Packages and RMarkdown

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BSDS 100 - Intro to Data Science with R

It came from the minute cards...

- **Plotting in R**: We will spend a whole section of the class on how to plot! Until then, if a plot is required you will be told what you need to type (exception: challenge questions)
- **Coding at Home**: Like any language, comfort comes with practice. Try things, play around!
- **Script vs. Console**: Whatever you put in your script is easily saved, while what you put in your console is lost. If you aren't sure, type as a script, you can always delete it from your script later.

Outline

- Packages in R
- RMarkdown
  - Installation and Use
  - The Markdown language

Part I: Packages in R

Packages in R

- Vanilla R comes with extensive capabilities

...BUT...

- some of the most exciting features in R are available as optional modules called Packages that you can download and install
- Like R, packages are free, user-contributed modules that you can create, download and install
- As of July 2018, there were over 10,000 R packages!

What are R Packages?

- Packages are collections of functions, data and compiled code in a well-defined format
- **Caution!** Given R packages are user-contributed, some contain errors, so feel free to use R for analysis, but maybe double-check your output before you buy or sell billions of dollars of stock based on R package calculations

Basic Package functions

Function	Action
`library()`	lists which packages have been *downloaded* on your current version of `R`
`library(blue)`	loads package `blue` to current environment
`search()`	lists which packages are loaded and ready to use in *current session*
`install.packages("blue")`	installs package `blue`

Important: You only need to download a package once, but you always need to load packages when on a new `R` session!

Downloading and Loading R Packages [EXAMPLE]

```
> install.packages("microbenchmark")
  % Total    % Received % Xferd  Average Speed   Time    Time     Time
                                 Dload  Upload   Total   Spent    Left
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--

The downloaded binary packages are in
  /var/folders/jm/3w7pqfms0nvg_ypvnvkkk83h0000gn/...

> microbenchmark(3^3)
Error: could not find function "microbenchmark"

# using the double colon operator allows you to access functions from
#   packages that are not loaded

> microbenchmark::microbenchmark(3^3)
Unit: nanoseconds
 expr min  lq   mean median    uq  max neval
  3^3 203 209 365.53    271 372.5 6112   100
```

Downloading and Loading R Packages [EXAMPLE]

```
# this loads the package
> library(microbenchmark)

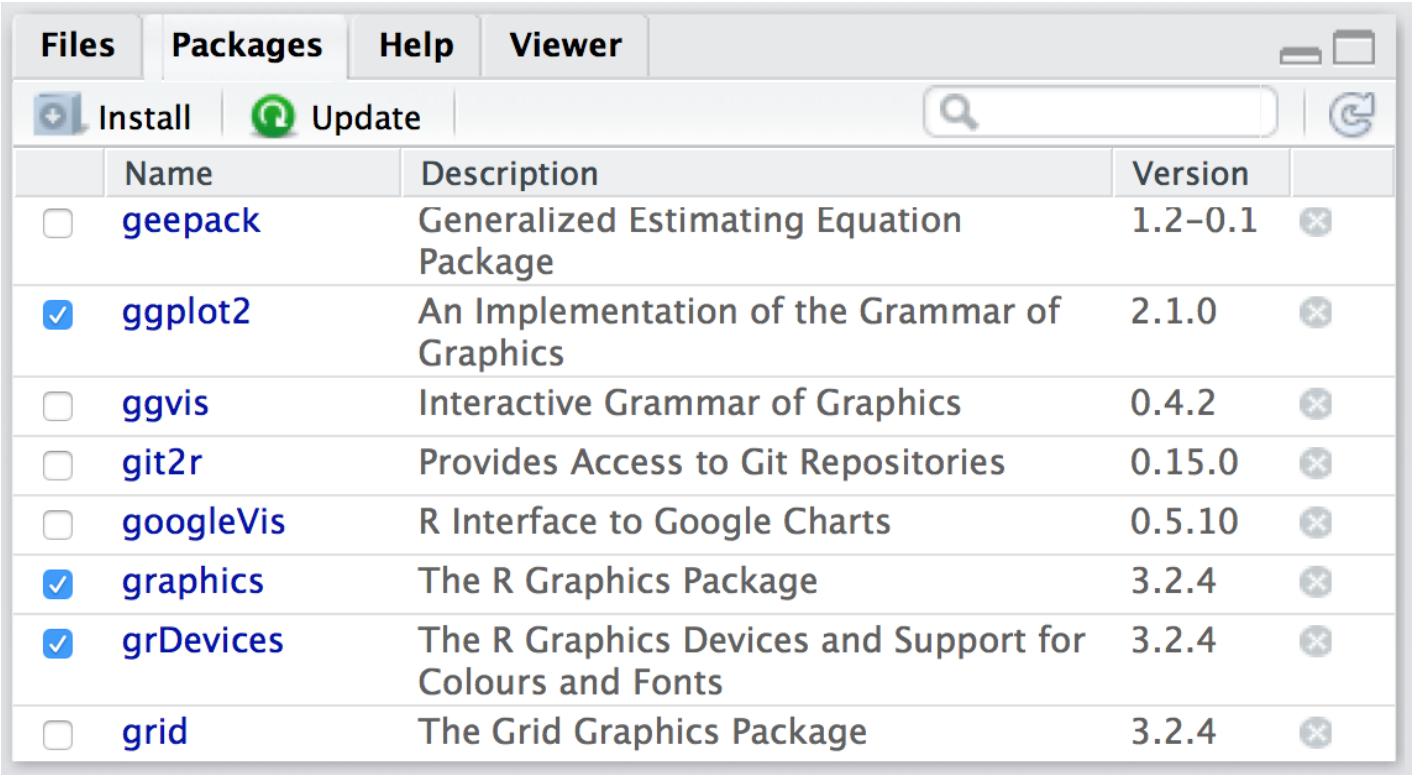
> microbenchmark(3^3)
Unit: nanoseconds
 expr min  lq   mean median  uq  max neval
  3^3 156 159 311.88    226 312 5372   100
```

