

Vowel  
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seminar

Vowel analysis

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extract data

plotting

R packages

vowels

phonTools

# Vowels

G. Moroz

10 February, 2018

# Previously

- Sound waves have
  - A — amplitude
  - f — fundamental frequency
  - $\varphi$  — phase
  - t — time
- Speech sounds are complex waves
- Fourier transform — allows to extract components of the complex wave

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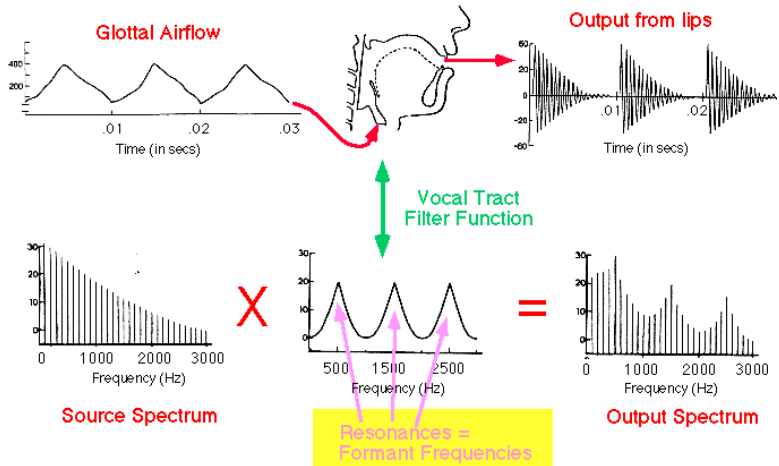
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# Source-Filter Model

- Larynx produce some sound
- Vocal tract filter some frequencies



# How shape of the vocal tract influences on vowels?

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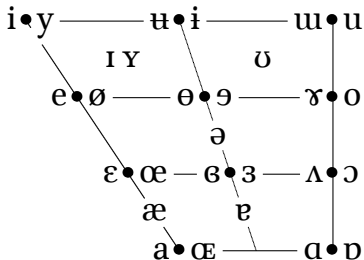
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Historically, height and backness are impressionistic linguistic terms

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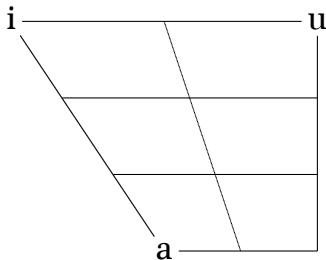
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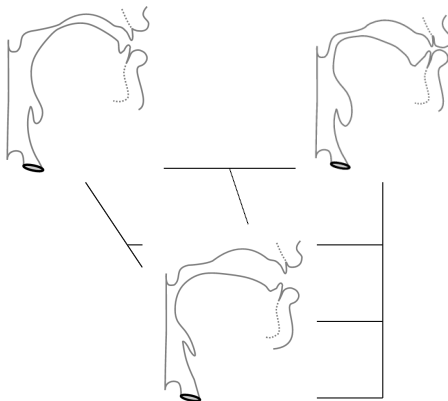
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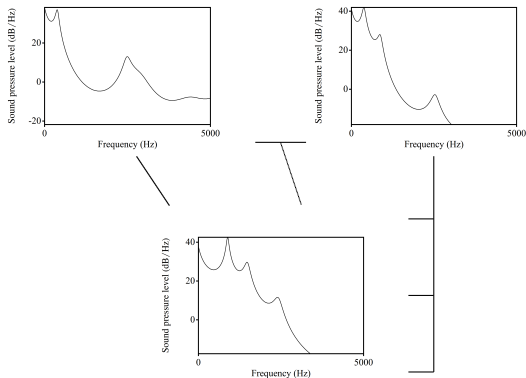
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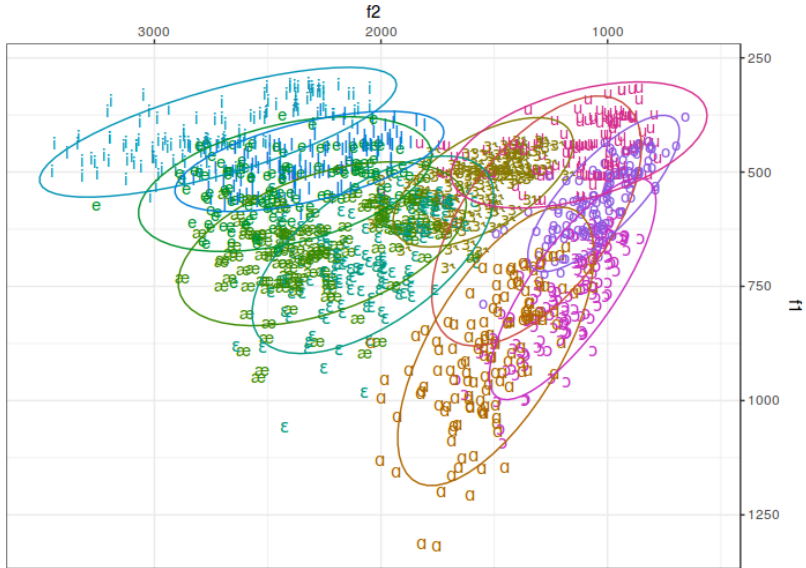
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	i	a	u
F1	300	700	300
F2	2300	1400	800

