RStudio - 02: Project, markdown, R markdown

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October 18, 2018

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PREFACE

**Markdown** and **RMarkdown** are amazing tools to create beautiful, dynamic documents that can be updated easily. In addition, unless it contains instructions for a specific kind of document, the same Markdown or RMarkdown document can be exported in multiple common and popular formats:

- HTML for web or local browser
- PDF
- Epub
- Microsoft MSWord
- and more

We’ll use the software **RStudio** that has extended options for creating such documents. Documents need not have any R code! In other words, it is possible to create e.g. an MSWord document *without* using that software!

*Note*: This tutorial may need to be preceded by a tutorial on how to use R and/or RStudio.

1 Goal: set up an RStudio project to analyze enzymatic results

1.1 Create a new project

Open the **RStudio** software now.

An **RStudio** project is a set-up that uses a specific directory to contain the data that we want to use for analysis.

To set-up a new project follow do the following in **RStudio**:

1. Click the **File** menu button, then **New Project**.
2. Click **New Directory**.
3. Click **Empty Project**.
4. Type in the name of the directory to store your project, e.g. **Project_1**.
5. For now don’t check “Create a git repository” (should be unselected by default)
6. Click the **Create Project** button.

The project will be saved in the default directory: `/Users/YourName` on the Mac unless you navigate to e.g. the **Desktop** to more easily find the it later (strongly suggested.)

1.2 Creating reports for “reproducible research”

Goal: to analyze data in reproducible way.

Analyzing data in a reproducible manner is easier to achieve if there is a proper documentation of the process. In “old days” this was achieved by adding comments within computer programs. Nowadays it is possible to “weave” the computer code (the R commands in our case) with
a narrative of the process (the story we need to report) in a manner where they are both updated automatically if the analysis method should change or if the data is altered or updated with new data.

This allows the "dynamic" creation of output report documents in e.g. PDF, HTML or MSWord format. The output document can be overwritten or replaced when data or methods are updated.

2 What are markdown ar R Markdown?

"Markdown is a text-to-HTML conversion tool for web writers. Markdown allows you to write using an easy-to-read, easy-to-write plain text format, then convert it to structurally valid XHTML (or HTML)." John Gruber inventor of markdown.

R Markdown is an authoring format that enables easy creation of dynamic documents, presentations, and reports from R. It combines the core syntax of markdown (an easy to write plain text format) with embedded R code chunks that are run so their output can be included in the final document. R Markdown documents are fully reproducible (they can be automatically regenerated whenever underlying R code or data changes).

We first need to learn just a little bit of R Markdown for this purpose. Then the knitr package will compile the file we create with a "story" and R code into one final, dynamically created document.

Note: this document was created with R Markdown!

3 Basic markdown syntax

Markdown is very simple and helps create structured text easily. As detailed above it is originally a method for creating HTML (mark-up language) and therefore there are similarities. For those that are more into Microsoft Word, the same type of structure easily applies as well with the "Styles" for titles and paragraphs.

There are a few variations on how to accomplish some effects, but we'll limit the examples to just the basic necessity.

Note: To have an “immediate experience” for the following markdown commands open the following web site: https://dillinger.io which will provide a split screen with markdown on the left panel and the rendered text on the right panel.

Alternatively you can use a markdown text editor such as Macdown on a Macintosh or markright on any system

3.1 Headings:

The following code is one way to create Headings levels:
After processing they become title headings in the final document:

Heading 1
Heading 2
Heading 3
Heading 4

3.2 Normal text:

Normal text is simply typed and paragraphs are created with an empty line in between.

For example the following text (placed here in a mode that does not process)

This is some text that
will become one line when processed.

A blank line will make a new
paragraph to continue the story.

will be processed as follows (which resembles the writing of this document as it was made
in this manner!)

This is some text that will become one line when processed.
A blank line will make a new
paragraph to continue the story.

3.3 Bold and italic

3.3.1 Italics

*Italics* are accomplished by * or _ before and after the word:

This word is *italic* and this one is _italic_ too.

