Vowels

G. Moroz

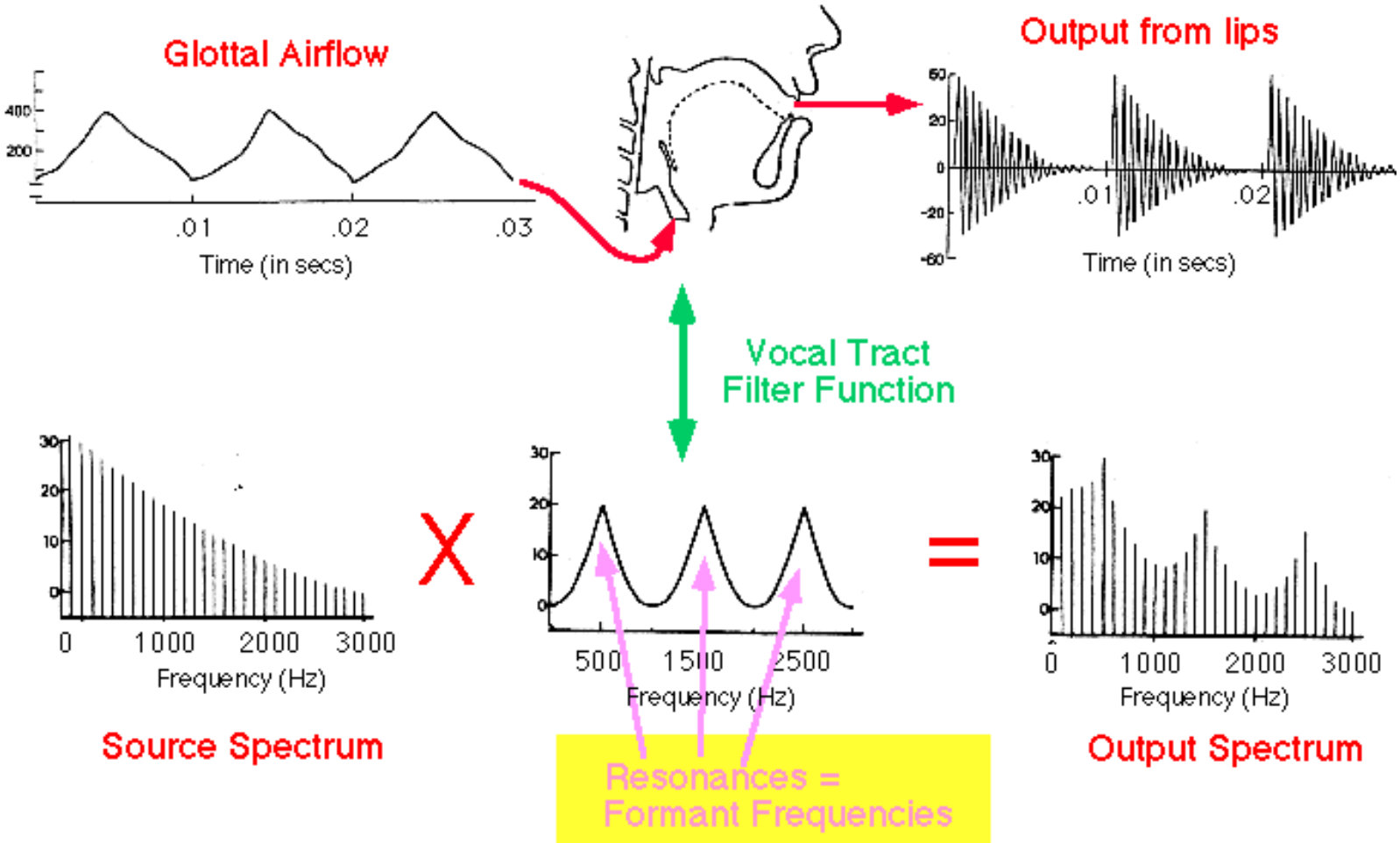
10 February, 2018

Previously

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

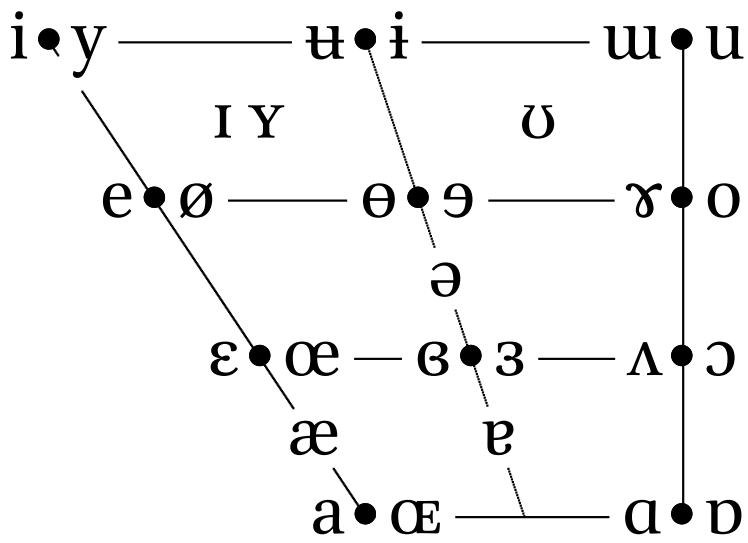
Source-Filter Model

