RMarkdown

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What is reproducible data analysis?

95% CI [0.99, 1.47], $z = 9.98$, $p < .0001$, and when discriminating more from less typical "transitional" colors (from 82.0 to 88.7%), $b = 0.80$, 95% CI [0.51, 1.10], $z = 5.32$, $p < .001$. When the target was the category prototype and the nontarget was also relatively typical, cues slightly decreased accuracy (from 82.1 to 79.9%), $b = -.18$, 95% CI [−41, .04], $z = 1.61$, $p = .11$), leading to a significant cue-by-trial-type interaction, $b = 0.75$, 95% CI [0.61, 0.89], $z = 10.56$, $p < .0001$. Trial-type was a significant predictor of accuracy on label trials, $b = 0.50$, 95% CI [0.39, 0.61], $z = 9.06$, $p < .0001$. This was because of significantly higher perfor-

Figure 1: Part of a Results section in Forder & Lupyan (2019).

- Any research that involves statistical data analysis will usually contain many figures and tables of statistical results, and also numerous statistical results within the text.
- The goal of reproducible data analysis is that anyone working independently could recreate all of these results exactly.

Necessary criteria for reproducible data analysis

- The following three criteria seem necessary for a given data analysis to be reproducible.
  1. The *raw* data must be available. Data that is processed and "cleaned up" is not sufficient.
  2. All the code for all the analysis must be available. All the code for all the data analysis pipeline is required, as are the scripts and build tools that execute the code.
  3. The reports of the analysis, e.g., journal articles, presentations slides, etc, must be made by *dynamic documents*.
- Gentleman and Temple Lang (2007) introduced the concept of a *research compendium*, which is a single package that contains all of the raw data, all the code for all the data analysis pipeline, and dynamic documents that generate all the final reports.

Software tools for reproducible data analysis

- There are numerous (open source, or freely available) software tools and service that facilitate creating and maintaining of a research compendium. These include the following:
  - RMarkdown (and knitr, pandoc, LaTeX, etc)
  - Git & GitHub
  - Make or Drake (and other build automation tools)
  - Jupyter
  - R packages
  - Docker and virtual machines
  - Git LFS, Git annex, Git fat, etc
- Here, we will deal with just the first item on this list.

What is RMarkdown?

- RMarkdown is an R based dynamic document format. It is used with knitr to generate documents in different formats that combine text with content, including figures, tables, etc., that are dynamically generated by R (or other languages).
- It can be used to create publication ready manuscripts, slides for presentations, scientific posters.
- It, and its variants `bookdown`, `blogdown`, `pkgdown`, etc, can be used to create books, websites, interactive online demos and tutorials, etc.

RMarkdown overview: Example 1

We write source code that is mixture of R code and explanatory text that optionally references the R variables.

````
```{r}
set.seed(101)
N <- 50
mu <- 100
sigma <- 15
x <- rnorm(N, mean=mu, sd=sigma)
```

The mean of a random sample of `r N` numbers,
drawn independently from a normal distribution
with mean `r mu` and standard deviation `r sigma`,
is `r round(mean(x), 2)`.
````

RMarkdown overview: Example 1 (rendered)

When we render this, we'll produce a document (in this case, LaTeX) with both the code and any output and any evaluated variables in the text.

```
set.seed(101)
N <- 50
mu <- 100
sigma <- 15
x <- rnorm(N, mean=mu, sd=sigma)
```

The mean of a random sample of 50 numbers, drawn independently from a normal distribution with mean 100 and standard deviation 15, is 98.14.

RMarkdown overview: Example 2

We may turn off the rendering of the R source code with `echo = FALSE`.

````
```{r, echo=FALSE}
set.seed(101)
N <- 50
mu <- 100
sigma <- 15
x <- rnorm(N, mean=mu, sd=sigma)
```

The mean of a random sample of `r N` numbers,
drawn independently from a normal distribution
with mean `r mu` and standard deviation `r sigma`,
is `r round(mean(x), 2)`.
````

RMarkdown overview: Example 2 (rendered)

Then we get e.g. just the rendered text, but not the R *chunk*.

The mean of a random sample of 50 numbers, drawn independently from a normal distribution with mean 100 and standard deviation 15, is 98.14.

