Session 1: Introduction to R

Overview

Introductions and introduction to R

Basic operations and data types

Packages

R Markdown

Data Frames

Introductions

My background:

- Visiting associate professor at Yale
- Associate professor of Statistics, Hampshire College
- Research Affiliate, Center for Brains, Minds and Machines at MIT

How I use R:

- Teaching: Statistics and Data Science courses using R
- Research: Develop/use machine learning to analyze neural data
  - NeuroDecodeR package

Introductions

Let’s do some quick introductions

- Your name
- Your academic department affiliation
- How are you interested in using R in your teaching/research?
- What you are most interested in learning in this workshop?
- Anything else you would like to share

Workshop plan: today

Session 1: Basic programming in R

Session 2: Statistics and plots, for loops, writing functions

Session 3: Basic statistical inference and simple linear regression

Session 4: Multiple regression, logistic regression, ANOVA

Workshop plan: tomorrow

Session 1: Data wrangling with dplyr

Session 2: Data visualization with ggplot

Session 3: Joining and mapping data

Session 4: String manipulation and/or interactive graphics

Even if you don't like today, come back tomorrow b/c that's when we're going to be doing the really fun stuff!

Why use R?


Why ?
R
1. Free Installation
2. Hottest Trend
3. Independent Platform
4. Latest cutting edge technology
5. Has Large community of users
Data Flair

Data analysis software vs. programming languages

Advantages of using data analysis software (STATA, SAS, SPSS, Minitab, etc.):

- Can be easier/quicker to do the basics: you don't need to know to how to program!

Advantages of using data analysis programming languages

- Reproducibility! Can see exactly which steps were taken in an analysis.
  - Can cut down on mistakes
- Ability to extend beyond functions built into software
  - Particularly useful for computational methods that work in more situations

Data analysis programming languages

MATLAB

- Disadvantage: Expensive
  - Makes it harder to distribute results because others might not own the software

Julia

- Disadvantage: Newer so less of a community, less functionality implemented

Python

- Advantages: general purpose programming language so useful if one already knows Python of if one wants to integrate into larger software ecosystem
- Disadvantage: Not quite as good as R for data analysis

R

- Advantages: Rich ecosystem designed specifically for reproducible data analysis
  - Free RStudio IDE, reproducibility, powerful packages, etc.
- Disadvantages: Not good for larger software development

AS SEEN BY USERS OF …

What are the strengths of R?

Statistical analyses: basic and advanced

Reproducibility: R Markdown

Tidyverse: Powerful packages for graphics, data manipulations, etc.

Interactive graphics: plotly and Shiny

Demos!