This word is italic and this one is italic too.

3.3.2 Bold

**Bold** is accomplished by ** (2 stars *) or ___ (2 underscores _) before and after the word:

This word is **bold** and this one is ___bold___ too.

This word is bold and this one is bold too.
3.3.3 Both italics and bold

To get both we can combine for a total of 3 markers before and after the word or phrase:

This word is ***both*** and this one is _**both**_ too.

This word is both and this one is both too.

<table>
<thead>
<tr>
<th>Table 1: Summary Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Italic</strong></td>
</tr>
<tr>
<td>Using *</td>
</tr>
<tr>
<td>Using _</td>
</tr>
<tr>
<td>Combining * and _</td>
</tr>
</tbody>
</table>

3.4 Quotes

Quotes are easily created with the `>` sign, for example:

> This is quoted text, simply by using a single `>` at the beginning of the line.
> Syntax highlight may or may not work: **bold** _italic_ ***both***
> > *This is a quote within a quote marked as italics.*

Becomes:

This is quoted text, simply by using a single `>` at the beginning of the line. Syntax highlight may or may not work: **bold** _italic_ ***both***

>This is a quote within a quote marked as italics.

3.5 Lists

Bullet list start with *:

* first item
* second item
* third item

becomes:

• first item
• second item
• third item

Ordered lists start with numbers:

1. first item
2. second item
3. third item

But in fact the manual numbering does not matter, this also works!
1. first item
1. second item
1. third item

Both become:

1. first item
2. second item
3. third item

3.6 Tables

Basic Markdown tables are created by lining up the columns and making headers, like so:

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>300</td>
</tr>
</tbody>
</table>

Table: Simple table with 3 columns

Table 2: A simple table

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>300</td>
</tr>
</tbody>
</table>

Another method allows justification to the right or left with the `:position` within the underlining header (second line.) Here column 1 is justified center, column 2 to the right and column 3 to the left as indicated by the position and number of `:` in the underline row.

<table>
<thead>
<tr>
<th align="center"></th>
<th align="center">Column 1</th>
<th align="center">Column 2</th>
<th align="center">Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td align="center">1</td>
<td align="center">10</td>
<td align="center">100</td>
<td align="center"></td>
</tr>
<tr>
<td align="center">2</td>
<td align="center">20</td>
<td align="center">200</td>
<td align="center"></td>
</tr>
<tr>
<td align="center">3</td>
<td align="center">30</td>
<td align="center">300</td>
<td align="center"></td>
</tr>
</tbody>
</table>

Table 3: Justified table

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>300</td>
</tr>
</tbody>
</table>

Note: In a previous document we used function `kable()` from package `knitr` to format existing R matrices or data frames.
3.7 Code blocks and inline code

3.7.1 Inline code

Quoting simple code in monospaced font is accomplished within the text with a the single backtick ` around the word. For example:

This `code` will be seen as a `special word` within the text when interpreted.

Will become: This code will be seen as a special word within the text when interpreted.

3.7.2 Code block

A code block is a series of lines that are all code. For example here is a code block in R:

```
# This code block starts with 3 backticks and will end the same way.
x <- rnorm(10)
y <- seq(1:10)
plot(x, y)
```

When processed this will become:

```
# This code block starts with 3 backticks and will end the same way.
x <- rnorm(10)
y <- seq(1:10)
plot(x, y)
```

This code is static and not dynamic: it is only formatted to look like code.

3.8 Dynamic Code block

Note: From this section on, we need to be back in RStudio. (Re)-open the project file created earlier.

3.8.1 Create an RMarkdown document

You can create a new R Markdown file with the following menu cascade:

File > New File > R Markdown...

- Change the default name “Untitled” to e.g. “Test.”
- Update the author name.
- Keep HTML as the default format

The document will come pre-filled with sample text and data that we will need to erase.

The top portion will look something like this, with your name as author:
DO NOT EDIT or alter the ``` triple dash marks!

