

# R Markdown as an Authoring Tool in Linguistics

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*September 16, 2018*

## **Abstract**

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There is an online version of this article with animated figures. To have a better reading experience, visit <https://bit.ly/2D0JtIT> for the article. The source of this article can be found at <https://github.com/liao961120/ling-rmd>.

# 1 Introduction

Authoring is a common task for all scholars and students in academia, from report preparation, teaching, journal submission to book writing. Yet many people in academia aren't familiar with using specialized tools and an integrated workflow for academic writing, especially in the fields of Social science.

Academic writing takes a great deal of time. However, much of the time spent *isn't related to the content or the idea the author wishes to convey* but the chores regarding repetitive works such as manually combining results from different analysis tools or formatting the papers to suit the requirements of journals. A great deal of time can be saved if there exists a recommended and integrated workflow for academic writing, either as a norm or a culture that encourages this. Currently, however, workflows for academic writing are a matter of tastes for different authors and are considered as personal skills. It should be argued that a workflow be proposed in a specific field of science, especially in the fields of Social science, where students often have no formal programming training in building custom programs to facilitate an integrated workflow.

## 1.1 A Non-integrated Workflow

An integrated workflow for academic writing is crucial in science. An example of a common, but not integrated, workflow is illustrated in figure 1:

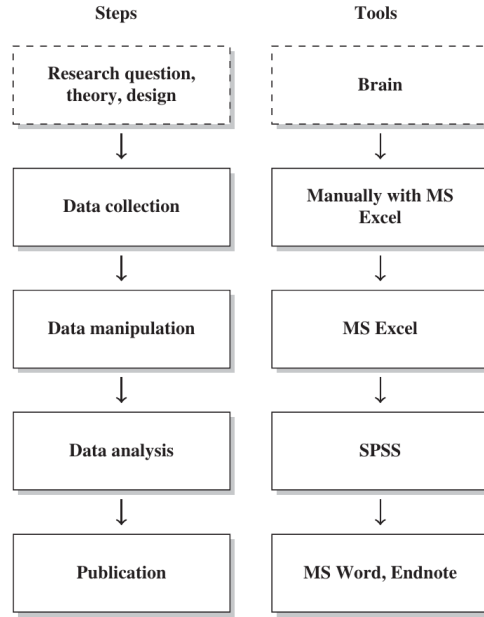


Figure 1: A common but not integrated workflow (Munzert, Rubba, Meißner, & Nyhuis, 2014, pp xviii).

One of the problem of this workflow is that authors have to manually copy-and-paste results from different sources, which are error-prone, and when errors are found, authors have to go through the process again, wasting substantial time. An even more serious problem related to this workflow is that it can hinder the progress of science, since when errors occurred but are not found, erroneous results enter a published paper, in which subsequent researches might base on.

Facilitating an integrated workflow for academic writing is related to specific tasks a field often does. Hence, no preexisting tools exist. However, general frameworks exist and are extendable and customizable to fit the specific needs of a field. This article surveys the R Markdown ecosystem and focuses particularly on features related to Linguistics in order to propose a integrated workflow for authoring.

## 2 Overview of R Markdown

### 2.1 A Brief Introduction

“Markdown” is a minimalist and easy-to-learn markup language<sup>1</sup>, which formats the text by using plain text markers, e.g., lines beginning with “#” are first level titles and “##” are second level titles, wrapping text with “\*” results in italics, etc. “R Markdown” extends the syntax of Markdown to allow more versatile styling of the text and therefore allows authoring documents with publication-ready qualities.

### 2.2 Benefits of Using R Markdown

There are several benefits for using R Markdown as an authoring tool. Most of them results directly from the extensibility of R, the language R Markdown bases on.

#### 2.2.1 R

R is a programming language developed not in a traditional CS<sup>2</sup>-context but for the purpose of statistical computing (R Core Team, 2018). This makes R a special language – although R has a steep learning curve compared to other GUI-based statistical softwares, it has a gentle learning curve compared to other “hardcore” programming languages. R is designed for scientists, not programmers. In addition, there is a huge and friendly community support for R, which means solutions to many problems new users often confront can easily be found on the web.