# Vowel chart



data from Hillenbrand et al. (1995)



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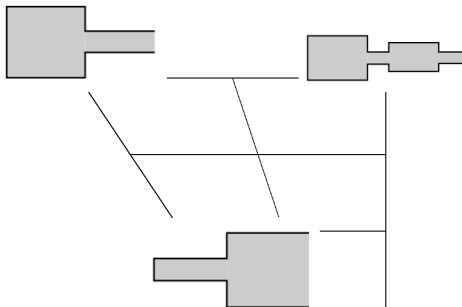
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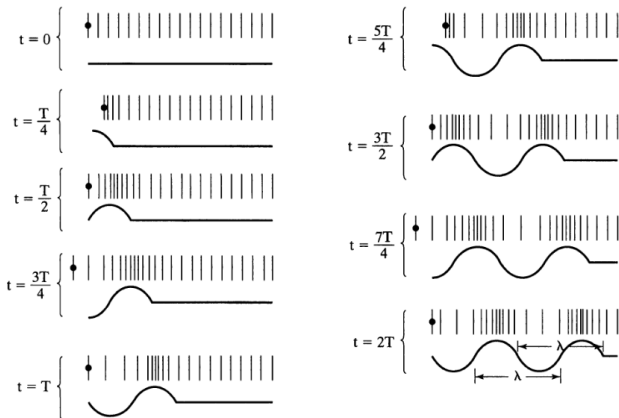
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Tube model, [Fant 1960]: vocal tract is a tube or a set of tubes

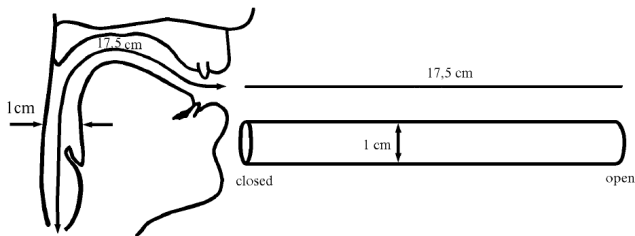
# Wavelength



$$c = \frac{\lambda}{T} = \lambda \times f \approx 33400 \text{ cm/s}$$

$c$  — speed of sound;  $\lambda$  — wavelength;  $f$  — sound frequency;  $T$  — period

## Neutral vocal tract in the position for the vowel ə

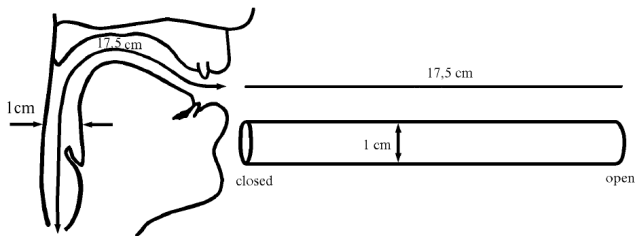


Resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies. The lowest natural frequency at which such a tube resonates will have a wavelength ( $\lambda$ ) **four times the length** of the tube ( $L$ ).

$$f = \frac{c}{\lambda} = \frac{c}{4 \times L} \approx \frac{33400}{17.5 \times 4} \approx 477 \text{ Hz} \approx 500 \text{ Hz}$$

The tube also resonates at **odd multiples** of that frequency.

## Neutral vocal tract in the position for the vowel ə

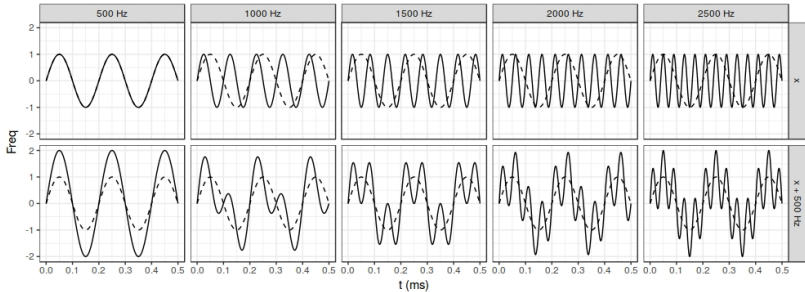


Resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies. The lowest natural frequency at which such a tube resonates will have a wavelength ( $\lambda$ ) **four times the length** of the tube ( $L$ ).