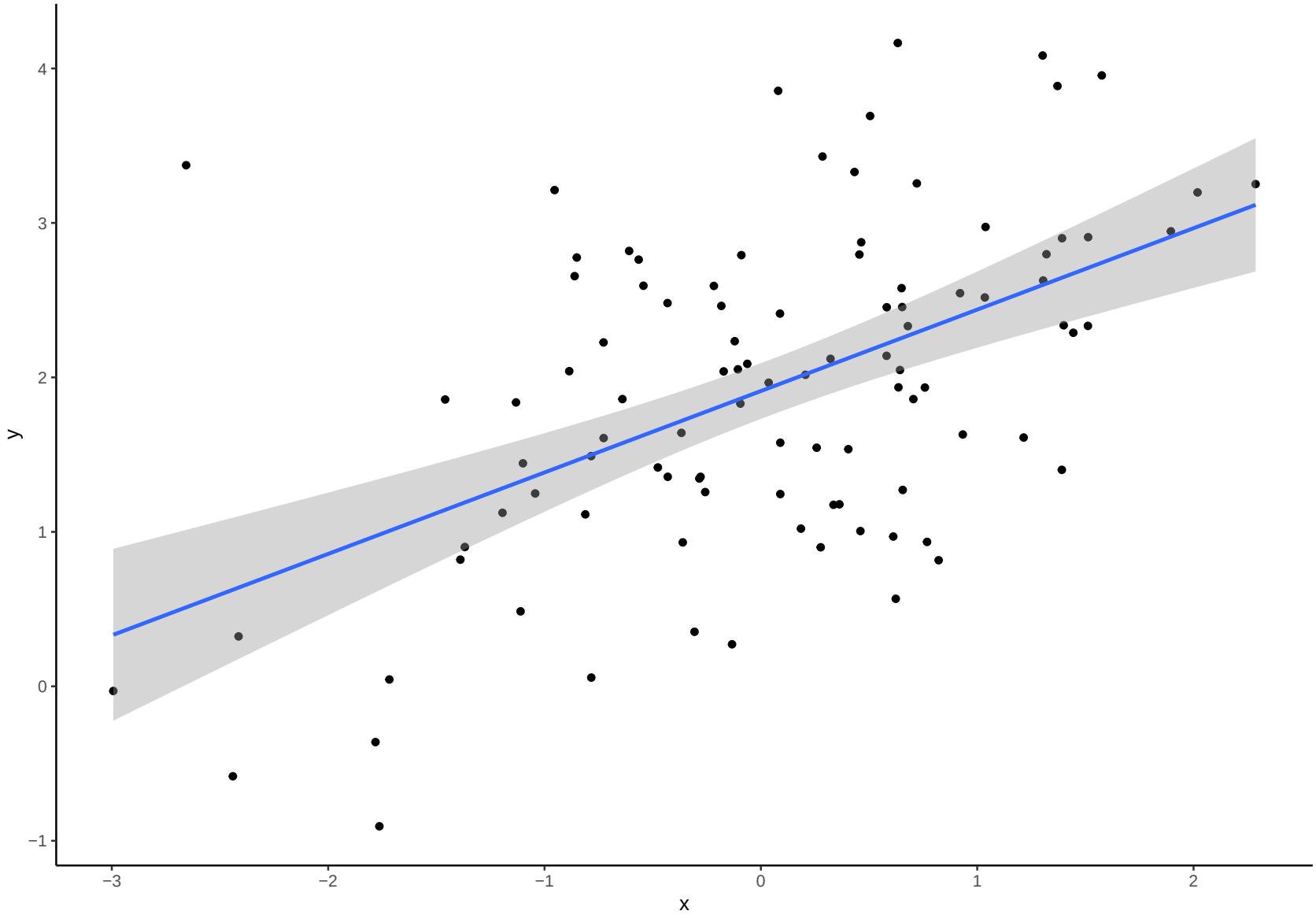
RMarkdown overview: Example 3

Figures will be rendered and inserted into the document in an identical manner.

````
```{r, echo=FALSE}
set.seed(42)
N <- 100
x <- rnorm(N)
Df <- data.frame(x = x,
                 y = 2 + 0.5*x + rnorm(N))
ggplot(Df,
       mapping = aes(x=x, y=y)) +
  geom_point() +
  stat_smooth(method='lm') +
  theme_classic()

```
````

RMarkdown overview: Example 3 (rendered)



RMarkdown overview: Example 4

Likewise, tables from statistical models can be rendered and inserted into the document.

````
```{r, echo=FALSE}
set.seed(42)
N <- 100
x <- rnorm(N)
Df <- data.frame(x = x,
                 y = 0.0 + 0.25*x + rnorm(N))

M <- lm(y ~ x, data=Df)
pander(summary(M))
```
````

RMarkdown overview: Example 4 (rendered)

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.08837	0.09088	-0.9724	0.3333
x	0.2772	0.08767	3.162	0.002089

Table 2: Fitting linear model: y ~ x

Observations	Residual Std. Error	R^2	Adjusted R^2
100	0.9083	0.09255	0.0833

RMarkdown overview: Example 5

RMarkdown allows us to typeset mathematical equations, symbols, etc., just as we would do with LaTeX.

````
```{r, echo=FALSE}
set.seed(42)
N <- 100
x <- rnorm(N)
Df <- data.frame(x = x,
                 y = 0.0 + 0.25*x + rnorm(N))
M <- lm(y ~ x, data=Df)
```


The linear model is
$$
y_i = \alpha + \beta x_i + \epsilon_i,
\quad \text{for $i \in 1 \ldots N$}.
$$

The $R^2$ value is `r round(mean(summary(M)$r.sq),2)`.
````

RMarkdown overview: Example 5 (rendered)

The linear model is

$$y_i = \alpha + \beta x_i + \epsilon_i, \quad \text{for } i \in 1 \dots N.$$

The R^2 value is 0.09.

References

Gentleman, Robert, and Duncan Temple Lang. 2007. "Statistical Analyses and Reproducible Research." *Journal of Computational and Graphical Statistics* 16 (1): 1–23.