- Larynx produce some sound
- Vocal tract filter some frequencies



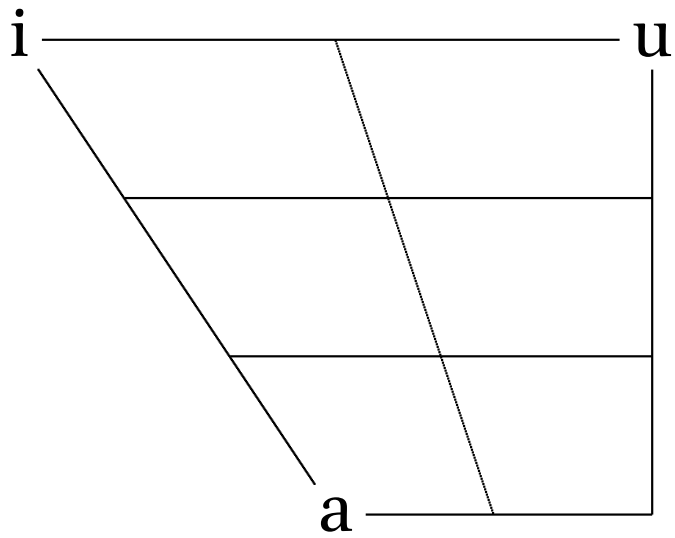
презентация доступна: **https://goo.gl/HUrRuk**

How shape of the vocal tract influences on vowels?

