Transparent and Reproducible Research with R (Part 1)

And a bit of git/GitHub

Daniel Anderson
Joshua M Rosenberg
April 7, 2019


WHALE HELLO THERE

Agenda

First two hours

- Introduction (8:00 - 8:45)
  - Who we are, who participants are and why they're here (15 min.)
  - Reproducible research and literate programming (20 min.)
  - Conducting science in the public and in an open way & OSF (10 min.)

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  - Who we are, who participants are and why they're here (15 min.)
  - Reproducible research and literate programming (20 min.)
  - Conducting science in the public and in an open way & OSF (10 min.)
- R Markdown (8:45 - 10:00)
  - Delineating code chunks from plain text (15 min.)
  - Creating headers (5 min.)
  - Creating lists and using other features of markdown (10 min.)
  - Whole-document and code chunk-specific options (15 min.)
  - Rendering and sharing documents in different formats (15 min.)
  - Lab (practice) (15 min.)


Break (10:00 - 10:15)

Last two hours

- Advanced R Markdown functionality (10:15 - 11:00 minutes)
    - Formatting tables (20 min.)
    - Creating manuscripts to submit for publication (via {papaja}; 25 min.)
- Use of git/GitHub for version control and collaboration (11:00 - 11:45)
    - Introduction to GitHub, RStudio interface, and GitKraken GUI (20 min.)
    - Making changes, committing them, and pushing them to the repository (15 min.)
    - Use of GitHub (and ignoring specific files via `.gitignore`; 10 min.)
- Wrap-up/ideas for next steps/staying in touch (11:45 - 12:00)

#whoami

- Research Assistant Professor: Behavioral Research and Teaching, University of Oregon (#goducks)
- Dad (two daughters: 6 (almost 7) and 4)
- Primary areas of interest
  - 💗💗R💗💗 and computational research
  - Open data, open science, and reproducible workflows
  - Growth modeling, achievement gaps, and variance between educational institutions (particularly spatially)

#whoami 2

- Assistant Professor: STEM Education, University of Tennessee, Knoxville
- Also a Dad (one-year-old toddler!)
- Primary areas of interest
  - Data science in education (network analytic methods, experience sampling method, computational grounded theory)
  - Data science education (integrating data science and science education)

#whoyouis

Introduce yourself What's your prior experience with R/R Markdown and git/GitHub? Why are you here?


This slide means we're
transitioning to Daniel

This slide means we're transitioning to Josh

Before we really get started

- Realize this is all going to be an intro
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  - Idea is to give you exposure and some basic familiarity

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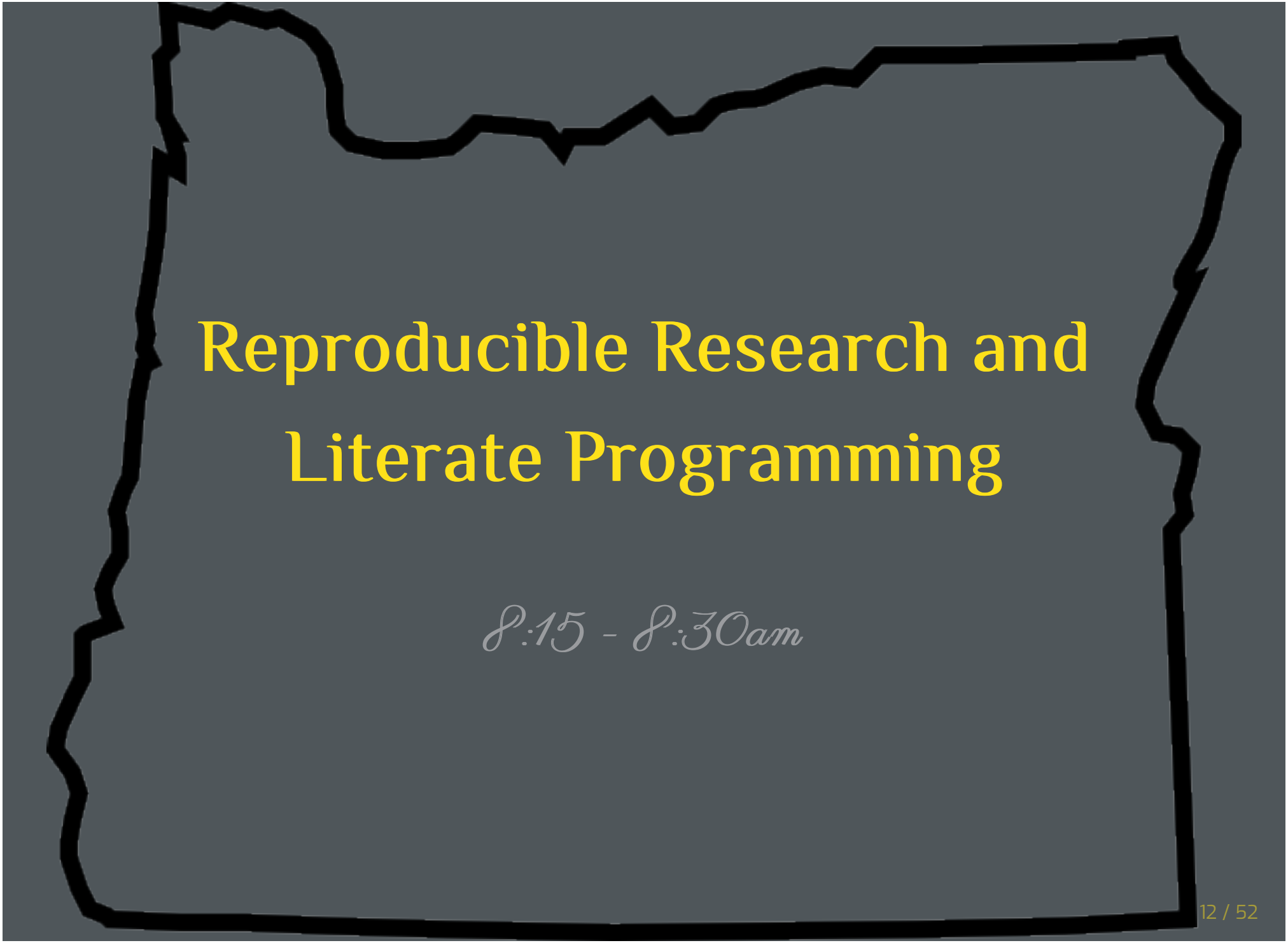
- Resources to learn more
  - Daniel's class(es)
  - Intro course
  - Data viz course
  - Functional programming
  - r4ds
  - R Markdown book
  - (Developing) data science in education book



Reproducible Research and Literate Programming

8:15 - 8:30am

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- None of what we will talk about should be taken as a referendum on you or your current practices. However, we hope to help to convince you that you should be working toward the reproducible research ideal, and that, as a field, we should be moving toward reproducible research being the *minimal standard*.