Many fields other than statistics either start to or already use R substantially, such as Biostatistics and

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<sup>1</sup>Markup languages are used to style text appearance. For example, HTML (Hyper Text Markup Language) is one of the most popular markup language, which is used to format web pages.

<sup>2</sup>Abbreviation of “Computer science”.

Bioinformatics, Ecology and Evolution, Finance, Psychometrics, Geospatial analysis, and even Linguistics (CRAN, 2018b). This is due to R's great extensibility, with more than 13,000 packages hosted on CRAN (2018a). As noted later, this extensibility also enables turning R Markdown into a specialized tool for authoring in Linguistics.

By integration with R language, R Markdown allows computed results be directly embedded into the document. To put it another way, the analysis of data (through R) is directly integrated into document writing, and hence, errors incurred by manual copy-and-pasting are eliminated. This also enhance the *reproducibility* of the workflow (Baumer, Cetinkaya-Rundel, Bray, Loi, & Horton, 2014), since every time the document is generated from R Markdown, the underlying code for data analysis is rerun to generate the embedded output. Generating the document is essentially reproducing the analysis of data.

### **2.2.2 Supporting Reproducibility**

A Reproducible analysis is an analysis with results that can be guaranteed to be reproduced from raw data anywhere by anybody (Berez-Kroeker et al., 2018). Besides rerunning analysis to generate results every time, two other features make R Markdown a good tool for facilitating a reproducible workflow:

#### **1. R Markdown is plain text**

Plain text format, contrary to binary files such as MS<sup>3</sup> Word, doesn't require specialised (and often propriety) software to open, hence facilitates the openness of science. Plain text format also makes the file easier to "version control", i.e, keeping the history of modifications, or versions, of the file by version control softwares.

#### **2. Python support**

The new R package reticulate (Allaire, Ushey, & Tang, 2018) enhances the ability of Python integration in R. It is now possible to run Python in R console. The new Python engine enabled by

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<sup>3</sup>Abbreviation of "Microsoft".

reticulate also solved a major drawback in previous versions of R Markdown – Python variables are shared across different code chunks, i.e., Python code chunks share states in R Markdown. This gives R Markdown similar power to Jupyter notebook.

Integrating R and Python is especially important for Linguistics, as many actively developed packages and libraries for Linguistics are written in Python. For example, the famous phonetic software, Praat (Boersma, 2002), has a third-party support in Python, which allows accessing low-level functions in Praat using Python syntax (Jadoul, Thompson, & de Boer, 2018).

Some tasks that R certainly does better than Python are data manipulation, statistical analysis, visualization, and report generation, hence, integrating R and Python combines the strengths of both languages. An analysis can be done in R, Python, or both. R Markdown can then act as a “glue”, combining different parts of analysis together into an integrated and reproducible whole.

### **2.2.3 Wide Range of Output Formats and Styles**

R Markdown supports a variety of output formats, owing to its foundation, Pandoc (MacFarlane, 2013). Some of the supported formats are MS Word, MS Powerpoint, LaTeX, PDF, and HTML. There are also multiple styles of document support, such as slides, books (Xie, 2016), journal papers<sup>4</sup>, and even websites or blogs (Xie, Hill, & Thomas, 2017). This large variety of output formats enables authors to publish their works through different formats with the same underlying R Markdown file.

#### **2.2.3.1 HTML Support**

It can be argued that the most prominent output format of R Markdown is HTML. In the Digital Age, the web becomes a popular, if not dominant, way to distribute publications. Web pages enable displaying

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<sup>4</sup>For a list of supported journal templates, see <https://github.com/rstudio/rticles>.

more varieties of contents, such as GIFs (animated figures) and tables with search bars, thus enhancing the ability to convey ideas.

With research becoming more complex, traditional medium might not be enough to present the results. For example, it might be useless to display a complex 3D graph in a static PDF. Using GIF, however, can facilitate the visualization of complex 3D graphs by using animation to rotate 3D objects in the graphs. Using HTML output thus enhances communication with the readers – the explanatory text is written next to dynamic visual elements, rather than links to external files or web pages.