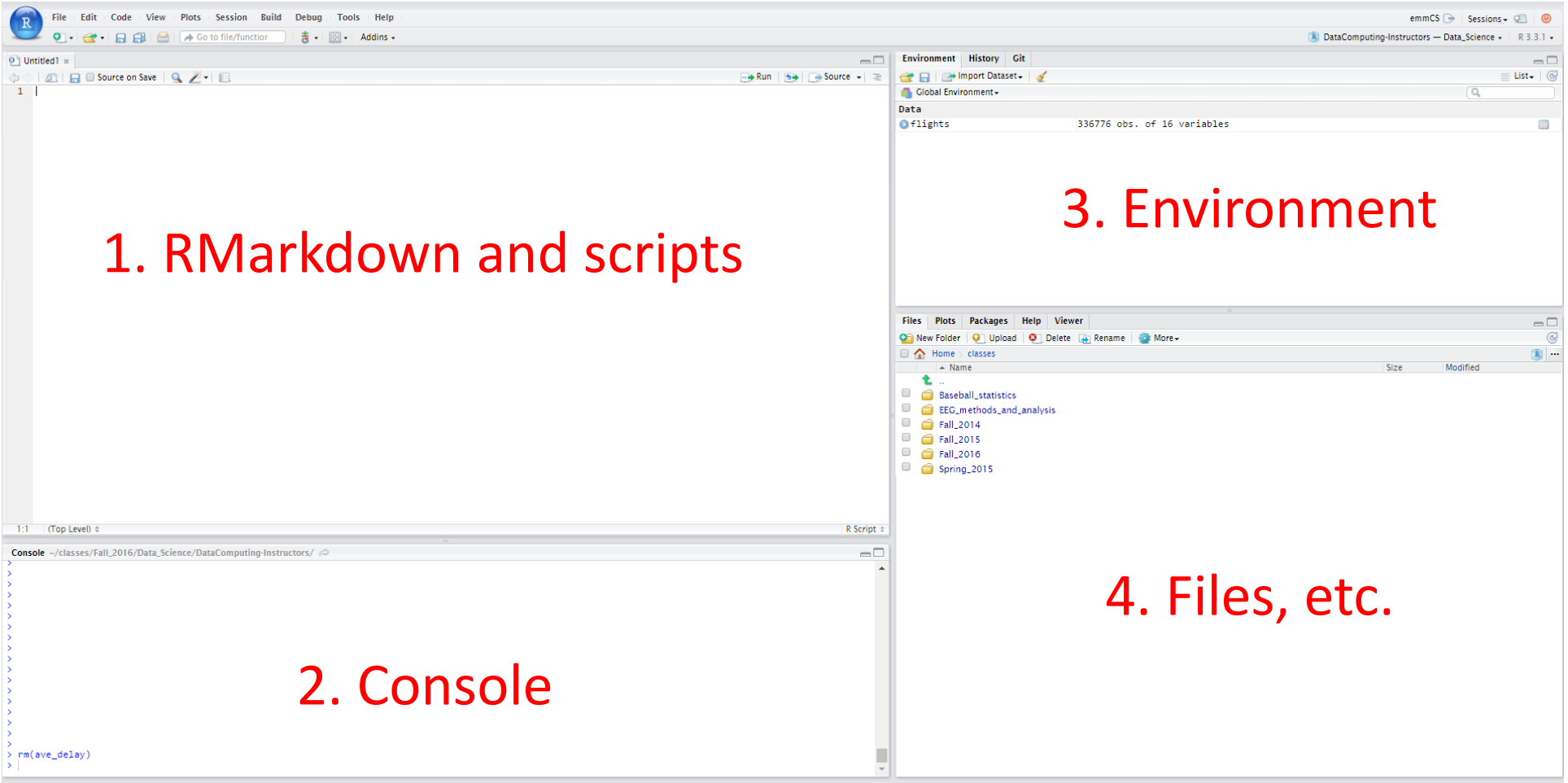
R Basics

R and R Studio

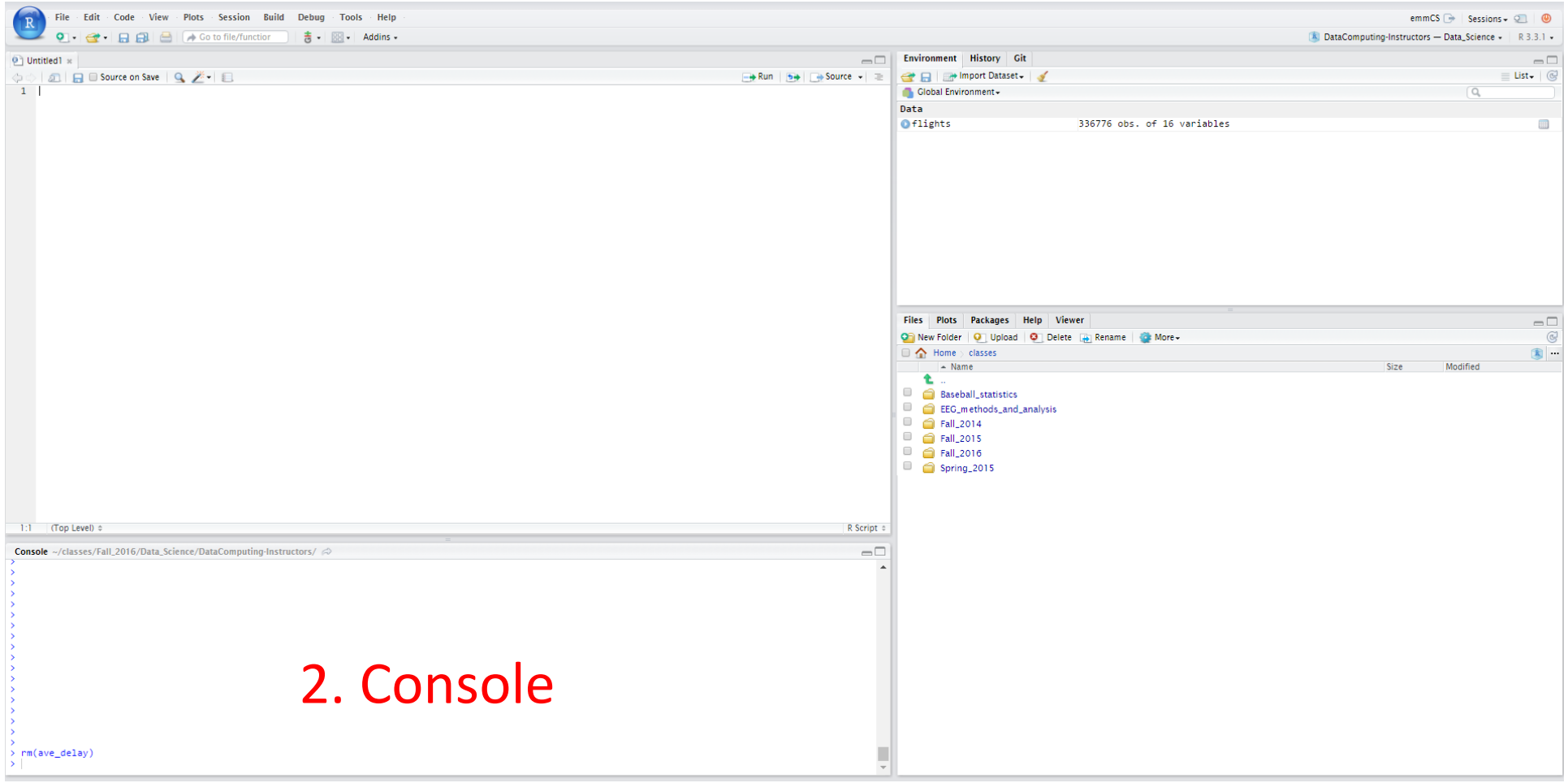
R: Engine

RStudio: Dashboard

RStudio layout



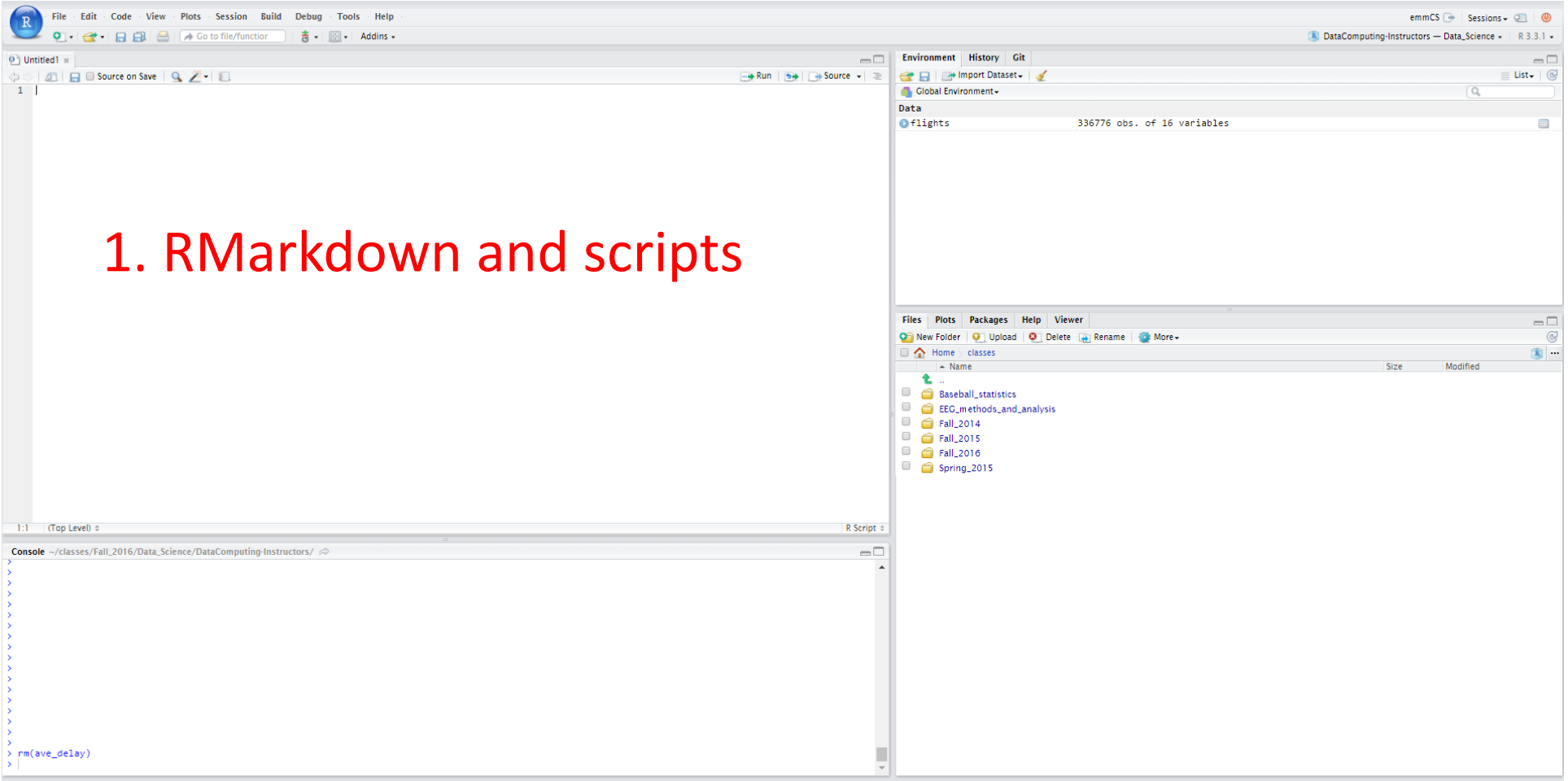
RStudio layout



R as a calculator

```
> 2 + 2
> 7 * 5
```

RStudio layout



<u>Create a new script</u>

File -> New File -> R Script

Save the script with a reasonable name, e.g., my_notes.R

R Basics

Arithmetic:

```
> 2 + 2
> 7 * 5
```

Assignment of values to ***objects***:

```
> a <- 4
> b <- 7
> z <- a + b
> z
[1] 11
```

Number journey…

Number journey

```
> a <- 7
> b <- 52
> d <- a * b
> d
[1]  364
```