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- We will be focusing on reproducible research with R (obviously). Other options are available but, in our view, none are as clear, comprehensive, and easy to implement as the tools at your disposal through R.

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- Reproducibility represents a **minimal** standard, which itself can aid replication (tremendously), by conducting and documenting the research sufficiently that an independent researcher could reproduce all the results from a study, provided the data were available
- Turns out this is a more difficult standard than we would generally like to admit.

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    - More transparency
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- If your work **is not** reproducible, it is often not truly replicable.
- If your work **is** reproducible, then others have a "recipe" for replication.

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- Initially, we may think of journal articles as research, but really the research is everything that went into the article, not the article itself.
- Some (Buckheit & Donoho, 2015) conceive of the article as the "advertisement".
- If all we have is the advertisement, can we really fully understand the steps and decisions made during the research?
  - In large-scale data analysis, the answer is generally "no".

Tangential benefits

Striving toward reproducible research will:

- Make your own code more efficient/easily interpretable
    - Can help with collaboration on a project
- Reduce errors
- Increase efficiency by not having to redo tables and figures with each tweak to a model.

What does literate programming look like?

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What this workshop is about!

1. Start with a basic text document (not Word, text)
2. Use the text document to write your article
3. Embed code within the text document that corresponds to your analysis. Note this is not just copying the code in. The code should be live and what you're working with while conducting your research.
4. Render the document into a different format (pdf, html, etc.).
    - Select which code (if any) will be displayed
    - Build tables of results and plots to be produced

End result

- Readers can then read the "advertisement", but if they are interested in reproducing your results they can access the text file that contains the analysis code.
- Single product that has the advertisement and the research process embedded.

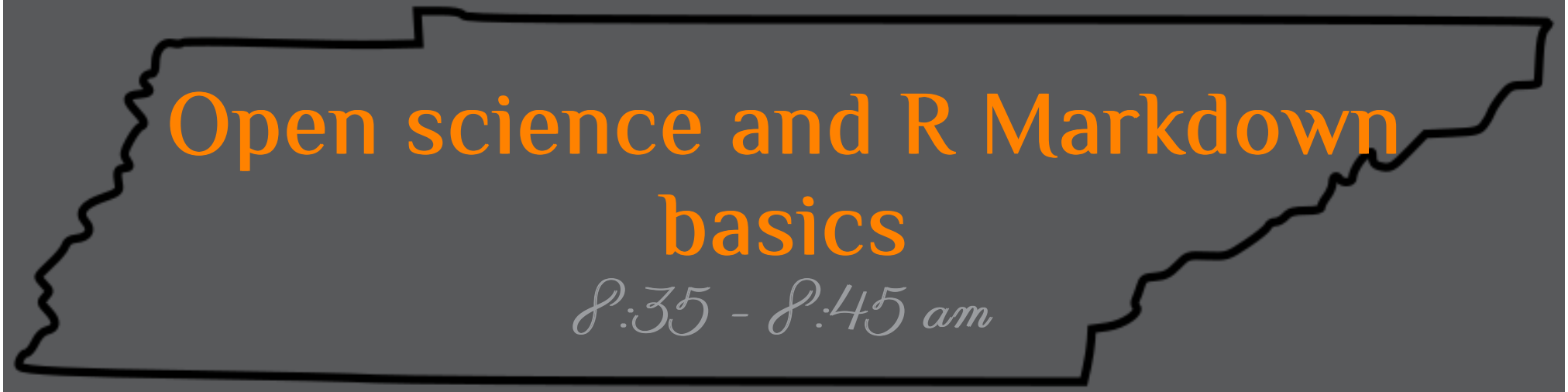
Other reasons dynamic documents are useful

Outside of reproducibility, you may want to use R Markdown to:

- Produce slides
- Keep track of your analysis (notes, essentially), even if you end up using something like Word
- Share code with others
- Quickly share results with others
- Produce professional looking data products

Challenges

- Word is the industry standard (frustratingly so, to us)
  - Word output is less than ideal
- Can be difficult when collaborating with others
- Some journal articles *require* papers submitted in Word
  - Potentially get a pdf to word converter, but still less than ideal
- Advanced features have a relatively steep learning curve



Open science and R Markdown basics

8:35 - 8:45 am

Open science and public work

Benefits

- Working in the public has potential benefits:
  - People know what your expertise is
  - Potential colleagues can reach out to you for collaborations
  - Allow others to build upon your work
  - Build a network

Dilemmas

- Working in the public has *some* potential dilemmas/drawbacks to manage:
  - Sometimes difficult to share pre-prints (due to copyright issues)
  - Getting 'scooped'
  - Often difficult to share data

