

Implementing reproducibility in phonetic research: a computational workflow

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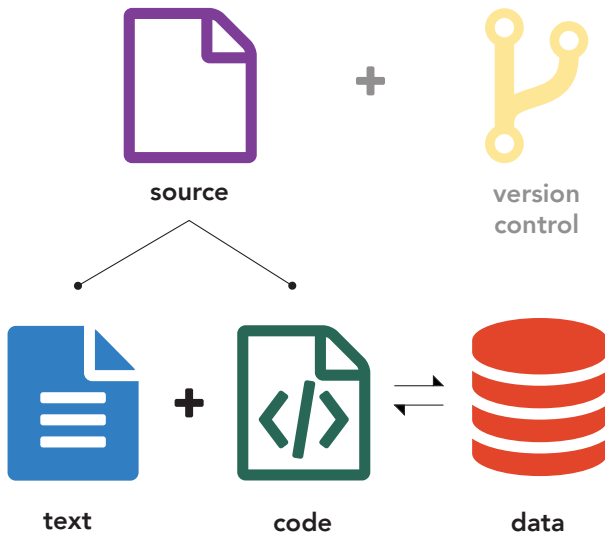
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Reproducible research

computational environment +
steps to reproduce the results +
results =

Reproducible Research

Reproducible research



Why should we care?

The **problem** (Sandve et al. 2013):

- difficulty of reproduction
- difficulty of replication
- retracted papers (<http://retractionwatch.com>)

The “Yokuts vowels” case (Weigel 2002):

- about **75%** of the data is contrived (Weigel 2005:149)
- some of the generalisations are **wrong** (Blevins 2004)

The **solution**:

- **Reproducible Research** (RR)

Reproducible Research in linguistics

- **linked data** (Bird & Simons 2003, Thieberger 2004)
- **computational grammar** (Maxwell & Amith 2005)
- RR in the Speech Sciences (Abari 2012)
 - lack of scientific culture
 - inefficiency of infrastructure

The workflow of phonetic research

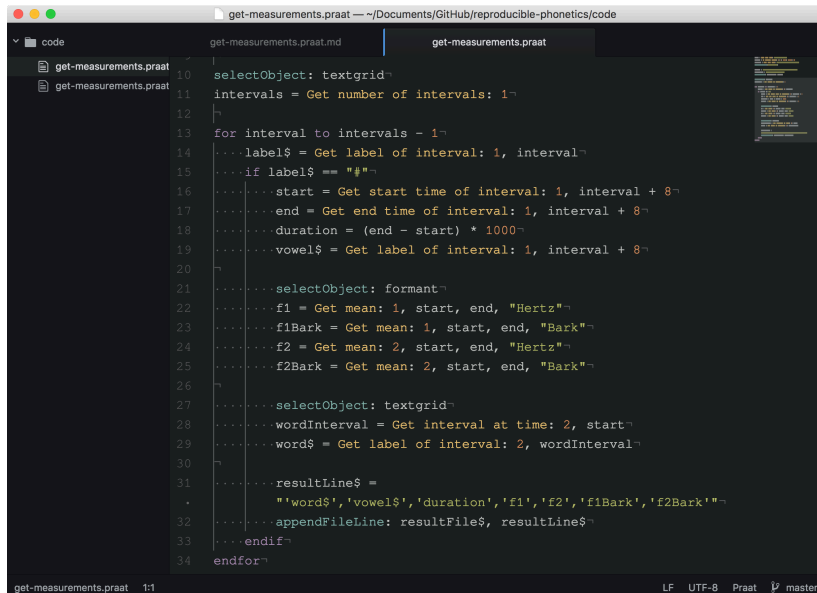
- **Phase A:** scripting (Praat)
- **Phase B:** results and analysis
- **Phase C:** dissemination

Phase A: source code and documentation

Praat scripting:

- Atom editor (<https://atom.io>)
 - syntax highlighting
 - snippets
- Literate Markdown
 - tangle: lmt (<https://github.com/driusan/lmt>)
 - weaving: pandoc (<http://pandoc.org>)

