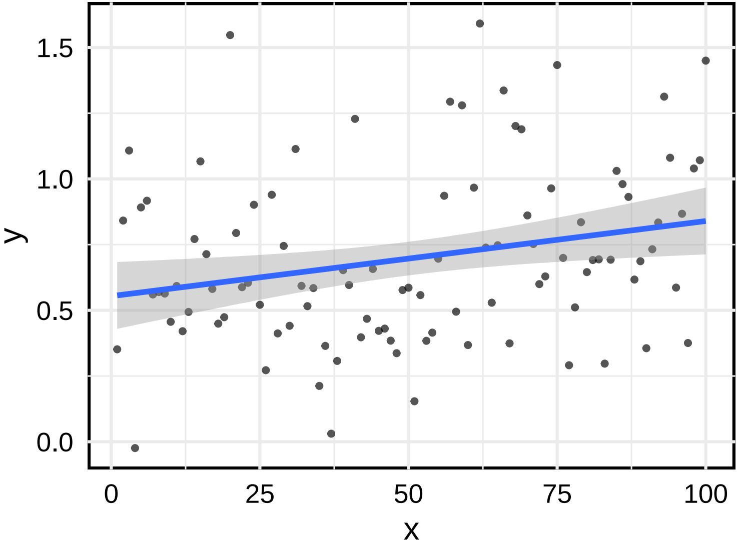
```
       x                y
 Min.   :  1.00   Min.   :-0.02408
 1st Qu.: 25.75   1st Qu.: 0.45454
 Median : 50.50   Median : 0.62307
 Mean   : 50.50   Mean   : 0.69827
 3rd Qu.: 75.25   3rd Qu.: 0.90550
 Max.   :100.00   Max.   : 1.59117
```

My Default ggplot() Aesthetics

```
sample_data %>%
    ggplot(aes(x = x, y = y)) + geom_point() + geom_smooth(method = "lm",
    formula = "y~x")
```



Adding Default Aes



Stargazer

```r
library(stargazer)
temp_lm <- lm(Sepal.Length ~ Sepal.Width + Petal.Length +
    Petal.Width, data = iris)

stargazer::stargazer(temp_lm, type = "text", omit.stat = c("ser",
    "f", "adj.rsq"), dep.var.caption = "")
```

Stargazer – Text Example

```
========================================
                    Sepal.Length
----------------------------------------
Sepal.Width           0.651***
                       (0.067)

Petal.Length          0.709***
                       (0.057)

Petal.Width          -0.556***
                       (0.128)

Constant              1.856***
                       (0.251)

----------------------------------------
Observations             150
R2                      0.859
========================================
Note:        *p<0.1; **p<0.05; ***p<0.01
```

Stargazer – Latex Example (type = 'latex')

```
% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.co
% Date and time: Fri, Jan 23, 2026 - 10:11:48 AM
\begin{table}[!htbp] \centering
  \caption{}
  \label{}
\begin{tabular}{@{\extracolsep{5pt}}lc}
\\[-1.8ex]\hline
\hline \\[-1.8ex]
\\[-1.8ex] & Sepal.Length \\
\hline \\[-1.8ex]
 Sepal.Width & 0.651$^{***}$ \\
  & (0.067) \\
  & \\
 Petal.Length & 0.709$^{***}$ \\
  & (0.057) \\
  & \\
 Petal.Width & $-$0.556$^{***}$ \\
  & (0.128) \\
  & \\
 Constant & 1.856$^{***}$ \\
  & (0.251) \\
  & \\
\hline \\[-1.8ex]
Observations & 150 \\
R$^{2}$ & 0.859 \\
\hline
\hline \\[-1.8ex]
\textit{Note:}  & \multicolumn{1}{r}{$^{*}$p$<$0.1; $^{**}$p$<$0.05; $^{***}$p$<$0.01} \\
\end{tabular}
\end{table}
```

Stargazer – Latex Example Rendered

Table 1: Rendered `stargazer` Table

	Sepal.Length
Sepal.Width	0.651^{***}
	(0.067)
Petal.Length	0.709^{***}
	(0.057)
Petal.Width	-0.556^{***}
	(0.128)
Constant	1.856^{***}
	(0.251)
Observations	150
R^2	0.859
Note:	*p<0.1; **p<0.05; ***p<0.01

Stargazer – Multiple Models

Table 2: Rendered `stargazer` Table with 2 Models

	Sepal.Length	
	(1)	(2)
Sepal.Width	0.651***	
	(0.067)	
Petal.Length	0.709***	
	(0.057)	
Petal.Width	−0.556***	−0.311***
	(0.128)	(0.114)
Sepal.Width:Petal.Length		0.185***
		(0.017)
Constant	1.856***	4.150***
	(0.251)	(0.078)
Observations	150	150
R^2	0.859	0.821
Note:	*p<0.1; **p<0.05; ***p<0.01	

Stargazer – Summary Data

```r
stargazer(iris, type = "text", summary = TRUE, title = "Summary of Iris Dat
```

```
Summary of Iris Dataset
===========================================
Statistic     N   Mean  St. Dev.  Min   Max
-------------------------------------------
Sepal.Length 150 5.843  0.828   4.300 7.900
Sepal.Width  150 3.057  0.436   2.000 4.400
Petal.Length 150 3.758  1.765   1.000 6.900
Petal.Width  150 1.199  0.762   0.100 2.500
-------------------------------------------
```

Visualization Example

- Using the `mtcars` dataset – `library(mtcars)` – complete the following:

  1. Using `mpg` as the dependent variable, compile two models using `cyl`, `disp`, `hp`, and `wt` – the second should have an interaction between `disp` and `wt`.
  2. Produce a table using `stargazer` of the resulting models.
  3. Use `ggplot` to illustrate the distribution of each of the variables listed in (1).

Looking Forward

- Homework: Problem Set (Class 2)
- Next Class: Parallel Computing