Recursive Wordle Solver

A reproducible R tutorial

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Introduction

Why use R to write reproducible reports?

Writing an entire report in R has a significant learning curve, but comes with many payoffs later down the line. For example, during the review process, analysis pipelines may change several times. This requires reported values and figures to be updated everywhere they appear, potentially leading to errors and discrepancies between the published results and the actual analysis that took place.

A report written in R can be published along with all the source code used to generate it, so that anyone can see exactly how you reached your results and reproduce everything for themselves, using either your data or their own. Whilst closed-source, proprietary software like MATLAB can be powerful tools in specific use-cases, they can present a significant roadblock to open science practices if used out of convenience rather than necessity.

Some initial reproducibility tips

`contents.R`

- The main script in each project is often named `contents.R`
- It is used to call all other project scripts in the correct order
  - Running this script will run your entire analysis, even generating your figures and finished article if desired
  - With descriptive filenames, it's easy to see what's going on in your analysis at a high level
- Each script called by `contents.R` should be as self-contained as possible
  - In practice, this means tidying up unnecessary variables at the end of every script, and not calling functions and variables from other scripts
- Initially clearing memory is optional, but helpful to avoid accidentally writing code that depends on variables that aren't produced inside the project itself, or are referenced before assignment in the code

`setwd()` vs. R Projects

It is common to see R scripts start with a call to `setwd()`, setting R's working directory to the directory of the main script. Whilst this does achieve the desired behaviour, it is far more optimal to create an R project instead.

- `setwd()` usually uses a hard-coded directory specific to the user's machine
- R projects are directory-agnostic and can store workspace images
- Can set up git with an R project for integrated version control

Loading libraries

- `config/libraries.R` checks for required packages and installs any missing ones
- It is useful to document which packages are used in which scripts, so that any redundant packages can be cleared out before making the code available to others
- Packages like `renv` can be used in situations where reproducibility is critical
- `renv` is similar to python's virtual environments `venv`, where dependencies are rolled up into a self-contained unit separate from the user's specific installation of R
- This means the code is less likely to break if run on different machines with different versions of R and R packages
- Note: `renv` uses static code analysis to detect package dependencies, so will not work with the custom package loading used in this project's `libraries.R` script; use `library()` instead

Reading data

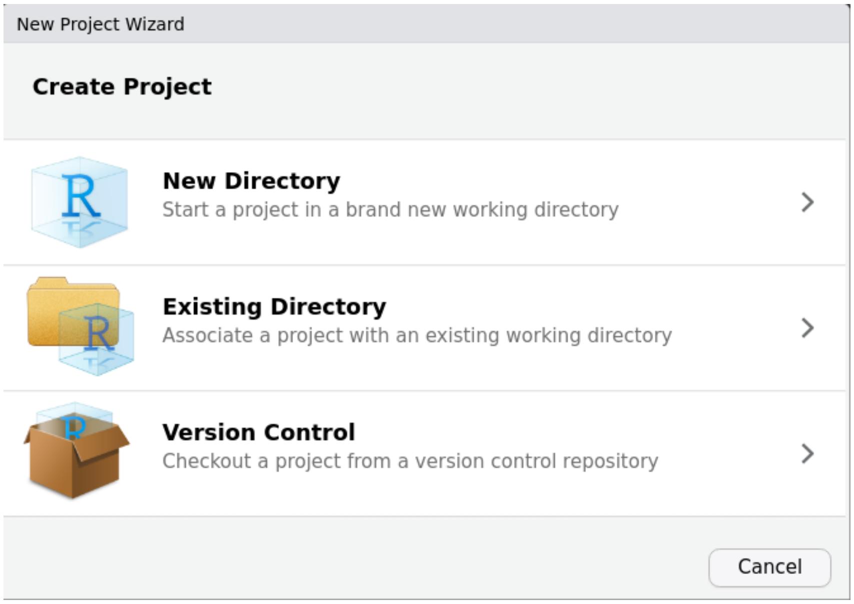
- The `data/` folder contains any data files used in the project
- This could be raw data which is then transparently cleaned in R, or – in cases where this is not appropriate or feasible – data that has been cleaned in a separate script/program (e.g., Fieldtrip)
- `src/` is the source code folder where most of your scripts will live
- The first script called after `config/libraries.R` is usually `src/read_data.R` to read all your raw data files into R
- Depending on how much reformatting and cleaning is required, you may include a separate script (or even folder of scripts) dedicated to this, or simply do it all in `read_data.R` if there is only a trivial amount required