Maintaining R Packages

- Packages are often updated by their authors, so be sure to keep your packages up to date
  - `update.packages()` will update all packages you've downloaded
  - `installed.packages()` will list all packages you have downloaded, along with their version numbers, dependencies and other information

User-friendly Package Functionality

A far less cumbersome way to install, load and update packages in RStudio is using the appropriate icons in the “Packages” window



Autoload of R Packages

Packages sometimes have dependencies on other packages, e.g.,

```
#load the package MatchIt
> library("MatchIt", lib.loc="/Library/Frameworks/R.framework/...")
Loading required package: MASS
```

- Without asking, when loading the `MatchIt` package, the `MASS` package is automatically loaded
- This is helpful in one respect, since `MatchIt` leverages certain functionality from `MASS`; if `MASS` wasn't automatically loaded, then calling certain functions from `MatchIt` might throw an error

Caution about Masking Functions

- Be careful of *function masking*: because there are so many `R` packages available from so many different authors, it often happens that different packages have identically named functions
- For example, if you load package `A` and it contains the function `foo` and then load package `B` that contains a different function, also named `foo`, then calling `foo` will resort in the use of package `B`'s function `foo`.

Searching for Functions from R Packages

When searching for a function, R searches the Global Environment first, then iterates through all packages for the function, beginning from the most recently added

```
> search()
 [1] ".GlobalEnv"         "package:reshape2"   "package:plyr"
 [4] "package:MatchIt"    "package:MASS"       "package:ggplot2"
 [7] "tools:rstudio"      "package:stats"      "package:graphics"
[10] "package:grDevices" "package:utils"      "package:datasets"
[13] "package:methods"    "Autoloads"          "package:base"

> (.packages())
 [1] "reshape2"  "plyr"      "MatchIt"   "MASS"      "ggplot2"
 [6] "graphics"  "grDevices" "utils"     "datasets"  "methods"
 [11] "stats"    "base"
```

Specifying Functions and Removing R Packages

- If you are using a lot of packages and want to be certain you are calling a function from a specific package, use the double colon operator, e.g., `plyr::rename()`
- If you feel you have too many packages loaded and want to unload (detach) one, you can use the following command:

```
detach("package:MatchIt", unload=TRUE)
```

Part II: RMarkdown

Technical Reporting & Presentation Tools

In many cases, we would like to present code and output in an easy-to-understand document.