Open Science Framework

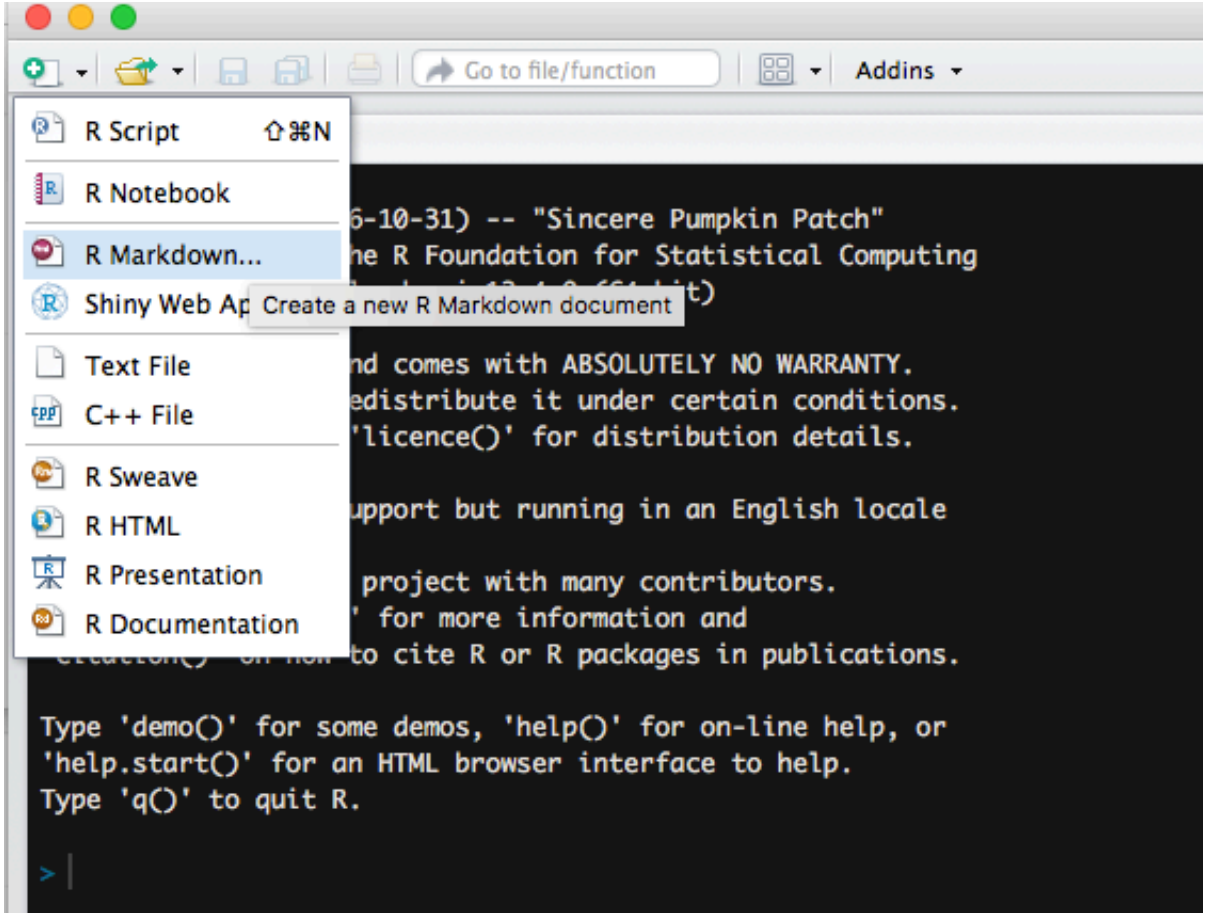
- Offers a platform in which you can store *private* data
- Has an Application Programming Interface (API) to connect with R
- Example: https://osf.io/9ex7k/