Using HTML outputs also enables authors to self-publish the content through the web, making resources available to a wider audience. This is especially useful for educational purposes.

## **2.3 Making R Markdown Suitable for Linguistics**

The power of R Markdown as an authoring tool that facilitates an integrated workflow in Linguistics comes from R's extendibility. By using R extensions, or R packages, R Markdown can be turned into a specialized tool for writing Linguistics-related documents. Below introduces several examples that reduce the burden of writing Linguistics-related documents in R Markdown.

### **2.3.1 Bibliographies and Citations**

It is necessary to insert citations when writing articles for journal submission, and many use EndNote, a reference management software, together with MS Word to accomplish this. R Markdown has native support for inserting and formatting citations and bibliographies, using a citation syntax provided by Pandoc (RStudio, 2018). With R's extendibility, the experience of inserting citations can become more comfortable. For example, the R package *citr* (Aust, 2017) lets authors insert citations through a GUI interface, where authors can search information (author, year, titles, etc.) about the articles they want to insert. This

extension makes the experience of inserting citations and references in R Markdown similar to that of using EndNote with MS Word.

citr integrates well with Zotero<sup>5</sup>, a free and open-source reference management software similar to EndNote. The citation and bibliography format is automatically styled based on the provided csl file<sup>6</sup>.

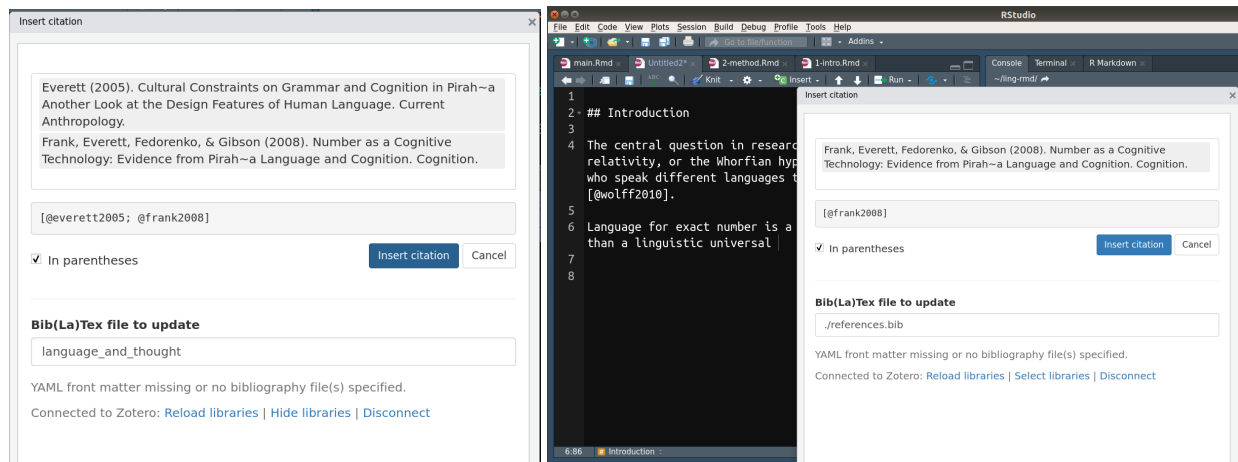


Figure 2: Using citr with R Markdown.

## 2.3.2 Inserting IPA Symbols

Problem often arise when inserting IPA symbols into documents, since there is no simple way to type IPA symbols with the keyboard. The author of this article created a package to deal with this problem. linguisticsdown (Liao, 2018) makes it possible to type IPA symbols by searching their phonetic descriptions, such as “plosive”, “bilabial”, “aspirated” etc., or by using the X-SAMPA input method (Wells, 1995). With this extension, authors can write documents containing IPA symbols with ease.

<sup>5</sup><https://www.zotero.org/>

<sup>6</sup>Citation Style Language. See <https://citationstyles.org/> for details. For supported citation formats, see <https://github.com/citation-style-language/styles>.