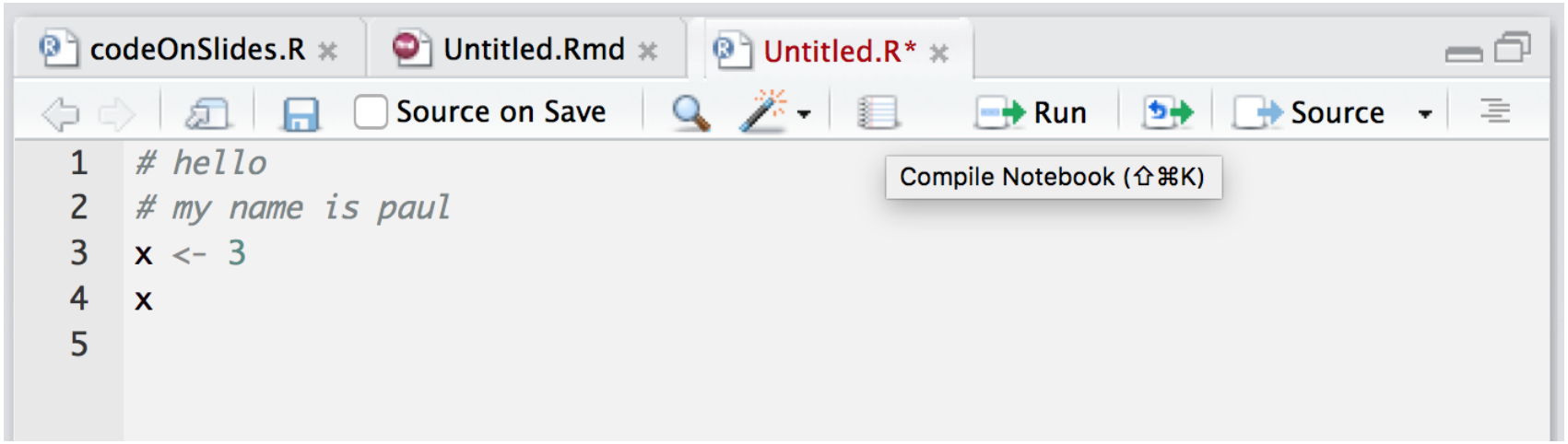
- Many ways to do this:
  1. LaTeX
  2. .html
  3. Markdown (RMarkdown and other variations)
  4. ...
- The (arguably) most generic and flexible technical report/presentation tool is LaTeX
- But, we'd like to deal directly with R output and code

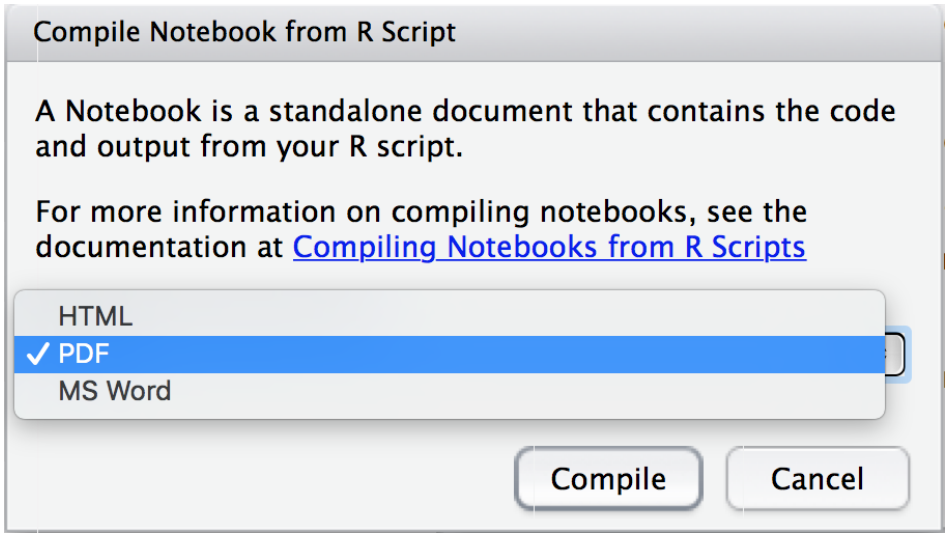
RMarkdown

When dealing with R code and R output, RMarkdown is a versatile and easy way to embed code and graphical output in a report or presentation