Character strings and Booleans

```
> a <- 7
> s <- "s is a terrible name for an object"
> b <- TRUE

> class(a)
[1] numeric

> class(s)
[1] character
```

Functions

Functions use parenthesis: functionName(x)

```
> sqrt(49)
> tolower("DATA is AWESOME!")
```

To get help

```
> ? sqrt
```

One can add comments to your code

```
> sqrt(49)    # this takes the square root of 49
```

Vectors

Vectors are ordered sequences of numbers or letters

The c() function is used to create vectors

```
> v  <-  c(5, 232, 5, 543)
> s  <-  c("statistics", "data", "science", "fun")
```

One can access elements of a vector using square brackets []

```
> s[4]        # what will the answer be?
```

We can get multiple elements from a vector too

```
> s[c(1, 2)]
```

Vectors continued

One can assign a sequence of numbers to a vector

```
> z <- 2:10
> z[3]
```

One can test which elements are greater than a value

```
> z > 3
```

Can add names to vector elements

```
> names(v) <- c("first", "second", "third", "fourth")
```

Vectors continued

One can also apply functions to vectors

```
> z <- 2:10
> sqrt(z)
> mean(z)
```

Questions?

R packages

Packages add additional functionality to R

We will use many additional packages in this class

- gplyr, ggplot2, tidyr, etc.