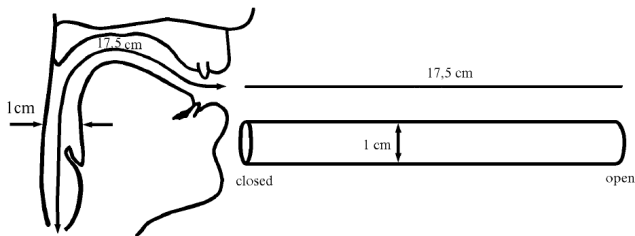
$$f = \frac{c}{\lambda} = \frac{c}{4 \times L} \approx \frac{33400}{17.5 \times 4} \approx 477 \text{ Hz} \approx 500 \text{ Hz}$$

The tube also resonates at **odd multiples** of that frequency. **Why?**

# Wave addition



# Neutral vocal tract in the position for the vowel ə



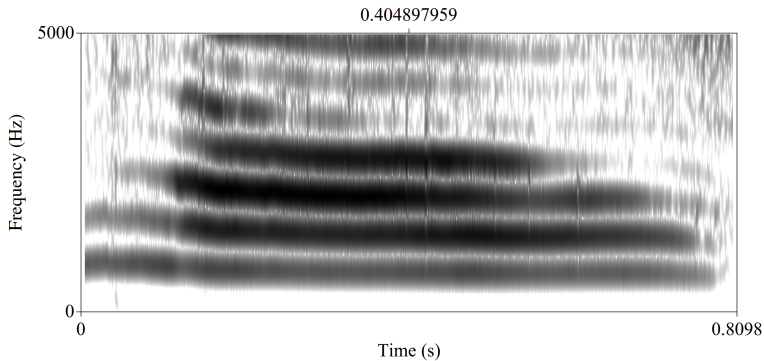
$$F_1 = \frac{c}{\lambda} = \frac{c}{4 \times L} \approx 500 \text{ Hz}$$

$$F_2 = \frac{c}{\lambda} = \frac{c}{\frac{4}{3} \times L} = \frac{3 \times c}{4L} \approx 1500 \text{ Hz}$$

$$F_3 = \frac{c}{\lambda} = \frac{c}{\frac{4}{5} \times L} = \frac{5 \times c}{4L} \approx 2500 \text{ Hz}$$

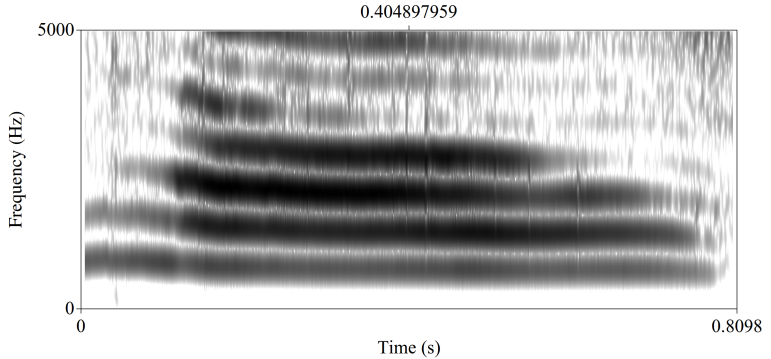
$$F_n = \frac{c}{\lambda} = \frac{c}{\frac{4}{n} \times L} = \frac{n \times c}{4L} \approx n \times 500 \text{ Hz}$$

???