TASK: KEEP the first code chunk and delete everything starting with and including:

```r
plot_test

This is an R Markdown document.
```

We’ll add our own text below.

### 3.8.2 Report Output

The report has to be transformed from Rmarkdown to the desired output format (here it is HTML.)

To obtain an output from this page:

- click the Knit button and select Knit to HTML pull down menu
- a new window, in HTML format will appear containing the report.
- for now it will only show the title, author and date contained in the header.

This is how we create dynamic documents with R code executed on the fly and the “narrative” story telling.

### 3.8.3 Dynamic Code block

In R Markdown we mark R code with `{r}` so that when we finalize the document this code will be run and the data read and updated, etc. making the final document dynamically rendered and updated.

The code chunk can be named within the brackets to describe the content, for example: `{r plot_test}`

Therefore, to have this code executed it needs to be written as:

Then within the document the code will be automatically syntax-highlighted and the code executed: in this case it creates a plot, itself embedded within the final document.

```r
x <- rnorm(10)
y <- seq(1:10)
plot(x, y)
```
3.9 Dynamic Inline code

Code can also be included within the text and computed on the fly by R. This is useful when writing reports with specific values calculated or taken out of model evaluations.

This is marked by the letter `r` within the code to signify that R should compute it:

Simple example:

Will be processed as:

I think that this is an interesting calculation: \( 2 + 2 = 4 \) when R evaluates the value within the specially marked code.

To really experience the fact that this is calculated on the fly we can add a random number to 2 (note that the result will be different each time as this is random! The number can be positive or negative.)

Let’s add a random number to 2: \( 2 + \text{rnorm(1)} = 2.7749211 \).

*Note:* a special R command `set.seed()` can be used so that results don’t change each time even for “random” number generation.

Here is a fancier example: we’ll set the seed to a user-defined value so that results are the same every time; then we assign the randomly generated number to object \( x \); then we print \( x \) and add it to 2 all the while explaining what we do in the text!

(*Note:* In the above code there is a space between `:` and `r` to prevent calculations to occur... The embedded code within that gives the result below was properly formatted to obtain the correct output.)

When processed this will become:

Let’s create a random number fixed with every iteration and assign it to the variable \( x \).

We can print the value of \( x \) which is 0.0187462.

We can add \( x \) to 2: \( x + 2 = 2.0187462 \).
3.10 HTML links:

Any link that starts with http:// or https:// will automaticall become a clickable link.

For example: http://wisc.edu

To create a hypertext link: place the text in square brackets [] followed by the link in parentheses () without any space in between. For example:

[Biochemistry Department](http://biochem.wisc.edu)

Will be processed as a live link: Biochemistry Department

4 Markdown and dynamic analysis resources:

4.1 R markdown

- BOOK (HTML): R Markdown: The Definitive Guide Note: This book has been published by Chapman & Hall/CRC. The online version of this book is free to read here (thanks to Chapman & Hall/CRC), and licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

- Reproducible reports with R Markdown - Prof Karl Broman, UW-Madison

- Cheat Sheets:
  - RStudio Cheat Sheet (2015) (PDF)
  - All sheets: https://www.rstudio.com/resources/cheatsheets/

Knitr in a knutshell a minimal tutorial by UW Prof Karl Broman

Minimal examples by Yihui Xie the author of knitr

Knitr reference card (PDF)

knitr example with built-in plot animations.

4.2 Markdown

The Markdown Guide:

- BOOK (PDF): The Markdown Guide
- BOOK (HTML): The Markdown Guide
- Cheat Sheet: https://www.markdownguide.org/cheat-sheet

Daring Fireball by John Gruber

Online Markdown editors: (just markdown, NOT R Markdown!)

https://stackedit.io/

http://dillinger.io/

Markdown syntax cheat sheet 1.0.1 by - John Gruber
4.2.1 Markdown editors:

- The Best Markdown Editor for Windows (Archived April 7, 2016: http://bit.ly/2p7ZYKg)

4.2.2 Math and formulaes in (R) markdown