R Markdown Basics

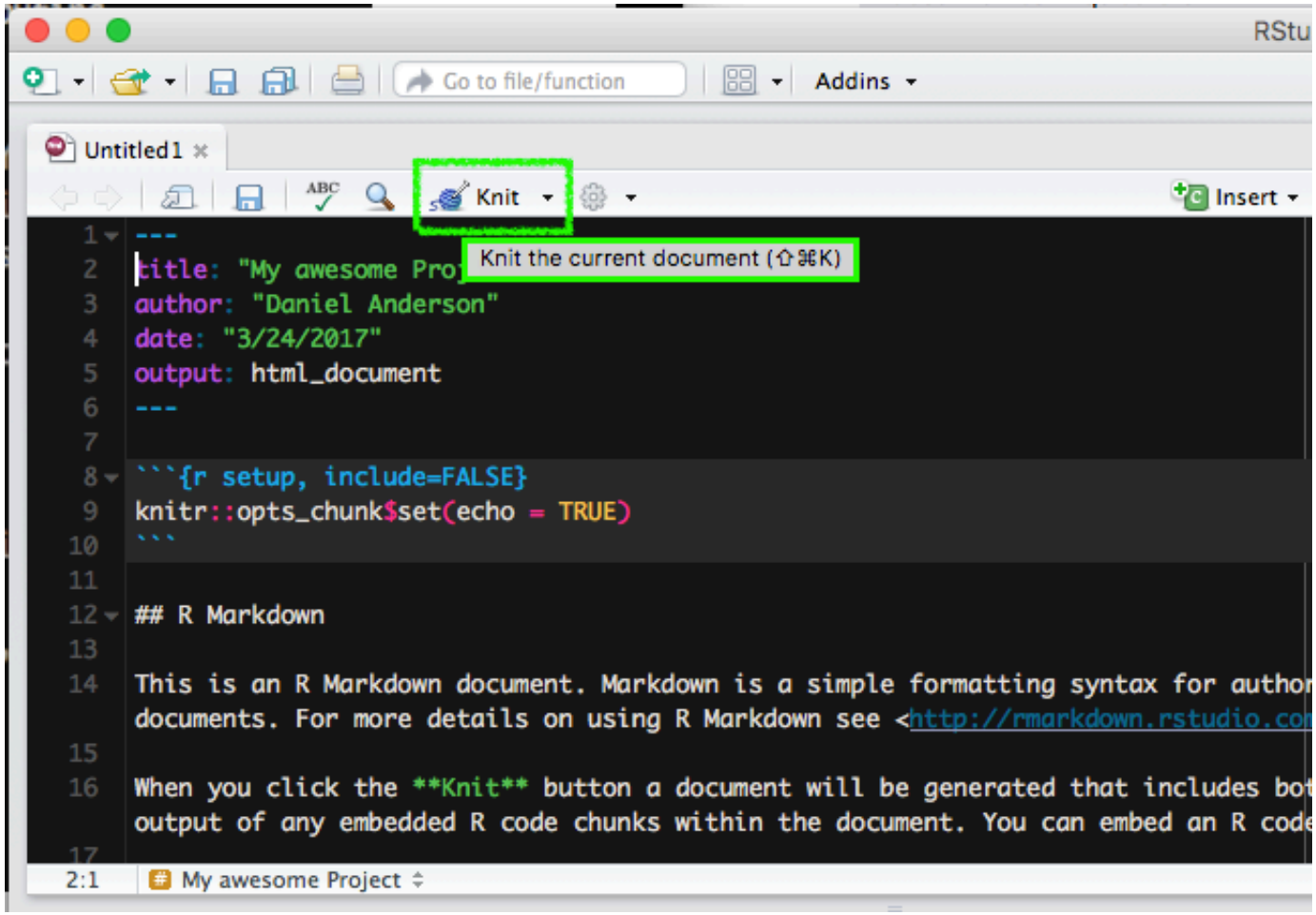
8:45 - 9:00

R Markdown

From within your R Studio Project:



First thing: Render!



Create new a R Markdown doc

Try it out!

YAML Front Matter

```
---
title: Example Markdown document
author:
- Daniel Anderson
- : "2019-05-07"
---
```

- Three dashes before and after the YAML fields
- Case sensitive
- Many other fields are possible.
  - For example, you may want to include an `output:` argument

Example: Change syntax highlighting

The YAML will control a lot of how a document looks. For example, if you wanted to render with a different syntax highlighter:

Standard Rmd

```
---
title: "Doc Title"
output: pdf_document
---
```

kate

```
---
title: "Doc Title"
output:
  pdf_document:
    highlight: kate
---
```

Code chunks versus text

```
---
title: "My awesome Project"
author: "Daniel Anderson"
date: "3/24/2017"
output: html_document
---

## R Markdown

Text here

```{r cars}
# Code here
summary(cars)
```

More text here

```{r pressure, echo=FALSE}
# More code here
plot(pressure)
```

Yet more text...
```

Code chunks

Start a code chunk with ```` ```{r} ````, then produce some r code, then close the chunk with three additional back ticks ```` ``` ````.

````
```{r rCalc}
a <- 3
b <- 5

a + b * (exp(a)/b)
```
````

Code chunks

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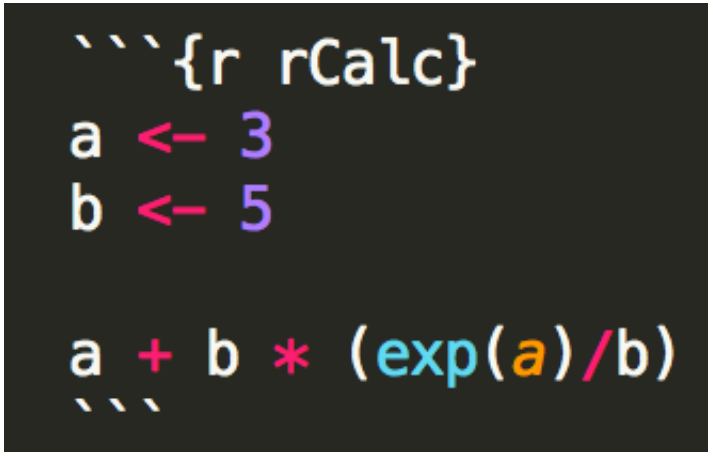


```
a <- 3
b <- 5

a + b * (exp(a)/b)
```

```
## [1] 23.08554
```

