

# Implementing reproducibility in phonetic research: a computational workflow

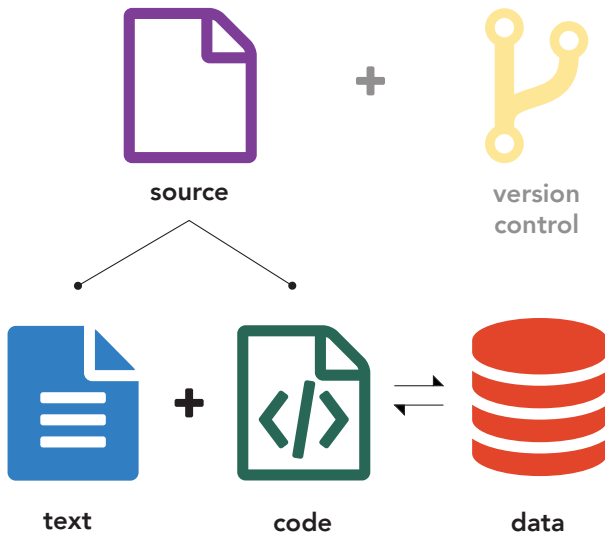
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# Reproducible research

A piece of research is **reproducible** when, along with its *results*, the *data* and the *computational environment* that produced those results are made available to other researchers (Fomel & Claerbout 2009).

# Reproducible research



# Why should we care?

The **problem** (?):

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

The “Yokuts vowels” case (Weigel 2002):

- about **75%** of the data is contrived (?: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

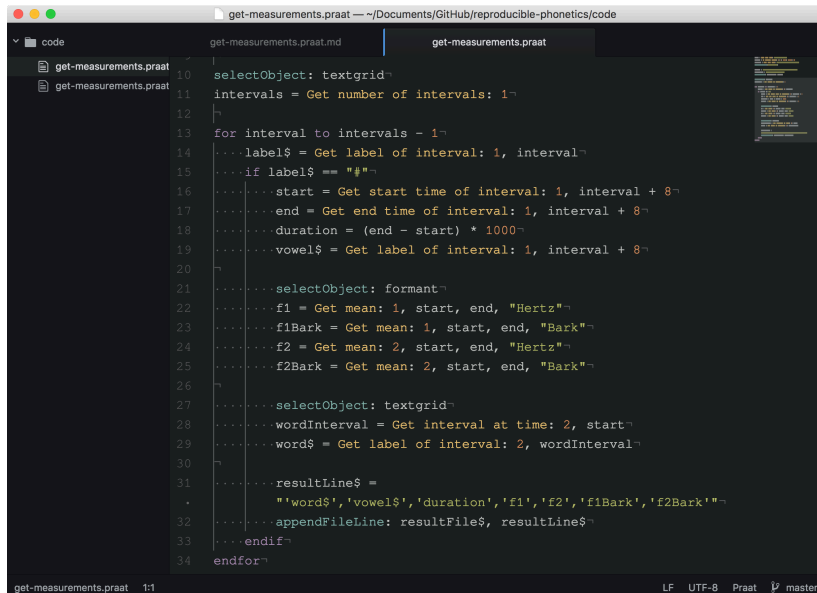
- **Phase A:** scripting (Praat, Boersma & Weenink (2016))
- **Phase B:** results and analysis
- **Phase C:** dissemination

# Phase A: source code and documentation

Praat scripting:

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

# Atom



The screenshot shows the Atom code editor with a file named 'get-measurements.praat' open. The file is located at '~/Documents/GitHub/reproducible-phonetics/code'. The editor displays a Praat script with the following content:

```
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↵
```