R workshop package

I have written a package to allow you to more easily download material for this workshop

```
> install.packages("devtools")
> devtools::install_github("emeyers/rworkshop")
> devtools:::initial_setup()
```

Once you have installed this package, please run the following command to download an R Markdown document that has code for this morning session

- `> rworkshop::download_class_code(1)`

R Markdown

R Markdown (.Rmd files) allow you to embed written descriptions, R code and the output of that code into a nice looking document

Creates a way to do reproducible research!

R Markdown

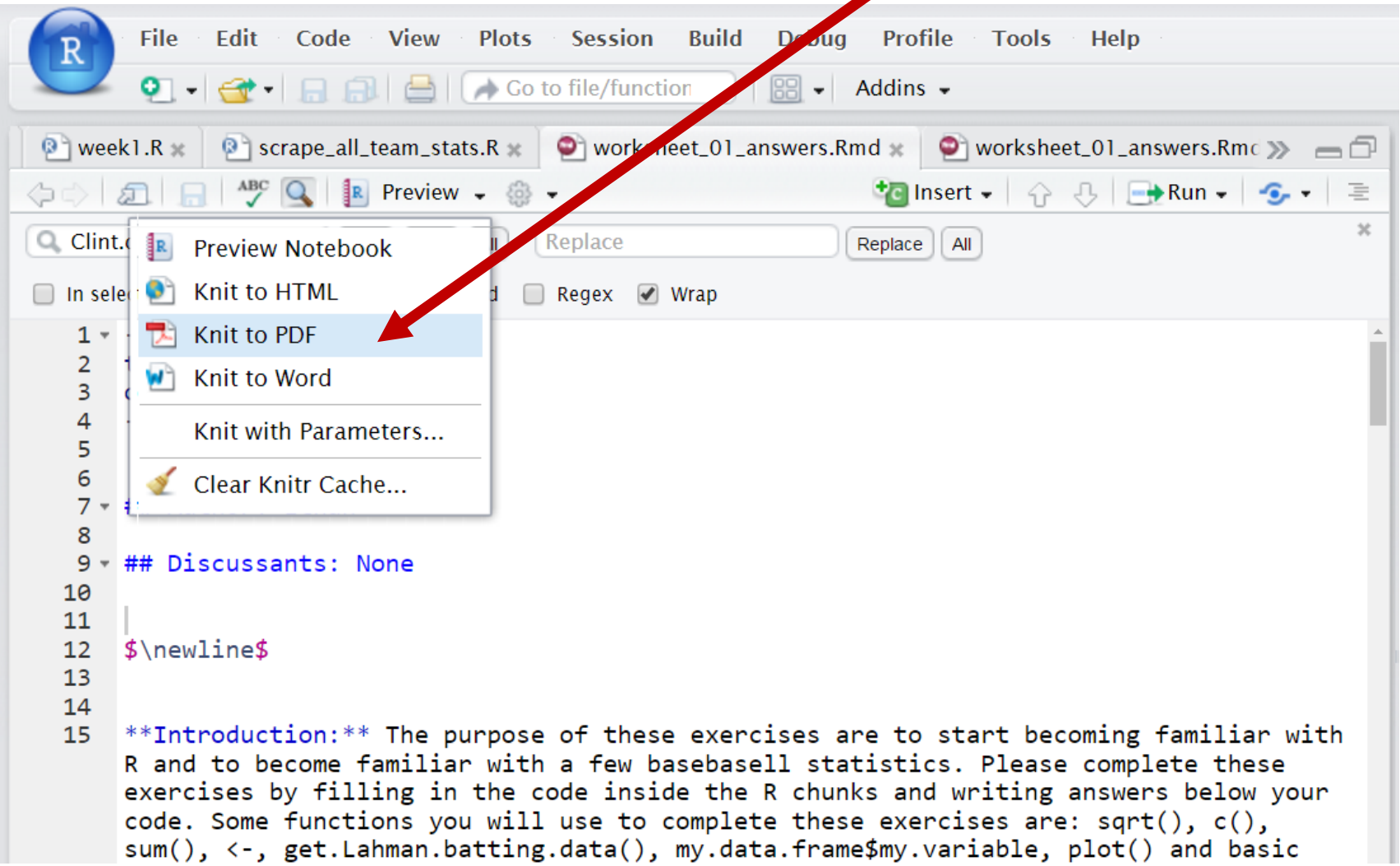
Everything in R chunks is executed as code:

```{r}
# this is a comment
# the following code will be executed
2 + 3
```

Everything outside R chunks appears as text

Knitting to a pdf

Turn in a pdf or html document with your solutions to Canvas



R Markdown

Note: When you knit, RMarkdown files **<u>do not have access to variables in the global environment</u>**, but instead have their own environment.