- Relies on the `knitr` package to compile and print code
- Documents are written in the Markdown language, which combines LaTeX and code
- Can directly create `.pdf` or `.html` files
- Used for presentations and for ensuring reproducibility

The Simplest RMarkdown Execution





The Simplest RMarkdown Execution

- `Rmd` source file
- `pdf` output

Untitled.R

Paul

Tue Jul 5 10:51:43 2016

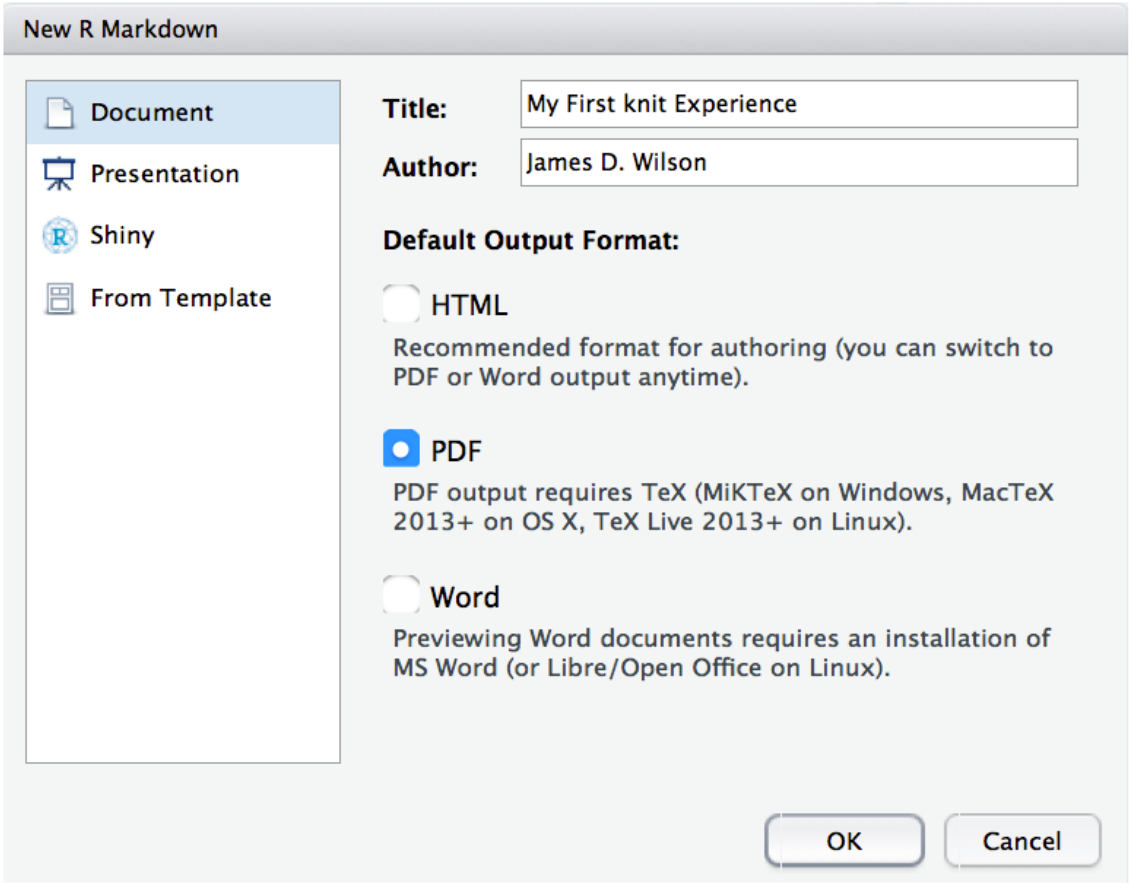
```
# hello
# my name is paul
x <- 3
x
```

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

An RMarkdown Document

Create a new RMarkdown file

`File` ⇒ `New File` ⇒ `RMarkdown...`



Note: MacTex (Apple) or MiKTEX (Windows) is Required for `pdf` Output

We will be generating `.pdf` documents, so please be sure to install!