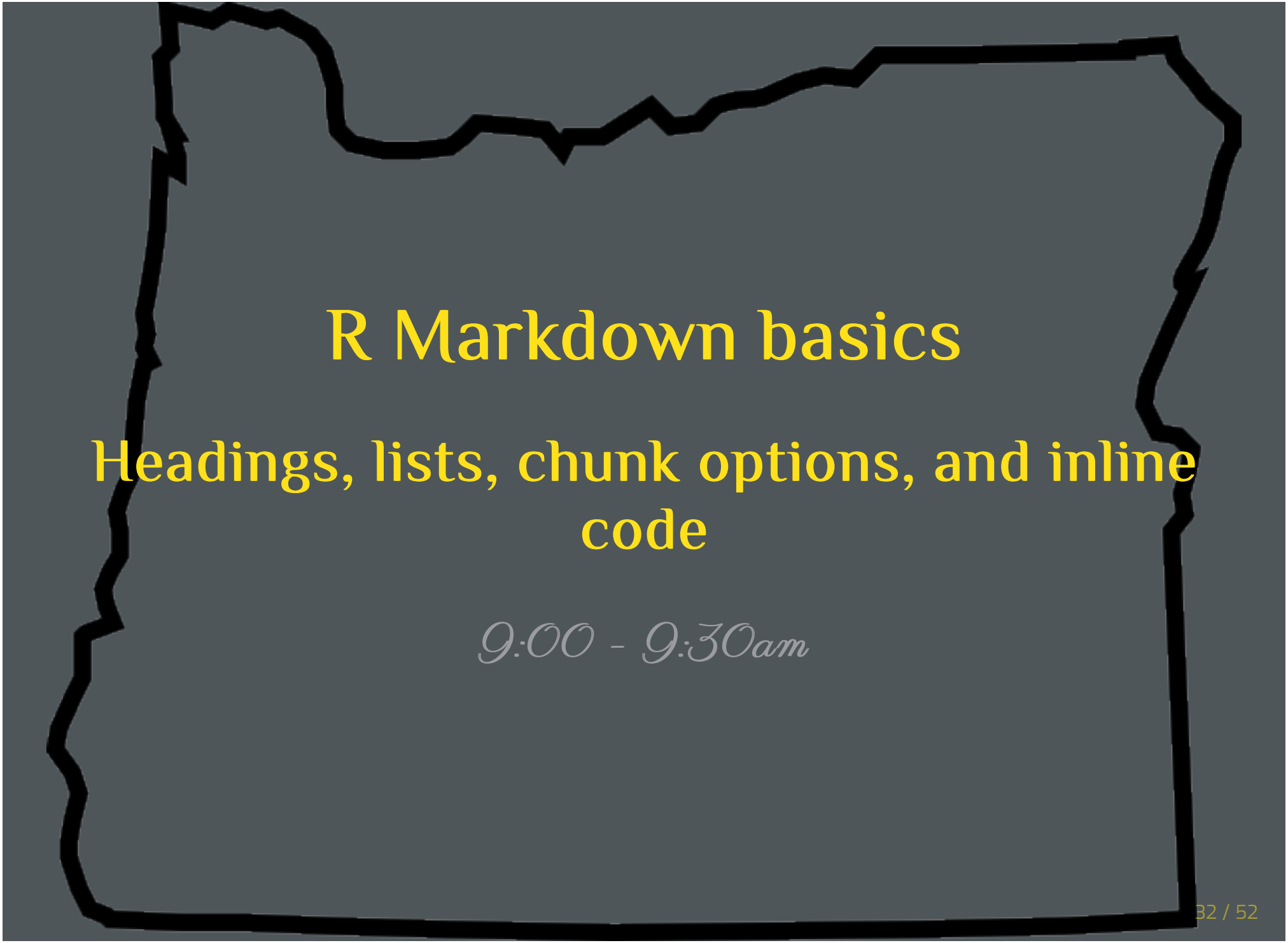

R Markdown basics

Headings, lists, chunk options, and inline code

9:00 - 9:30am

Headings and Lists

Not R-lists

```
# Level 1
## Level 2
### Level 3 (etc.)
```

Level 1

Level 2

Level 3 (etc.)

```
 * Unordered list
  - inset
    + inset more
  - etc.

1. Ordered list
  a. blah blah
2. More stuff
```

- Unordered list
  - inset
    - inset more
  - etc.

1. Ordered list
   a. blah blah
2. More stuff

echo and eval

You can show code without evaluating it, using `eval = FALSE`.

````
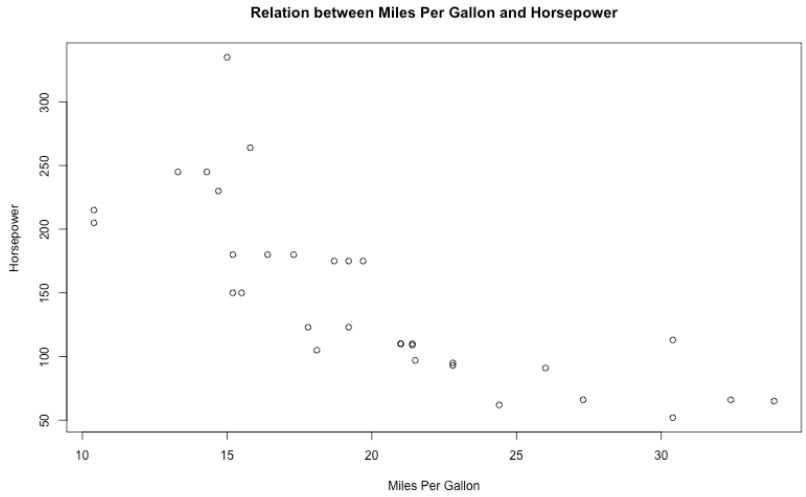
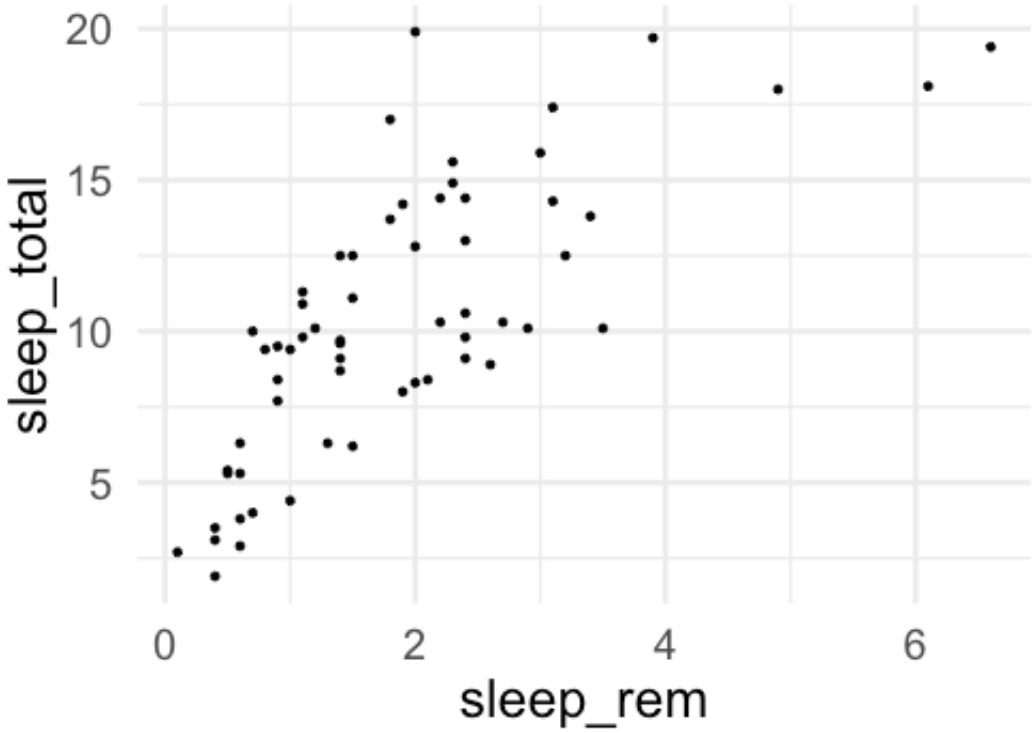
```{r ex_rCalc2, eval = FALSE}
a + b * (exp(a)/b)
```
````

```
a + b * (exp(a)/b)
```