listen

# Cat meow



listen



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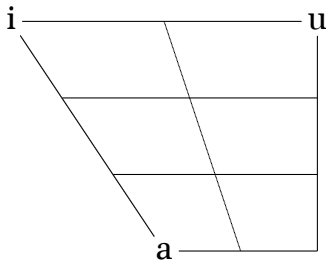
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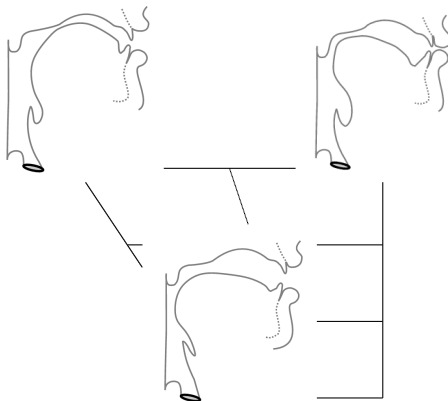
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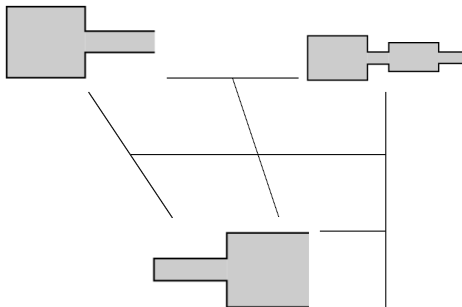
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When there is a constriction, back tube and constriction form **Helmholtz resonator**

$$f = \frac{c}{2\pi} \times \sqrt{\frac{A}{V \times L}}$$

$A$  — the area of the neck;  $L$  — length of the tube;  $V$  — volume of the air in the body

презентация доступна: <https://goo.gl/HUrRuk>

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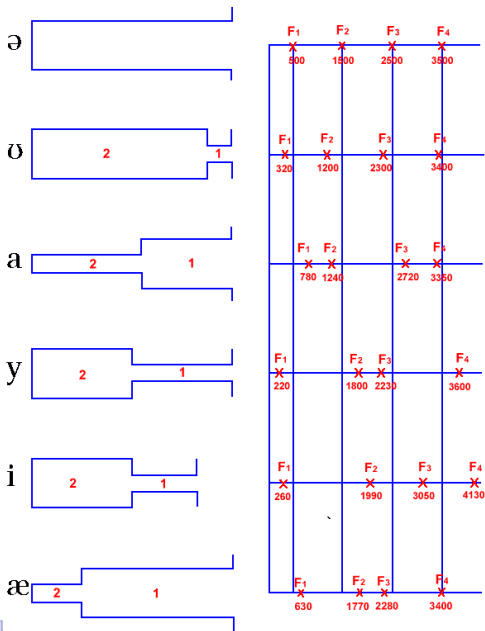
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# Other models

- Perturbation Theory Kajiyama 1941, Mrayati et al. 1988
- Quantal Theory Stevens 1989
- Theory of adaptive dispersion Lindblom 1990
- ...

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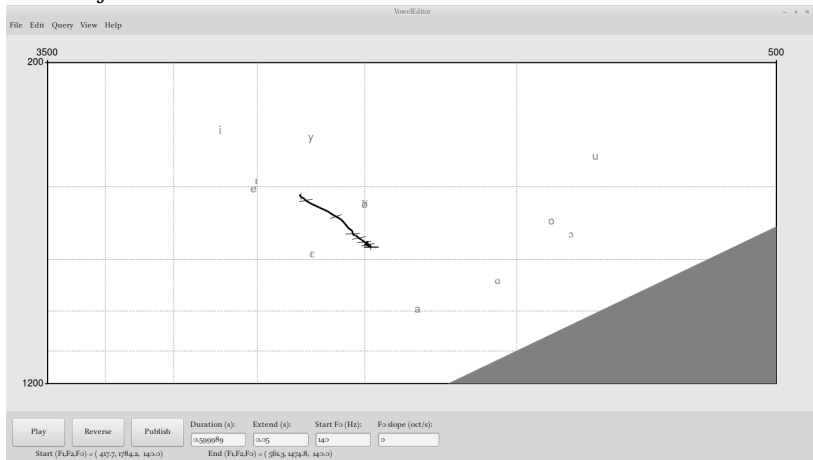
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# Vowel editor

Praat objects > New > Sound > Create sound from VowelEditor...



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- record sounds
- annotate sounds
- make an exploratory analysis
- extract duration and formant information from your data
- create the plot



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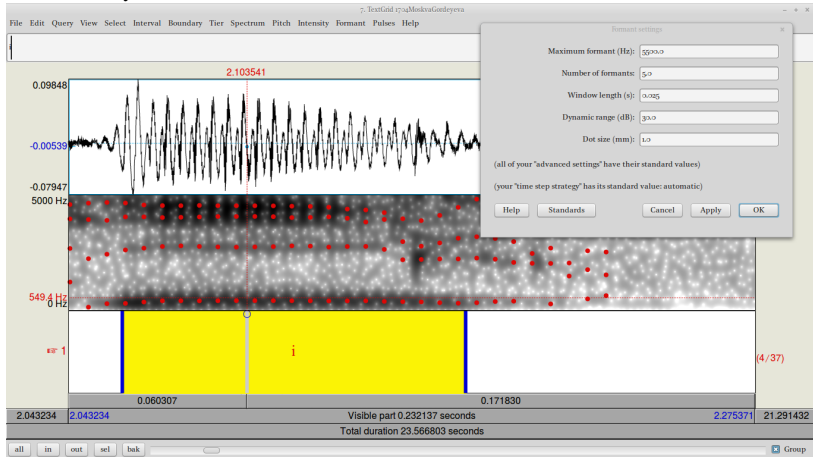
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# Formants in Praat