Why is this a good thing???

Formatting in R Markdown

We can add formatting to text outside the code chunks

Examples:

```
## Level 2 header
**bold**
![](https://statistics.yale.edu/sites/default/files/logo2.png)
```

LaTeX in R Markdown

We can also add LaTeX symbols to documents using $\symbol$ syntax

For example, try these:

θ

$\hat{p}$

$\hat{\theta}$

Knit early and knit often to avoid errors!!!

Avoid hard to debug code!

Only change a few lines at a time and then knit your document to make sure everything is working!

If you document isn't knitting:

- **For code chunks:** use the # symbol to comment out code until you can find the line of code that is giving the error message
- **Outside of code chunk:** cut out part of the document until it knits and then paste it back

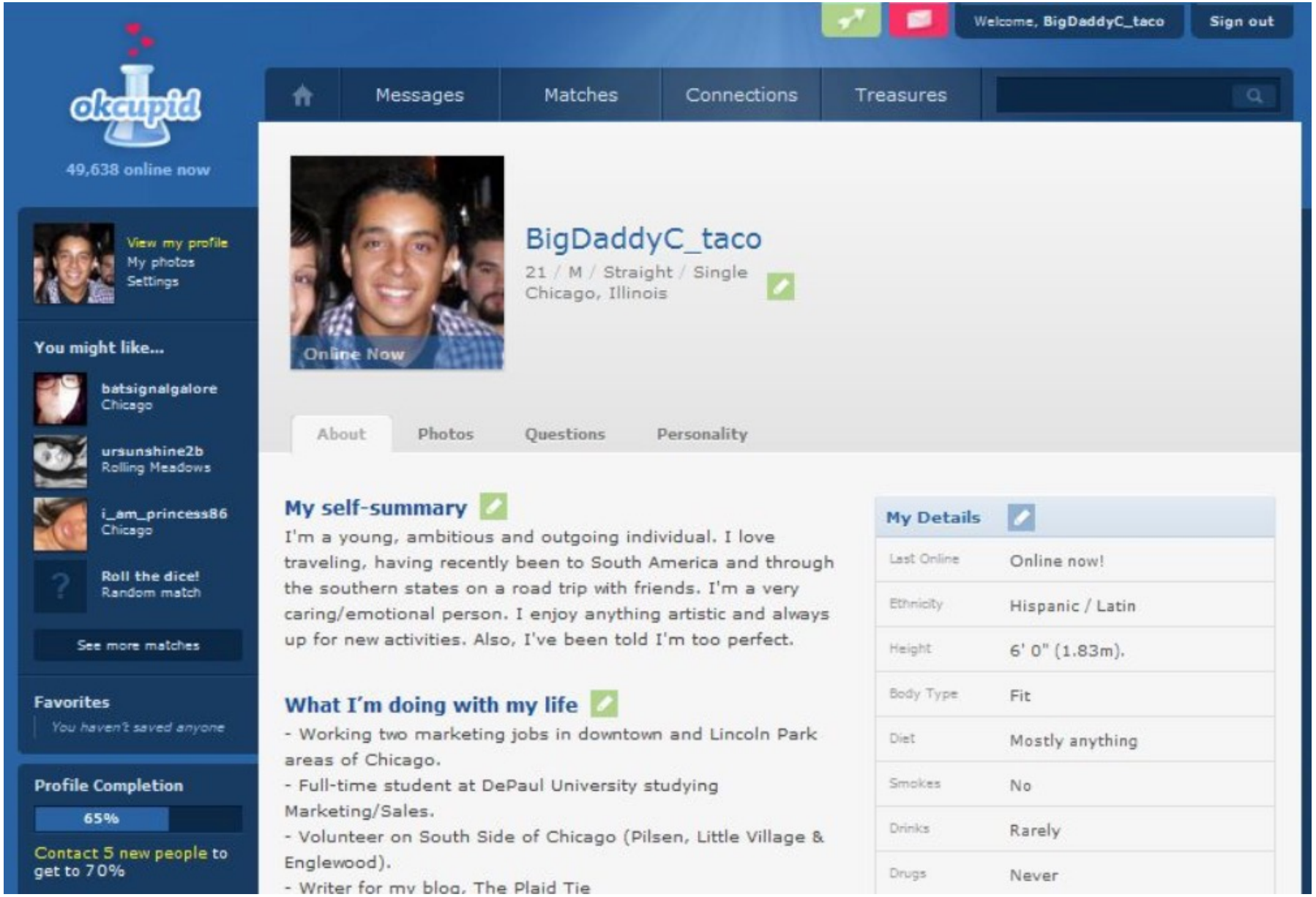
Questions?

