Markdown and the `knitr` Package in R

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Baggerly and Coombes

There's a really infamous talk from 2010, called

The Importance of Reproducible Research in High-Throughput Biology: Case Studies in Forensic Bioinformatics:
https://www.youtube.com/watch?v=7gYIs7uYbMo

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Their talk illustrates what can go seriously wrong when people working with data are not transparent about how they get their results.

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Baggerly and Coombes are bioinformaticians who study cancer. They attempted to replicate this study:

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ture.com/naturemedicine

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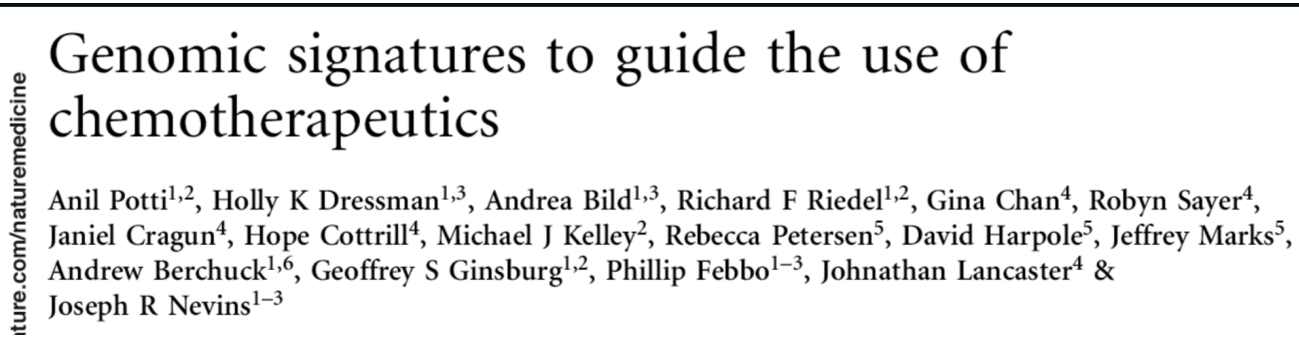

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This was an important finding and was published in a prominent journal.

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But the problem was that the authors **did not provide any scripts or discussion** of what they did to the data prior to running the tests.

As a result, Baggerly and Coombes had to reproduce the results in a "forensic" way: figuring out after-the-fact what the authors must have done to get these results.

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2. The treatment was coded as 1 or 2, but someone along the way confused what 1 and 2 meant. So the treated patients were reported as control, and vice versa.

That means that the reported positive effect for the treatment group is actually a positive effect for the control group. In other words, *the treatment harms people*.

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The study continued for many months. It was only stopped when it was revealed that the principal investigator on the original study had lied on his CV about being a Rhodes Scholar.

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3. Self-interest and ego: covering up mistakes instead of risking the penalties of correcting them, thereby making the mistakes worse.

4. Magical thinking: because the work involves data, there's a tendency by most people to simply believe that the work is correct without digging in to it (not Baggerly and Coombes though!)

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4. Working with code and explaining what each part of the code does goes a long way towards dispelling the anxiety people have about data, and overcomes magical thinking.

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This afternoon we will walk through an entire research pipeline using R markdown, documenting everything we need to do to raw data to prepare it for analysis, and including the final results in the document.

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Practice on your own computer as we discuss the steps for creating a markdown document.

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- Cons: More syntax to learn in addition to R code. Might take a while to compile documents.

The Markdown Language

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This will call up an example page with some text and code already in it. (You will end up deleting this example text and code and writing your own.)

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By default the table of contents appears at the top of the document, just under the title. But, you can also use a floating and collapsable table of contents window like this:

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Other options for the header are listed here:
http://rmarkdown.rstudio.com/html_document_format.html

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If you need space on the web to host this page, click on "**Publish**", then click "**RPubs**". RPubs is a free service, run by R Studio, that provides server space for your markdown documents. If you post online using RPubs, you can use a URL to share your work with your audience.

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*this will be italicized*
**this will be bold**
~~this will be struck out~~
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For block quotes, push Enter/Return TWICE then start every line of the quote with `>` and a space.

```
Here's a profound quote:

> I'd rather have this bottle in front of me
> than a frontal lobotomy
```

Sectioning

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If the `toc: true` option is specified, the section titles will appear in the **table of contents** automatically.

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`{.tabset .tabset-fade}` does the same thing, but include a nice fade-in animation when switching between tabs.
`{.tabset .tabset-fade .tabset-pills}` places the tabs into squares with rounded-edges.

Equations

In statistics and data science, sometimes it makes sense to include mathematical equations in the document. In Microsoft Word, you have to point-and-click every symbol, but in Markdown, you can quickly **type out equations**.

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Some special math characters:

- `^` exponentiation
- `_` subscripts
- `\ sqrt{5}` $\sqrt{5}$
- `\ frac{1}{2}` $\frac{1}{2}$

A list of the code for many other math symbols is here: http://reu.dimacs.rutgers.edu/Symbols.pdf

Equations

For example, to include the quadratic formula in your document,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

type

```
$$ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} $$
```

(Here the `\ pm` refers to the "plus or minus" symbol)

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2. Item 2
3. Item 3
    a. Item 3a
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```

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4. You can change the first number to anything you want. But the following numbers will **always count up by 1** from the first number, no matter what you type there

Creating tables by hand

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The table will appear in a neatly formatted way when you compile.

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Or pull them directly off the web by entering the image's URL:

```
![](http://1funny.com/wp-content/uploads/2010/08/Baby-Animals-24.jpg)
```

Embedding Code

Remember that the purpose of an R markdown file is to weave text, code, and the results of code together in one, readable document. There are three ways to include code in a document:

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To write in-line code, use single, forward-sloping quotes `` ` `` (on the same key as the tilde). Then if you write about the `lm()` function, or the `ggplot2` package, it will appear in this different font and have a grey background.

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This feature is great for filling in details about the data into your text automatically.

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End a code chunk by typing **three more forward single-quotes** on a new line:

```
```
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You can type as many lines of R code as you want inside one code chunk. But, best practice is to only write a few lines at a time in one code chunk.

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Take a moment to try out some code chunks in your markdown document.

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Other options are listed here: https://yihui.name/knitr/options/

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You can set other global options here if you want them applied to all code chunks. Just write `knitr::opts_chunk$set(`*option*`)` in this chunk.

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This option saves A LOT OF TIME when using commands that take a while to run, such as loading a big dataset or running a complicated model. But don't use this option for every chunk, as it can cause problems with the keeping results accurate as code changes.

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For example:

````
```{r plot, fig.width=6, fig.height=8}
ggplot(mtcars, aes(x=wgt, y=mpg)) + geom_point()
```
````