Alternatively, you can evaluate the code without displaying it, using `echo = FALSE`.

````
```{r plotExample, echo = FALSE, fig.width = 6, fig.height = 3.8}
data(mtcars)
with(mtcars, plot(mpg, hp,
  xlab = "Miles Per Gallon",
  ylab = "Horsepower",
  main = "Relation between Miles Per Gallon and Horsepower"))
```
````



warning

Warning = FALSE

```
ggplot(msleep, aes(sleep_rem, sleep_total)) +
  geom_point()
```

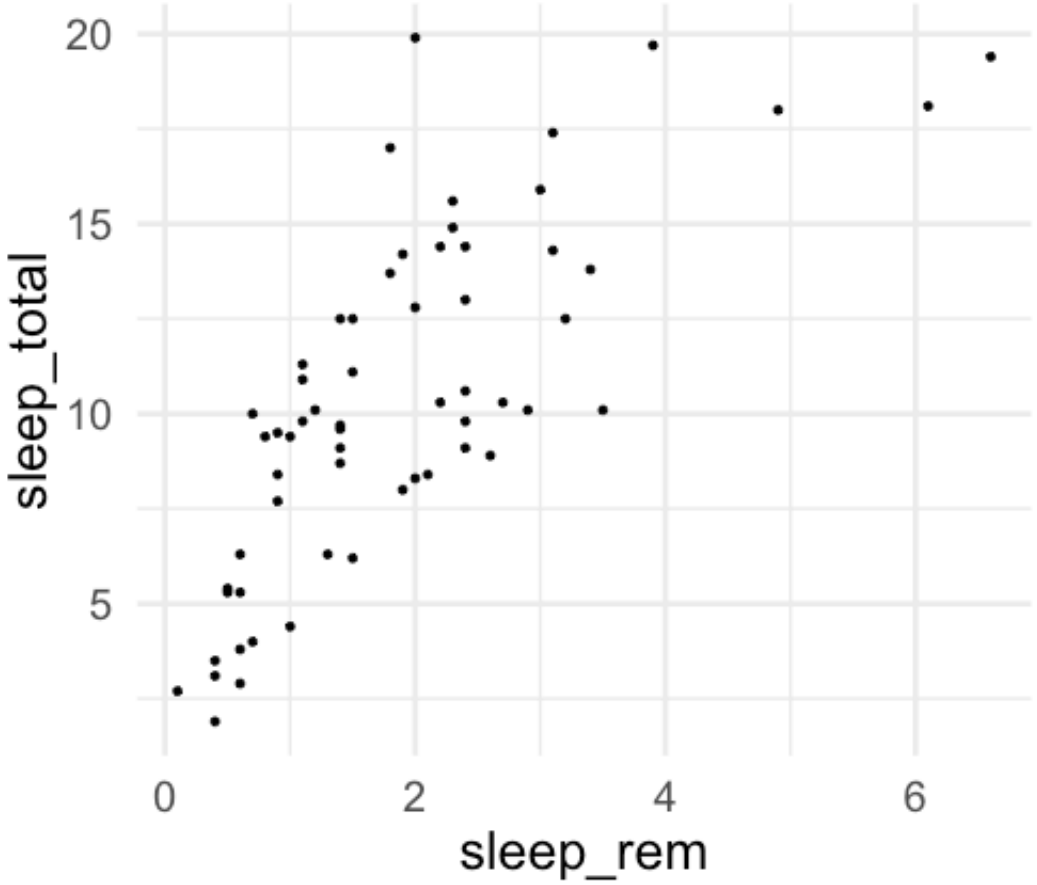


Warning is printed to the console when rendering.

Warning = TRUE

```
ggplot(msleep, aes(sleep_rem, sleep_total)) +
  geom_point()
```

```
## Warning: Removed 22 rows containing missing values (geom_point).
```



Show errors

`error = TRUE`

```
ggplot(msleep, aes(sleep, sleep_total)) +
  geom_point()
```

```
## Error: Aesthetics must be either length 1 or the same as the data (83): x
```

Show errors

`error = TRUE`

```
ggplot(msleep, aes(sleep, sleep_total)) +
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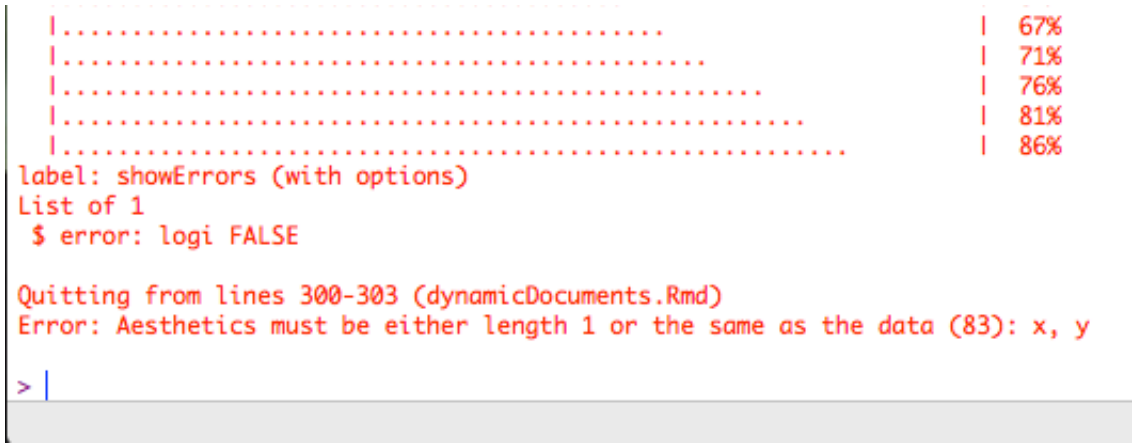
```

```
## Error: Aesthetics must be either length 1 or the same as the data (83): x
```

If `error = FALSE`, the document won't render if it encounters an error.