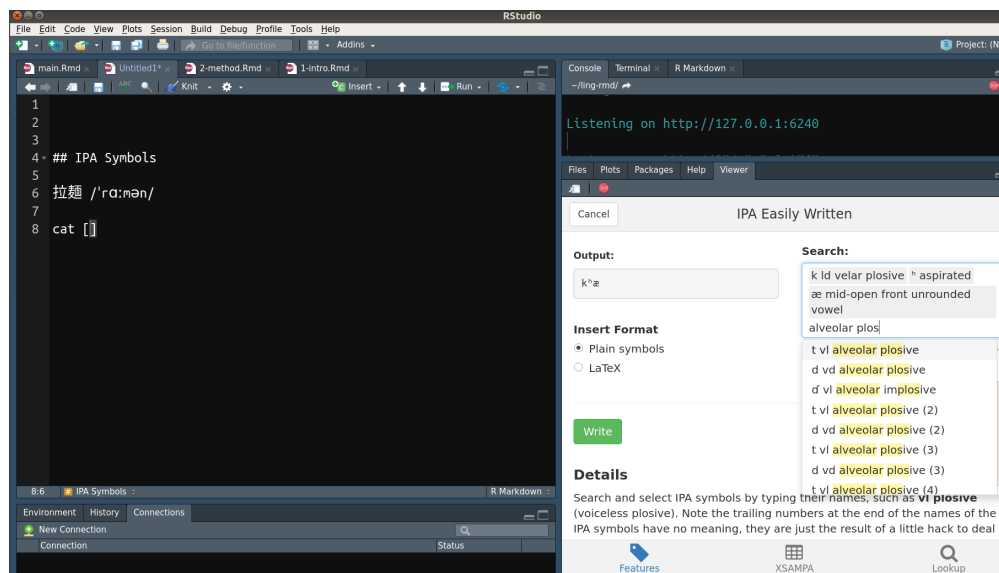


Figure 3: Using linguisticsdown with R Markdown.

### 2.3.3 Using Templates

As suggested previously, R Markdown can output formats meeting the requirements of journal submission. Authors can thus write documents with the simple R Markdown syntax without worrying about the typesetting. Currently, officially supported journal templates<sup>7</sup> are mostly journals under big publishers such as Elsevier, Springer, and SAGE. The support can be extended, however, as long as there are LaTeX template provided. For example, thesisdown (Ismay, 2016/2018) provide an R Markdown template for writing thesis at Reed College, and several other thesis templates based on thesisdown modified it to fit their institutions' needs.

<sup>7</sup>For a list of supported journal templates, see <https://github.com/rstudio/rarticles>.

### 3 A Proposed Workflow

Figure 4 illustrates the flow of text (for readers) and data (for analysis) processing in R Markdown. Based on figure 4, authors can do the following to achieve an integrated workflow and don't need to navigate around several softwares during authoring:

1. Put R or Python code that clean, manipulate, and analyze data in the R Markdown source file. If there are too many code, put them in separated R or Python scripts and include them into R Markdown by using “source functions”. For even more complex analyses, use the structure of *R Package* as a basis for project management, in which documentation of data sets and functions<sup>8</sup>, raw data, and reports can be put together into a well-structured package (Flight, 2014; H. Wickham, 2015).
2. Put R code that generate figures or tables in the R Markdown source file, making it easy to see how they were generated.
3. For values that can be computed from data and needed to be included as inline text in the document, save them as R variables and put them inline with special syntax. For example, use  $p$ -value = ‘r p\_val’. The variable p\_val will be converted to the value when the output document is generated. Hence, when data changes (e.g. addition of new data) or the analysis code are modified, the value of the variable p\_val gets automatically updated as well.
4. Use citr to search and insert citations.
5. Use linguisticsdown to type IPA symbols.

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<sup>8</sup>For complex analyses, there are often long and repetitive code. Wrapping these redundant code into functions can make the analyses more manageable.