Atom

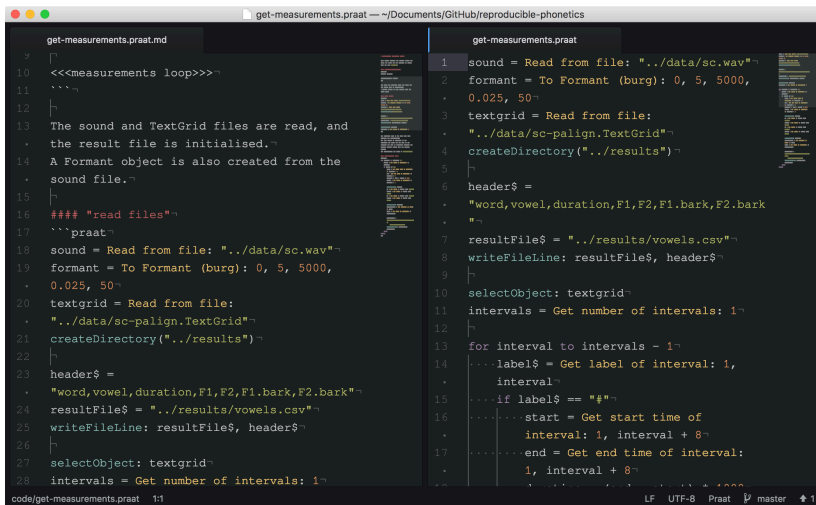


The screenshot shows the Atom text editor interface. The title bar indicates the file is 'get-measurements.praat' located at '~/Documents/GitHub/reproducible-phonetics/code'. The left sidebar shows a file explorer with 'code' expanded, containing two files: 'get-measurements.praat' and 'get-measurements.praat.md'. The main editor area displays the Praat script code for 'get-measurements.praat'.

```
get-measurements.praat
10 selectObject: textgrid
11 intervals = Get number of intervals: 1
12
13 for interval to intervals - 1
14   ...label$ = Get label of interval: 1, interval
15   ...if label$ == "#"
16     ...start = Get start time of interval: 1, interval + 8
17     ...end = Get end time of interval: 1, interval + 8
18     ...duration = (end - start) * 1000
19     ...vowel$ = Get label of interval: 1, interval + 8
20   ...
21   ...selectObject: formant
22   ...f1 = Get mean: 1, start, end, "Hertz"
23   ...f1Bark = Get mean: 1, start, end, "Bark"
24   ...f2 = Get mean: 2, start, end, "Hertz"
25   ...f2Bark = Get mean: 2, start, end, "Bark"
26   ...
27   ...selectObject: textgrid
28   ...wordInterval = Get interval at time: 2, start
29   ...word$ = Get label of interval: 2, wordInterval
30   ...
31   ...resultLine$ =
32     ..."word$', 'vowel$', 'duration', 'f1', 'f2', 'f1Bark', 'f2Bark'"
33   ...appendFileLine: resultFile$, resultLine$
34   ...endif
35 endfor
```

The status bar at the bottom shows 'get-measurements.praat 1:1' on the left and 'LF UTF-8 Praat master' on the right.

lmt (iterate markdown tangler)



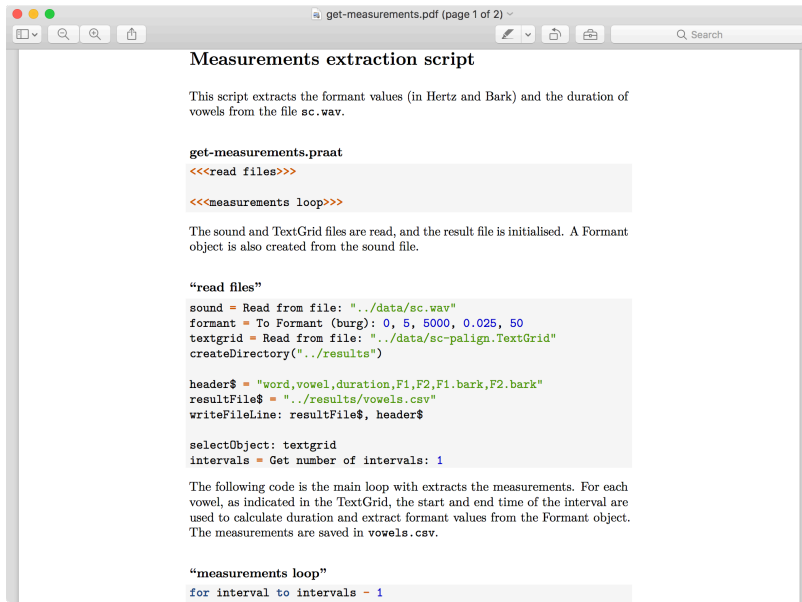
The screenshot shows a code editor with two panes. The left pane displays a Praat script named 'get-measurements.praat.md' with line numbers 10 through 28. The script contains comments in markdown format and Praat code. The right pane displays the same script as 'get-measurements.praat', showing the raw Praat code with line numbers 1 through 28. The status bar at the bottom indicates 'code/get-measurements.praat 1:1' on the left and 'LF UTF-8 Praat master' on the right.

```
get-measurements.praat.md
10 <<<measurements loop>>>
11 ```
12 |
13 The sound and TextGrid files are read, and
14 the result file is initialised.
15 |
16 A Formant object is also created from the
17 sound file.
18 |
19 ##### "read files"
20 ```praat
21 sound = Read from file: "../data/sc.wav"
22 formant = To Formant (burg): 0, 5, 5000,
23         0.025, 50
24 textgrid = Read from file:
25         "../data/sc-align.TextGrid"
26 createDirectory("../results")
27 |
28 header$ =
29         "word,vowel,duration,F1,F2,F1.bark,F2.bark"
30 resultFile$ = "../results/vowels.csv"
31 writeFileLine: resultFile$, header$
32 |
33 selectObject: textgrid
34 intervals = Get number of intervals: 1
```

```
get-measurements.praat
1 sound = Read from file: "../data/sc.wav"
2 formant = To Formant (burg): 0, 5, 5000,
3         0.025, 50
4 textgrid = Read from file:
5         "../data/sc-align.TextGrid"
6 createDirectory("../results")
7 |
8 header$ =
9         "word,vowel,duration,F1,F2,F1.bark,F2.bark"
10 resultFile$ = "../results/vowels.csv"
11 writeFileLine: resultFile$, header$
12 |
13 selectObject: textgrid
14 intervals = Get number of intervals: 1
15 |
16 for interval to intervals - 1
17     label$ = Get label of interval: 1,
18             interval
19     if label$ == "#"
20         start = Get start time of
21                 interval: 1, interval + 8
22         end = Get end time of interval:
23               1, interval + 8
24         writeFileLine: resultFile$, label$
25         start, end, duration, F1, F2, F1.bark, F2.bark
26     end
27 |
28 
```