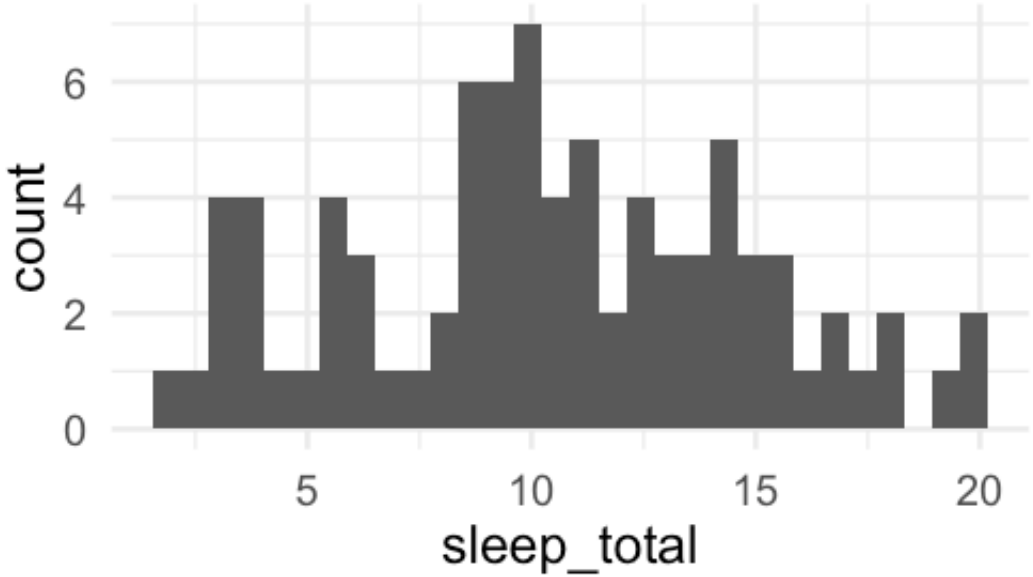


Message

Some functions will return messages. You may want to suppress these.

message = FALSE

```
ggplot(msleep, aes(sleep_total)) +
  geom_histogram()
```

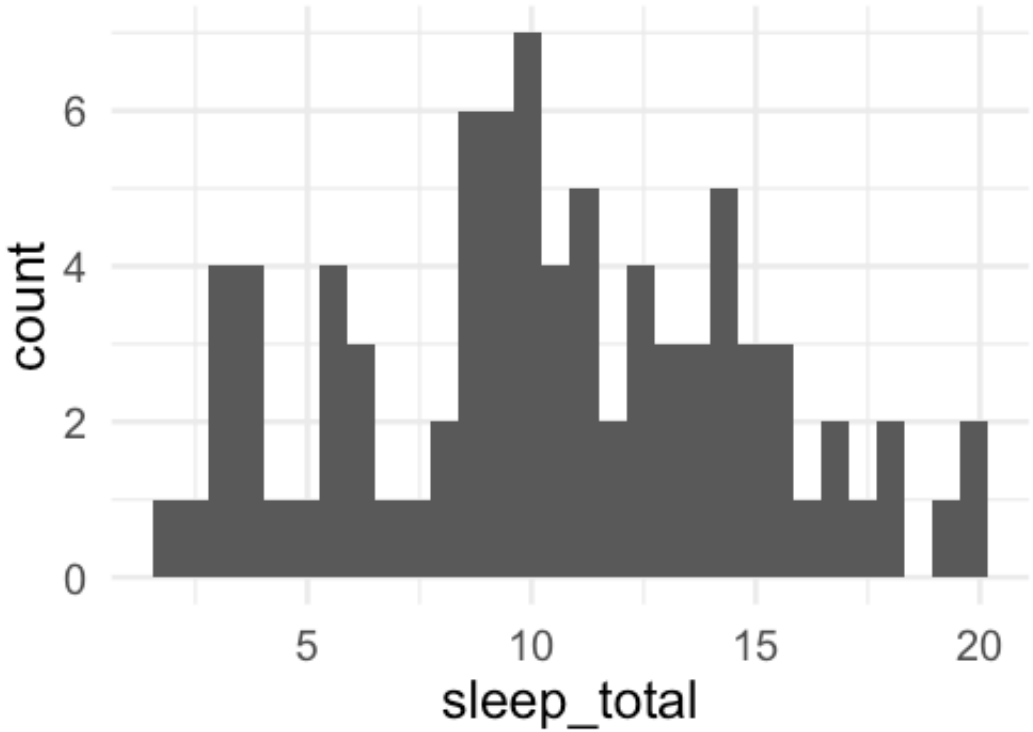


Message

message = TRUE

```
ggplot(msleep, aes(sleep_total)) +
  geom_histogram()
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



include

```
```{r setup, include = FALSE}
library(knitr)

# Set global chunk options
opts_chunk$set(cache = TRUE, cache.comments = FALSE, autodep = TRUE)

dep_auto()
```
```

The `include` argument is used to evaluate code that is not included in the document at all. For example, when setting up your global options.

Setting global options

Change the default behavior

```
opts_chunk$set(...) # insert options here
```

For example, you can set `echo = FALSE` and `fig.width = 6.5` and `fig.height = 8` with the following code.

```
opts_chunk$set(echo = FALSE, fig.width = 6.5, fig.height = 8)
```

This is most useful when producing a report for somebody who doesn't use R and has no use or knowledge of the code.

You can always override the global options within a particular chunk, e.g.