Example Project: Recursive Wordle Solver

Initial Setup

Creating a new project

- You can choose to start a project in a new or existing directory, or provide a URL to a repository hosted online (e.g., GitHub)



New Project Wizard

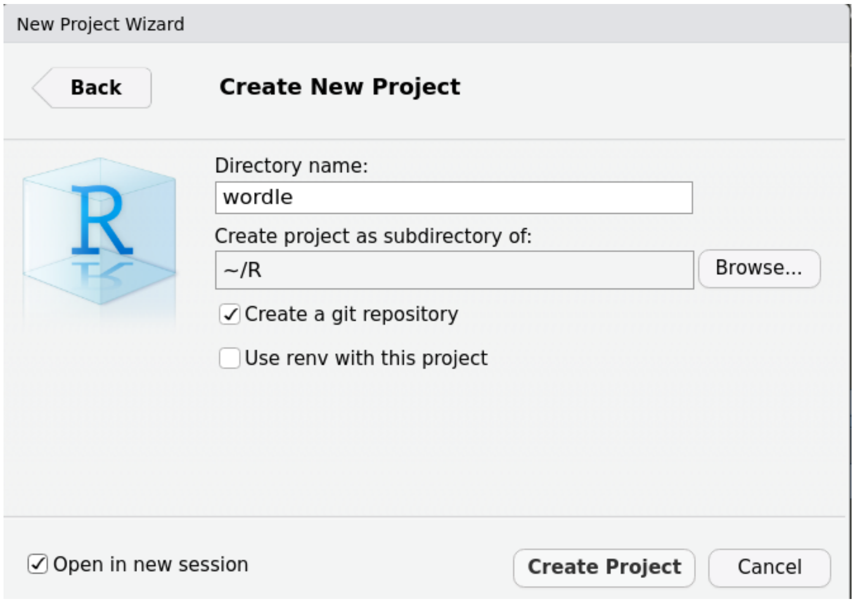
Create Project

New Directory
Start a project in a brand new working directory

Existing Directory
Associate a project with an existing working directory

Version Control
Checkout a project from a version control repository

- This project was created in a new directory with a git repository setup alongside it
  - It is also advisable to open in a new session to clear your workspace and any loaded packages



New Project Wizard

Create New Project

Directory name: wordle

Create project as subdirectory of: ~/R

☑ Create a git repository

☐ Use renv with this project

☑ Open in new session

Libraries

- `tidyverse` is a collection of packages which greatly improve upon the basic functionality of R, and is usually worth loading at the start of every new project

- `magrittr` is a handy `tidyverse` package, but is not loaded by default when `library('tidyverse')` is called; it contains the very useful `%<>%` assignment pipe operator

Word list

```
source('src/read_data.R')

print(head(words$split))
```

```
##      [,1] [,2] [,3] [,4] [,5]
## [1,] "a"  "a"  "h"  "e"  "d"
## [2,] "a"  "a"  "l"  "i"  "i"
## [3,] "a"  "a"  "r"  "g"  "h"
## [4,] "a"  "a"  "r"  "t"  "i"
## [5,] "a"  "b"  "a"  "c"  "a"
## [6,] "a"  "b"  "a"  "c"  "i"
```

- We first load the raw Wordle word list from `data/word_list.txt`
- This list is then split into a character matrix for easier data handling
  - Don't hard-code values! If they release Wordle 2 next week using 6+ letters instead of 5, this entire project should run without changing a single thing beyond the word list