Data frames

Data frames contain structured data

	age	body_type	diet	drinks	drugs	education
1	22	a little extra	strictly anything	socially	never	working on college/university
2	35	average	mostly other	often	sometimes	working on space camp
3	38	thin	anything	socially	NA	graduated from masters program
4	23	thin	vegetarian	socially	NA	working on college/university
5	29	athletic	NA	socially	never	graduated from college/university
6	29	average	mostly anything	socially	NA	graduated from college/university

OK Cupid data



Data frames

Data frames contain structured data

```
> library(rworkshop)
> download_data("profiles_revised.csv")     #  only needs to be run once
> profiles <- read.csv("profiles_revised.csv")
> View(profiles)       # the View() function only works in R Studio!
```

	age	body_type	diet	drinks	drugs	education
1	22	a little extra	strictly anything	socially	never	working on college/university
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Data Frames

Variables

Cases

	age	body_type	diet	drinks	drugs	education
1	22	a little extra	strictly anything	socially	never	working on college/university
2	35	average	mostly other	often	sometimes	working on space camp
3	38	thin	anything	socially	*NA*	graduated from masters program
4	23	thin	vegetarian	socially	*NA*	working on college/university
5	29	athletic	*NA*	socially	never	graduated from college/university
6	29	average	mostly anything	socially	*NA*	graduated from college/university

An Example Dataset

Quantitative Variable

Categorical Variable

Cases (observational units)

	age	body_type	diet	drinks	drugs	education
1	22	a little extra	strictly anything	socially	never	working on college/university
2	35	average	mostly other	often	sometimes	working on space camp
3	38	thin	anything	socially	NA	graduated from masters program
4	23	thin	vegetarian	socially	NA	working on college/university
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Data frames

We can extract the columns of a data frame as vector objects using the $ symbol

```
> the_ages <- profiles$age
```

Can you get the mean() age of users in this data set?

```
> mean(the_ages)
```

Extracting rows from a data frame

We can extract rows from a data frame in a similar way as extracting values from a vector by using the square brackets

```
> profiles[1, ]  # returns the first row of the data frame
> profiles[, 1]  # returns the first column of the data
```

Note, the first column of the profiles data frame is the variable *age*, so we can also get the first column using:

```
> profiles$age  # this is the same as profiles[, 1]
```

Extracting rows from a data frame

We can also create vectors of numbers or Booleans specifying which rows we want to extract from a data frame

```
# create a vector with the numbers 1, 10, 20
> my_vec <- c(1, 10, 20)

# use my_vec to get the 1st, 10th, and 20th row in profiles
> small_profiles <- profiles[my_vec, ]
> dim(small_profiles)  # number of rows and columns in the data frame
```

Extracting rows from a data frame

Finally, we can also extract rows by creating a Boolean vector that is of the same length as the number of rows in the data frame

TRUE values will be extracted from the data frame while FALSE values will not

```
# create a vector of booleans
> my_bools <- c(TRUE, FALSE, TRUE)

# use the Boolean vector to get the 1st and 3rd row
> small_profiles[my_bools, ]
```

Questions?

Break time?