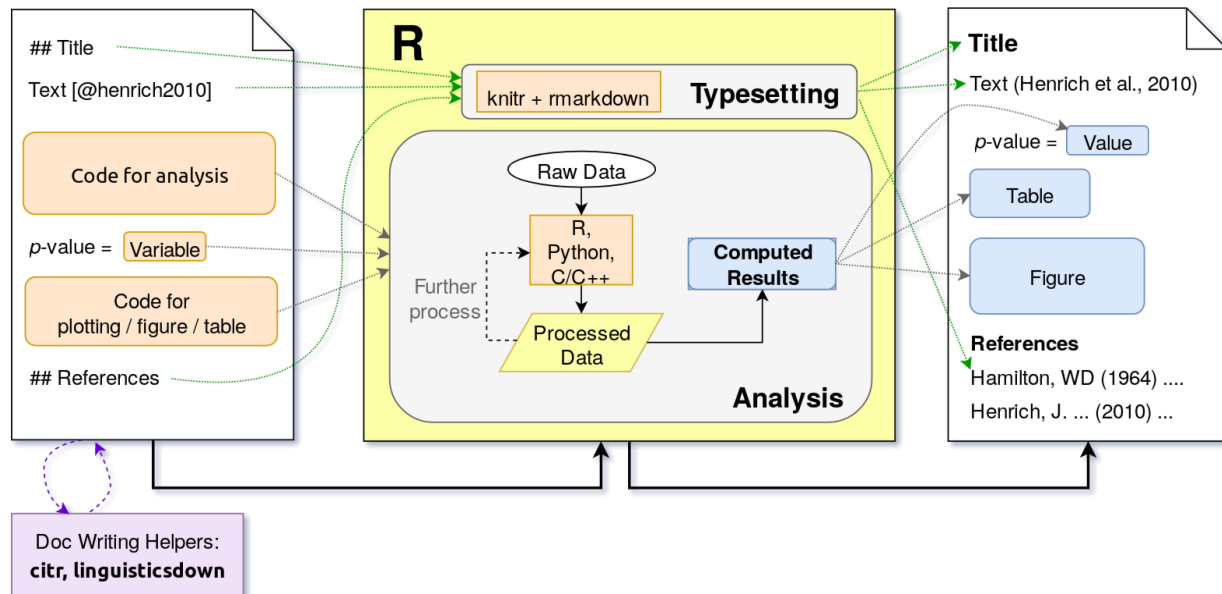


Figure 4: Combining R's data analysis and typesetting abilities to generate a reproducible report. The leftmost is a representation of an R Markdown source file; the rightmost is a generated document. The middle is the process underlying the conversion from source file to output document. For documents with complete template support, the typesetting is automated, so authors only need to focus on analysis and contents of the article.

## 4 Discussion

The nature of R, a programming language, lend itself to facilitating reproducibility, since writing down the analysis as *code* is essentially *recording every step of the analysis*.

R Markdown fully harnesses the capabilities of R language, not only R's ability in dealing with data but also its ability to typesetting documents. Putting these two features together makes R Markdown a powerful tool for scientific authoring.

### 4.1 Limitations

#### 4.1.1 Template Support

There are some limitations however. For complete template supports, such as templates provided by the package *rticles* (Allaire et al., 2018), R Markdown can be used in an integrated fashion, from dealing with data to typesetting, without additional manual setup. For partial template supports, i.e, native LaTeX templates exist but are not modified to work natively in R Markdown, it can be extended to fully support R Markdown without too much efforts.

However, there are instances where no LaTeX templates exists. For example, the *Chinese Journal of Psychology* doesn't provide any template and only accepts submission in MS Word format. This problem can be fixed by using the MS Word output (.docx) provided by R Markdown. A Word template can also be set up manually (Layton, 2015) in advance, so the output format complies the one set in that template. Formatting thus has to be done only once in the Word template.

#### **4.1.2 Extension Specific to Linguistics**

R Markdown's capability depends on the R community. With more packages being developed, R Markdown becomes more powerful. The number of users in a field matters as well, with more users comes more demand of functionalities, and hence more volunteers creating new packages to meet the needs.

There are few supports of R and R Markdown related to Linguistics, except for fields like Text Mining and Natural Language Processing. To make R Markdown an authoring tool more suitable for Linguistics, a larger userbase is needed. Linguists familiar with R can also make functions that they used regularly available to others by bundling the functions into a package.

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