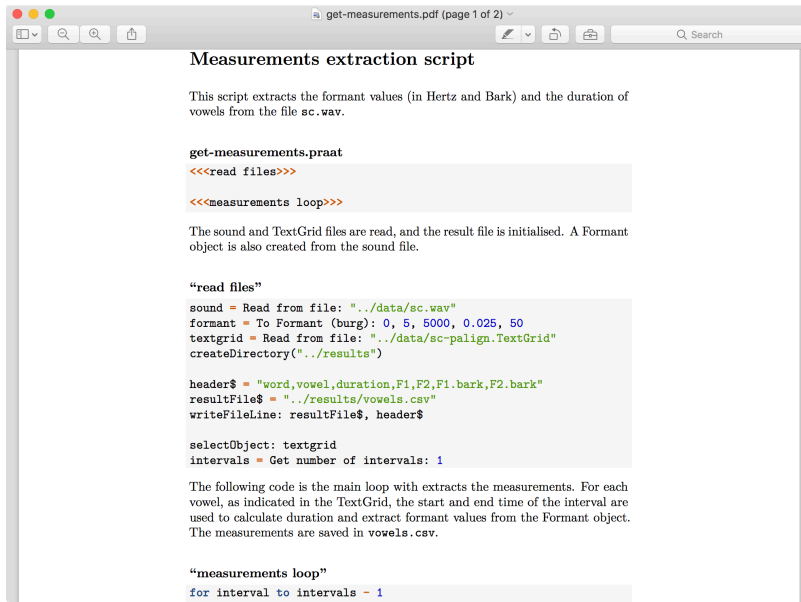
The status bar at the bottom indicates the file is named 'get-measurements.praat', the line number is '1:1', the encoding is 'UTF-8', the dialect is 'Praat', and the branch is 'master'.



## lmt (iterate markdown tangler)

```
get-measurements.praat.md
9
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
22 sound = Read from file: "../data/sc.wav"~
23 formant = To Formant (burg): 0, 5, 5000,
24 ~ 0.025, 50~
25
26 textgrid = Read from file:
27 ~ "../data/sc-palign.TextGrid"~
28
29 createDirectory("../results")~
30 |
31 header$ =
32 ~ "word,vowel,duration,F1,F2,F1.bark,F2.bark"
33 ~
34
35 resultFile$ = "../results/vowels.csv"~
36
37 writeFileLine: resultFile$, header$~
38 |
39 selectObject: textgrid~
40
41 intervals = Get number of intervals: 1~
42 |
43 for interval to intervals - 1~
44 | | |
45 | | ...label$ = Get label of interval: 1,
46 | | ~ interval~
47 | |
48 | | ...if label$ == "#"~
49 | | |
50 | | | | start = Get start time of
51 | | | | ~ interval: 1, interval + 8~
52 | | | |
53 | | | | end = Get end time of interval:
54 | | | | ~ 1, interval + 8~
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```

# 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 (R Core Team 2015) 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

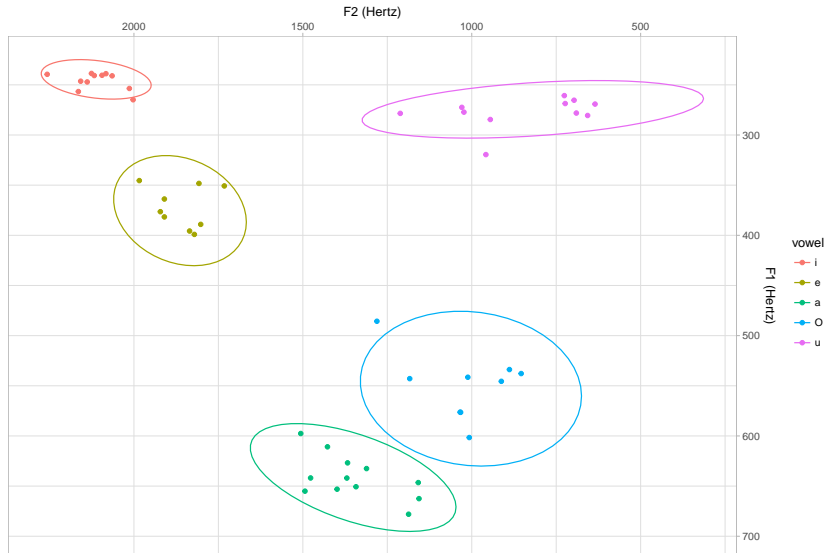
```
# Tangle a Praat script
lmt("code/get-measurements.praat.md")

# 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

*There is no investigation without dissemination.*

Ricardo Bermúdez-Otero (p.c.)

- 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

- share data, source file(s), versioning
- increasing awareness of RR in linguistics
- Atom, lmt, pandoc, speakr, knitr
- this presentation (along with source code and data) is available at <https://github.com/stefanocoretta/reproducible-phonetics>

## Summary

THANK YOU!



# References I

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## References III

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