## Praat Analyser > Formant > Show Formants

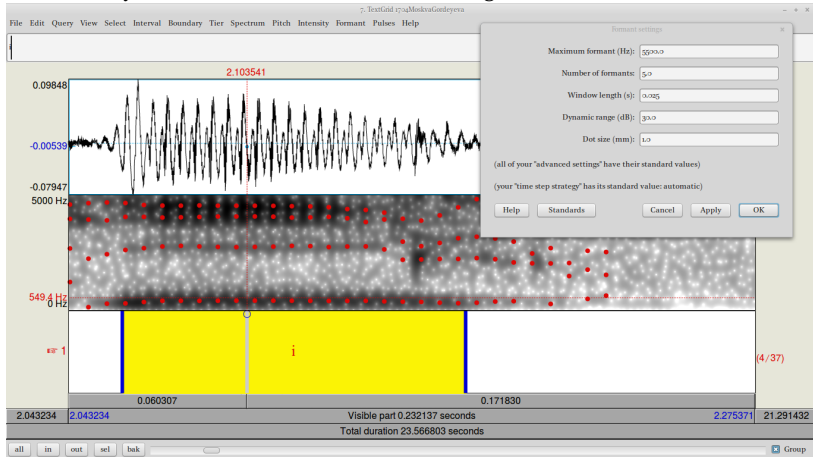


- F1 select the nearest first formant value or mean value for selection
- F2 select the nearest second formant value or mean value for selection
- F3 select the nearest third formant value or mean value for selection

презентация доступна: <https://goo.gl/HURuk>

# Formants in Praat

## Praat Analyser > Formant > Formant Settings...



During analysis you should set Maximum Formant value so as to distinguish [i], [a] and [u].

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# Change writing preferences to UTF-8!

Praat Objects > Preferences > Text writing preferences...

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# Praat scripting

Praat have its own scripting language. You can read about it:

Praat Objects > Help > Scripting tutorial

There are a lot of Praat scripts [here](#).

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# Praat scripting: extracting duration

- Open Praat Objects
- Open some TextGrid
- Praat Objects > Praat > New Praat script
- Copy script from [here](#) to the new window
- Select TextGrid
- Praat Script > Run > Run
- Provide some valid path for the result file
- Press OK

# Praat scripting: extracting formant values

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- Open Praat Objects
- Praat Objects > Praat > New Praat script
- Copy script from [here](#) to the new window
- Praat Script > Run > Run
- Provide some path with your sound and TextGrid
- Provide Maximum Formant value
- Press OK



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# Plotting formant values with ggplot2

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```
library(ggplot2)
setwd("...") # Put here path with the result.tsv file
df <- read.csv("result.txt", sep = "\t", fileEncoding = "UTF-8")
ggplot(data = df, aes(F2, F1, color = intervalname, label = intervalname))+
  geom_text(show.legend = F)+
  scale_y_reverse(position = "right")+
  scale_x_reverse(position = "top")
```

# Plotting formant values with ggplot2



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# vowels

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**vowels**

phonTools

- **Version: 1.2-1**
- **Date: 2014-11-14**
- **Author: Tyler Kendall and Erik R. Thomas, [Kendall and Thomas 2014]**

```
install.packages("vowels")
```

# phonTools

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**phonTools**

- Version: 0.2-2.1
- Date: 2015-07-30
- Author: Santiago Barreda, [Barreda 2015]

```
install.packages("phonTools")
```

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# Thank you!

Please, don't hesitate to write me

[agricolamz@gmail.com](mailto:agricolamz@gmail.com)

# Reference

- Barreda, S. (2015). phonTools: Functions for phonetics in R. R package version 0.2-2.1.
- Fant, G. (1960). Acoustic theory of speech production: with calculations based on X-ray studies of Russian articulations, Volume 2. Walter de Gruyter.
- Kendall, T. and E. R. Thomas (2014). vowels: Vowel Manipulation, Normalization, and Plotting. R package version 1.2-1.

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