Letter Frequencies

- Expensive computations can be cached to speed up runtime next time `knitr::knit()` is called to generate a .pdf from the .rmd file
- We can use `knitr::kable()` to neatly format R data structures into tables

```
source('src/frequency_tables.R')

# Create desired matrix
df = do.call(cbind, rev(frequencies))

# Format to table and add column names
knitr::kable(df, col.names = c(paste0('Position ', 1:n[2]), 'Total'))
```

	Position 1	Position 2	Position 3	Position 4	Position 5	Total
a	737	2263	1236	1074	680	5990
b	909	81	335	243	59	1627
c	922	176	392	411	127	2028
d	684	84	390	471	823	2452
e	303	1628	882	2327	1522	6662
f	598	24	178	233	82	1115
g	638	76	364	423	143	1644
h	489	546	120	235	370	1760
i	165	1383	1051	880	280	3759
j	202	11	46	29	3	291
k	376	95	272	503	259	1505
l	577	699	848	771	476	3371
m	693	188	511	402	182	1976
n	325	345	963	788	530	2951
o	262	2095	993	698	389	4437
p	859	231	364	418	147	2019

	Position 1	Position 2	Position 3	Position 4	Position 5	Total
q	78	15	13	2	4	112
r	628	940	1198	719	673	4158
s	1565	93	533	516	3958	6665
t	815	239	616	898	726	3294
u	189	1187	667	400	67	2510
v	242	52	240	156	4	694
w	413	163	271	128	64	1039
x	16	57	133	12	70	288
y	181	271	213	108	1301	2074
z	105	29	142	126	32	434

```r
# Clean up
rm(df)
```