```
```{r, chunkName, echo = TRUE}

```
```

Other things to consider setting globally:

- `warnings = FALSE`
- `message = FALSE`
- `errors = TRUE`
- `echo = FALSE`
- Caching options (next slides)

More complete chunk options

Options	Arguments	Default	Result
eval	logical	TRUE	Evaluate the code?
echo	logical	TRUE	Show the code?
results	markup, asis, hold, hide	markup	Render the results
warning	logical	TRUE	Print warnings?
error	logical	TRUE	Preserve errors? (if FALSE, quit)
message	logical	TRUE	Print any messages?
include	logical	TRUE	Include any of the code or output or code?
tidy	logical	FALSE	Tidy code? (see formatR package)

(and a few more)

	Options	Arguments	Default	Result
9	cache	logical, 0:3	FALSE	Cache code chunks?
10	cache.comments	logical	NULL	Cache invalidated by comment changes?
11	dependson	char, num	NULL	Current chunk depend on prior cached chunks?
12	autodep	logical	FALSE	Depends determined automatically?
13	fig.height/fig.width	numeric	7, 7	Height and width of figure
14	fig.show	asis, hold, animate, hide	asis	How the figure should be displayed
15	interval	numeric	1	Animate speed

For complete documentation, see http://yihui.name/knitr/options/

Inline code

A single back tick followed by `r` produces inline code to be evaluated.

```
This is an example of inline code, where I want to refer to the sum of `a` and
  `b`, which is `r a + b`.
```

This is an example of inline code, where I want to refer to the sum of `a` and `b`, which is 8.

This is *extremely* useful in writing reports. Never have to update any numbers in text, regardless of changes to your models or data (if you are careful about it).

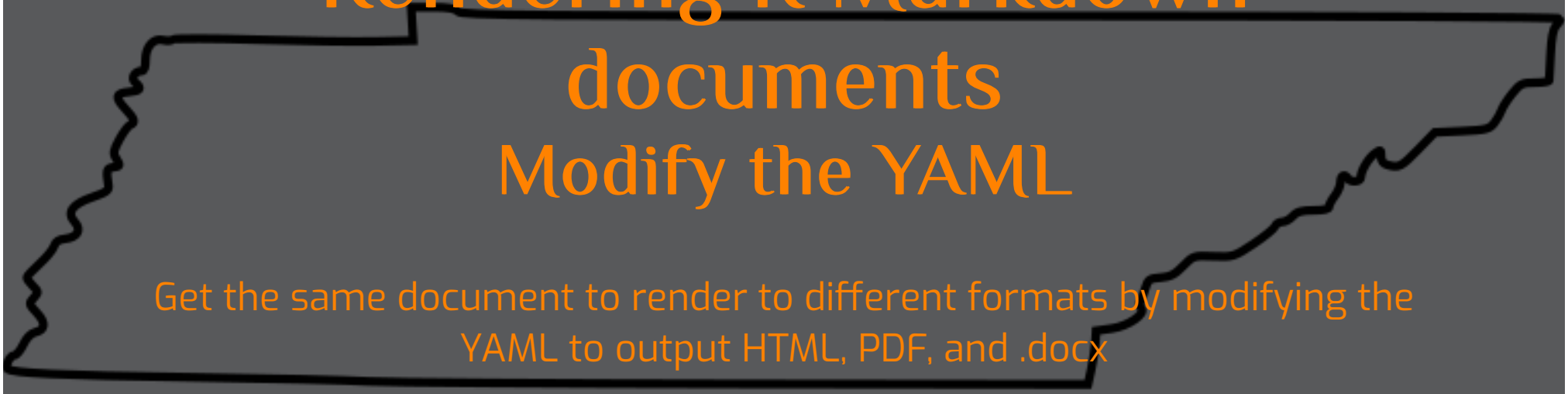
Real example

```
```{r ell_grp_means}
ell_means <- with(d, tapply(reading, ell, mean, na.rm = TRUE))
```

Figure 2 represents a example of why the PP plot is such a powerful
visualization of group differences. As previously stated, the *Monitor* group
had the highest average achievement, scoring `r round(ell_means[2] - ell_means[
  3], 2)` points higher than *Non-ELL* students and `r round(ell_means[2] -
  ell_means[1], 2)` points higher than *Active* students, on average. However,
the data visualization provides a more nuanced picture of the achievement
differences. The *Monitor* curve is below the reference line on the lower end
of the scale, but above the reference line at the upper end of the scale. In
other words, students in the *Monitor* group only scored higher than students
in the *Non-ELL* group at the bottom of the scale. At the upper end of the
scale the effect was reversed, and students in the *Non-ELL* group had the
higher achievement. In this case, the line crosses at essentially the 50th
percentile of achievement for non-ELL students. Observing these achievement
differences may help lead us to more refined research questions and research
hypotheses. For example, a reasonable hypothesis stemming from Figure 2 may be
that low-performing students are in need of additional attention, and that
providing additional attention is beneficial to their academic achievement
even if the intervention is not strictly focused on academics. Interestingly,
although not reported here, when the equivalent plot is produced with the
mathematics outcome, the overall group differences appear very similar at the
bottom of the scale, but the groups are essentially indistinguishable above
the 50th percentile.
```

Rendering and documents
9:30 - 10:00am-

Rendering R Markdown documents
Modify the YAML



Get the same document to render to different formats by modifying the YAML to output HTML, PDF, and .docx

From

```
---
title: "My Document"
author: "Stephanie Lawson"
output: html_document
---
```

To

```
---
title: "My Document"
author: "Stephanie Lawson"
output: pdf_document
---
```

Rendering to HTML

```
---
title: "My Document"
author: "Stephanie Lawson"
output:
  html_document:
    toc: true
    toc_depth: 2
    toc_float: true
    number_sections: true
    higlight: kate
---
```

Re# Rendering to a PDF

- Need a tex (pronounced tek) distribution
  - Our recommendation for this workshop with probably everything you'll ever need: {tinytex}

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- Need a tex (pronounced tek) distribution
  - Our recommendation for this workshop with probably everything you'll ever need: {tinytex}

```
install.packages("tinytex")
tinytex::install_tinytex()
```

This is another amazing package by Yihui Xie. See more about it here

ndering to PDF

```
---
title: "My Document"
author: "Stephanie Lawson"
output:
  pdf_document:
    toc: true
    number_sections: true
    higlight: kate
---
```

Rendering to .docx

A key feature is the ability to use a reference document; see here

```
---
title: "My Document"
author: "Stephanie Lawson"
output: word_document
---
```

Break

10:00 - 10:15