Markdown Language

- RMarkdown documents are written in the Markdown language
- You can get fancy with this, but a few simple commands can bring you a long way!
- We'll review some simple rules and syntax next so you can get started.

RMarkdown: The Header

- The header begins and ends with three dashes ---
- There are many header options, we will examine a few basic options

```
---
title: "Untitled"
author: "James D. WIlson"
date: "January 1, 2017"
output: pdf_document
---
```

RMarkdown: Body Text

- How do you write plain text?

```
Just like this
```

- How do you comment out a line of text?

```
[//]: (comment goes here)
<!-- (comment goes here) -->
```

- You can create sections / section headers using the “#” symbol

```
# Header 1

## Header 2

### Header 3

#### Header 4

##### Header 5

###### Header 6
```

Header 1

Header 2

Header 3

Header 4

Header 5

Header 6

RMarkdown: Body Text

- Inline equations are identical to LaTeXsyntax, but only *some* of the syntax is available

  See the LaTeXcheatsheet here for syntax:
  https://wch.github.io/latexsheet/latexsheet.pdf

  Example: $e^{i\pi} - 1 = 0$ is written `$e^{i \pi} - 1 = 0$`

- Bold and italicized statements are written using
  - `**myBoldText**` and `*myItalicizedText*`

RMarkdown: In-line code

- In-line code that is **not** executed can be included in backticks

  CODE: To assign a value to a variable: ‘myVar <- 1‘

- In-line code that **is** executed can be included as ‘r <insert code here>‘

  CODE: Calculate 2 + 3 and print to document: ‘r sum(c(2, 3))‘

RMarkdown: Code Chunks

- At the heart of RMarkdown are code chunks, which allow for great flexibility when including raw code as well as results, from simple computations to complex graphs and analyses.
  Example:

```
```{r <sectionTitle>, <options>}
<include code here>
```
```

- Use `ctrl + option + I` as a shortcut to include code chunk
- `<sectionTitle>` is the *unique* name of the code chunk
- `<options>` are a sequence of options separated by commas

  Note: all labels and code chunk options must be on the same line

RMarkdown: Several Code Chunk Options

- `eval`: whether or not to run the code chunk
- `echo`: whether or not to include code in output document
- `include`: when `FALSE`, the code chunk is evaluated, but the code and results are not included in the output document
- `tidy`: whether or not to have `knitr` format printed code chunks
- `results`: when `FALSE`, the code chunk is evaluated, the code is included in the output document, but the results are not printed to the output document

RMarkdown: Selected Global Chunk Options

- To set global options for all code chunks, include the following code chunk after the header

```
```{r <sectionTitle>, include = FALSE}
knitr::opts_chunk$set(<options>)
```
```

- `include = FALSE` or `echo = FALSE` is included so that the code chunk is not printed to the output document
- To have all code chunks in an RMarkdown document be suppressed, include all code in the output document

```
```{r preamble, include = FALSE}
knitr::opts_chunk$set(echo = FALSE)
```
```

Including Non-R Code in Code Chunks

- RMarkdown is not limited to R code
- knitr can run code from a variety of other languages, including Python, Ruby and Bash
- To include non-R code in a code chunk, set the engine code chunk to tell knitr which language you are using
- **Example**: To include Python code, use

```
```{r engine = 'python'}
print "Hello World"
```
```

- Additional non-R programming language interpretation is available using the highlighter package

RMarkdown Resources

- "Reproducible Research with R and RStudio" by Christopher Gandrud
  - This is a less technical, more pragmatic approach to RMarkdown
- "Dynamic Documents with R and knitr" by Yihui Xie
  - A more technical, detailed and rigorous treatment of RMarkdown and knitr

Quick RMarkdown Resources

- RMarkdown Cheat Sheet

  http://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf

- RMarkdown Reference Guide

  http://www.rstudio.com/wp-content/uploads/2015/03/rmarkdown-reference.pdf

- RMarkdown PDF Documents: Overview

  http://rmarkdown.rstudio.com/pdf_document_format.html

IMPORTANT: Style Guide

Now that Introduction to RMarkdown is complete, be sure to **thoroughly read** the Style Guide (Chapter 5), in Hadley Wickham's Advanced R. You will be held to that standard in your coding style moving forward.

http://adv-r.had.co.nz/Style.html