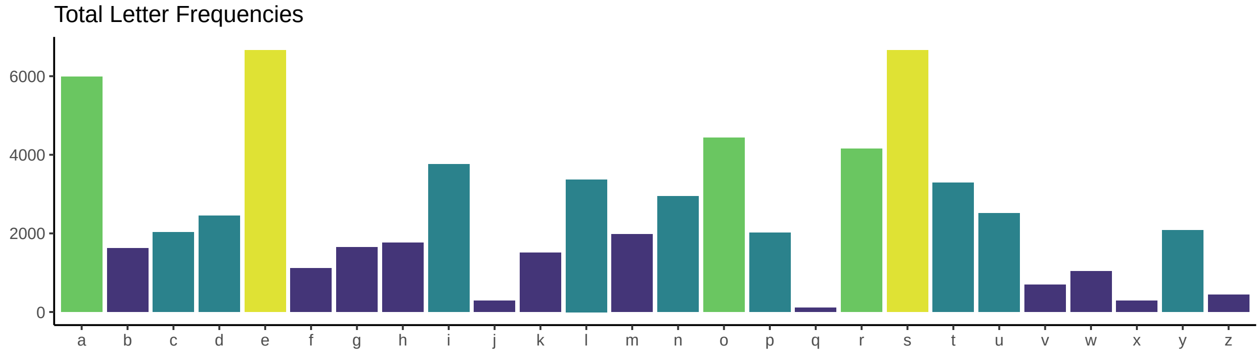
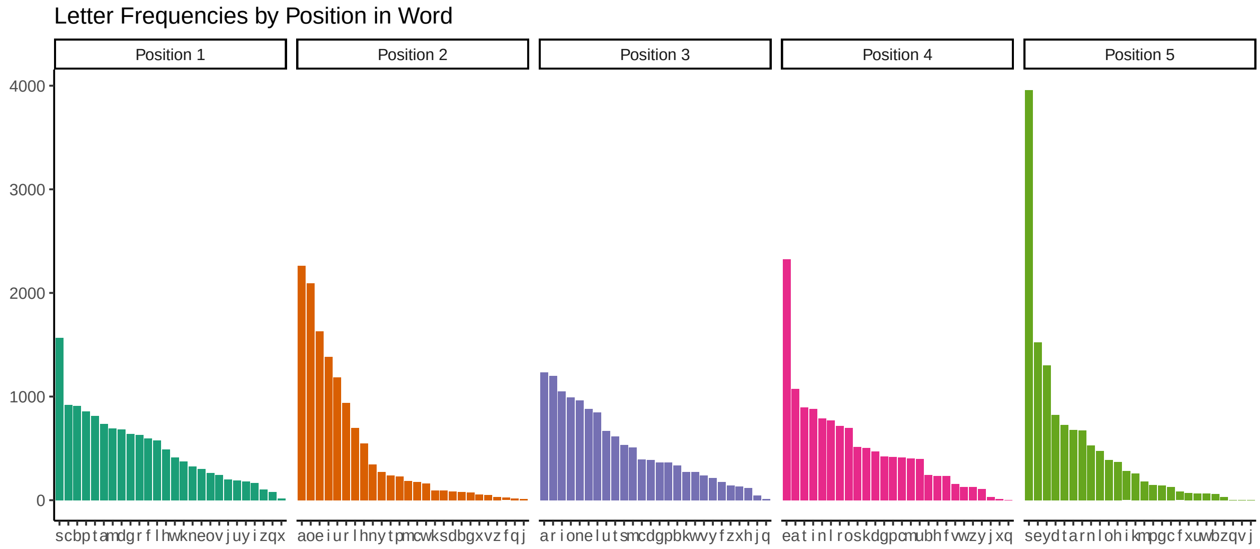
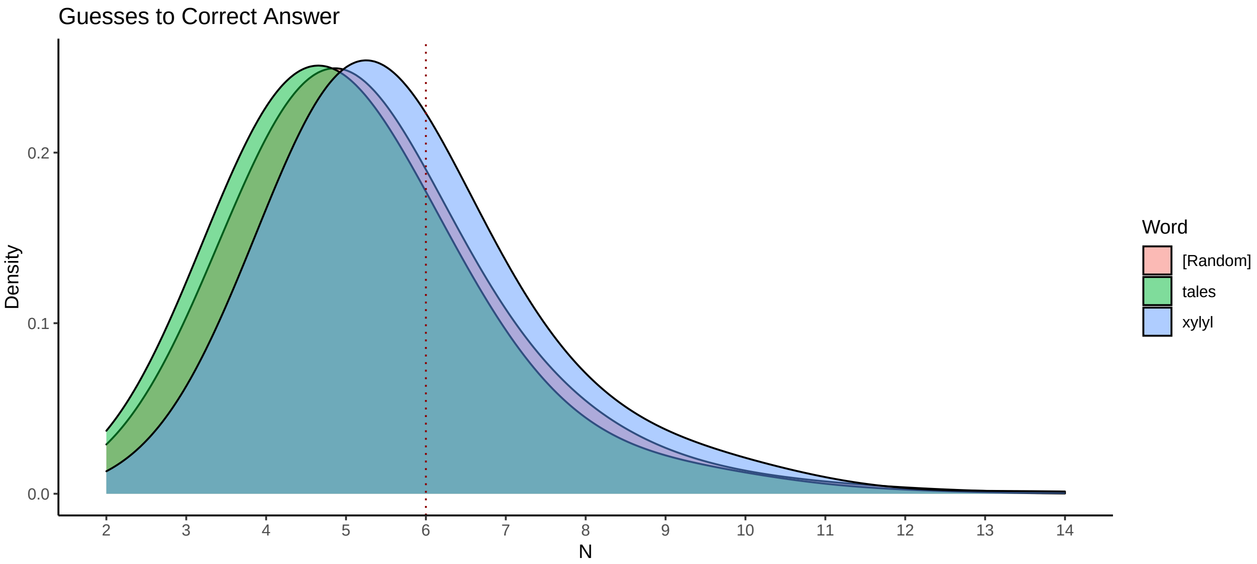


Figure 1:



- Here we have plots of the total and positional letter frequencies over the entire Wordle word list
- Any changes in the script will be updated in the plot
- Figure properties can be set in the chunk header e.g., `{r chunk-title, fig.height=3}`
- RMarkdown can create links to figure captions[1] and headings



#TODO: Bootstrapping and data caches, simulated guess distribution plots