code/get-measurements.praat 1:1 LF UTF-8 Praat master ↗ 1

pandoc (universal document converter)



The screenshot shows a PDF viewer window titled "get-measurements.pdf (page 1 of 2)". The document content is as follows:

Measurements extraction script

This script extracts the formant values (in Hertz and Bark) and the duration of vowels from the file `sc.wav`.

get-measurements.praat

```
<<<read files>>>

<<<measurements loop>>>
```

The sound and TextGrid files are read, and the result file is initialised. A Formant object is also created from the sound file.

“read files”

```
sound = Read from file: "../data/sc.wav"
formant = To Formant (burg): 0, 5, 5000, 0.025, 50
textgrid = Read from file: "../data/sc-align.TextGrid"
createDirectory("../results")

header$ = "word,vowel,duration,F1,F2,F1.bark,F2.bark"
resultFile$ = "../results/vowels.csv"
writeFileLine: resultFile$, header$

selectObject: textgrid
intervals = Get number of intervals: 1
```

The following code is the main loop with extracts the measurements. For each vowel, as indicated in the TextGrid, the start and end time of the interval are used to calculate duration and extract formant values from the Formant object. The measurements are saved in `vowels.csv`.

“measurements loop”

```
for interval to intervals - 1
```

Phase B: the speakr package

speakr is an R package to aid Praat users (under development):

- aim: tangle and run Praat scripts from within R
- two main functions
 - `lmt()`: tangle a Praat script
 - `praatRun()`: run a Praat script

Phase B: the speakr package

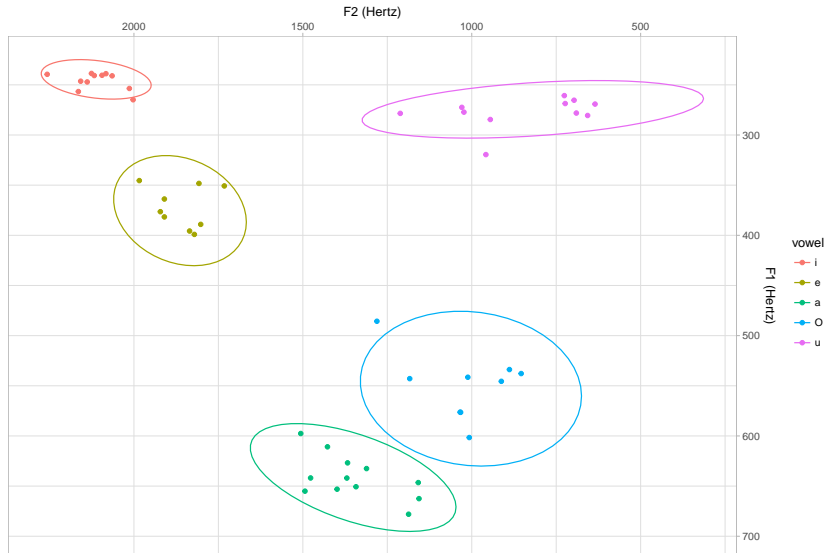
```
# Tangle a Praat script
lmt("code/get-measurements.praat.md")

# Run the script
praatRun("code/get-measurements.praat")

# Read the results of the script
vowels <- read_csv("results/vowels.csv") %>%
  mutate_if(is.character, as.factor) %>%
  mutate(vowel = factor(vowel, c("i", "e", "a",
                                "O", "u")))
```

Phase B: the speakr package

Vowel plot of one speaker of Italian



Phase C: dissemination

- knitr (Xie 2014)
 - dynamic reports
 - reproducible documents
- GitHub (<https://github.com>)
 - versioning system (git)
 - online repository
- Open Science Framework (<https://osf.io>)
 - online repository (for data)

Summary

- what is RR
- RR in linguistics
- computational workflow for phonetic RR

References I

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- Xie, Yihui. 2014. knitr: A comprehensive tool for reproducible research in R. In Victoria Stodden, Friedrich Leisch & Roger D. Peng (eds.), *Implementing reproducible computational research*, Chapman and Hall: CRC.