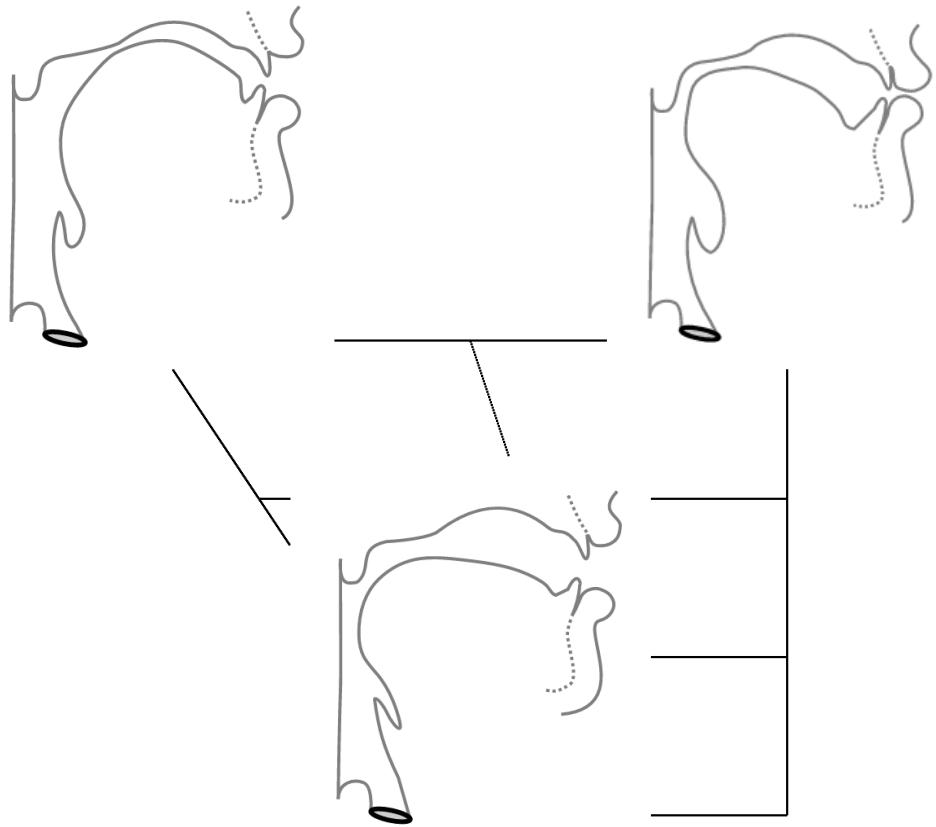


Historically, height and backness are impressionistic linguistic terms

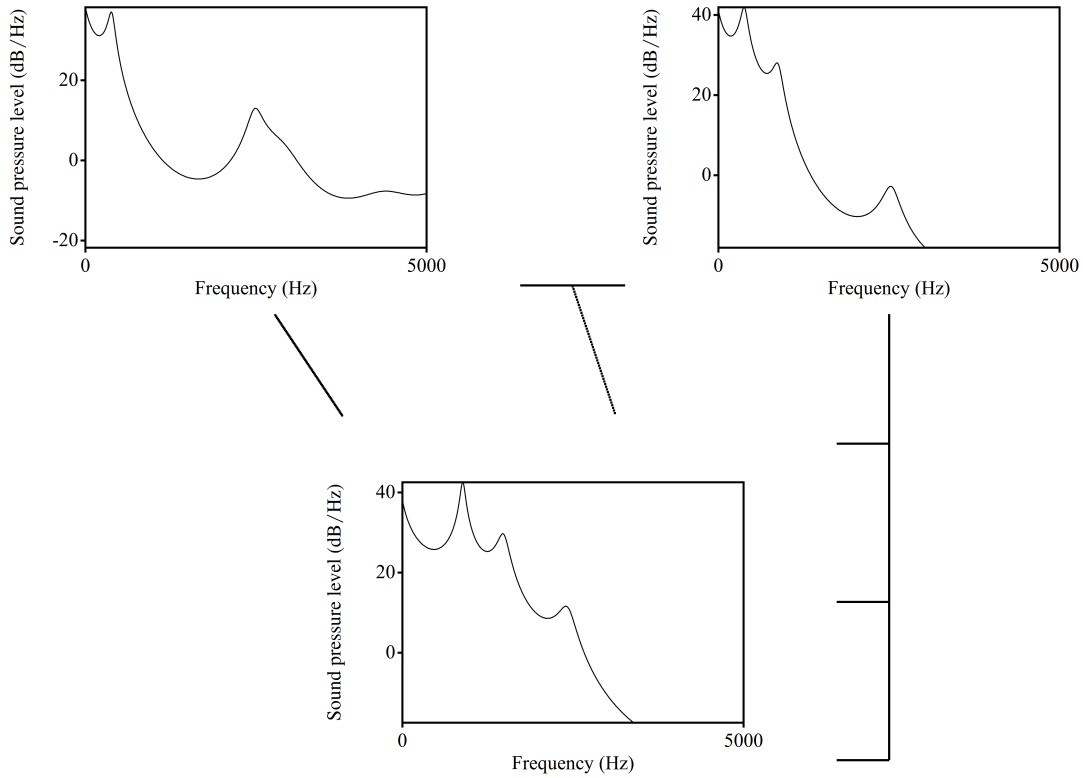
How shape of the vocal tract influences on vowels?



How shape of the vocal tract influences on vowels?



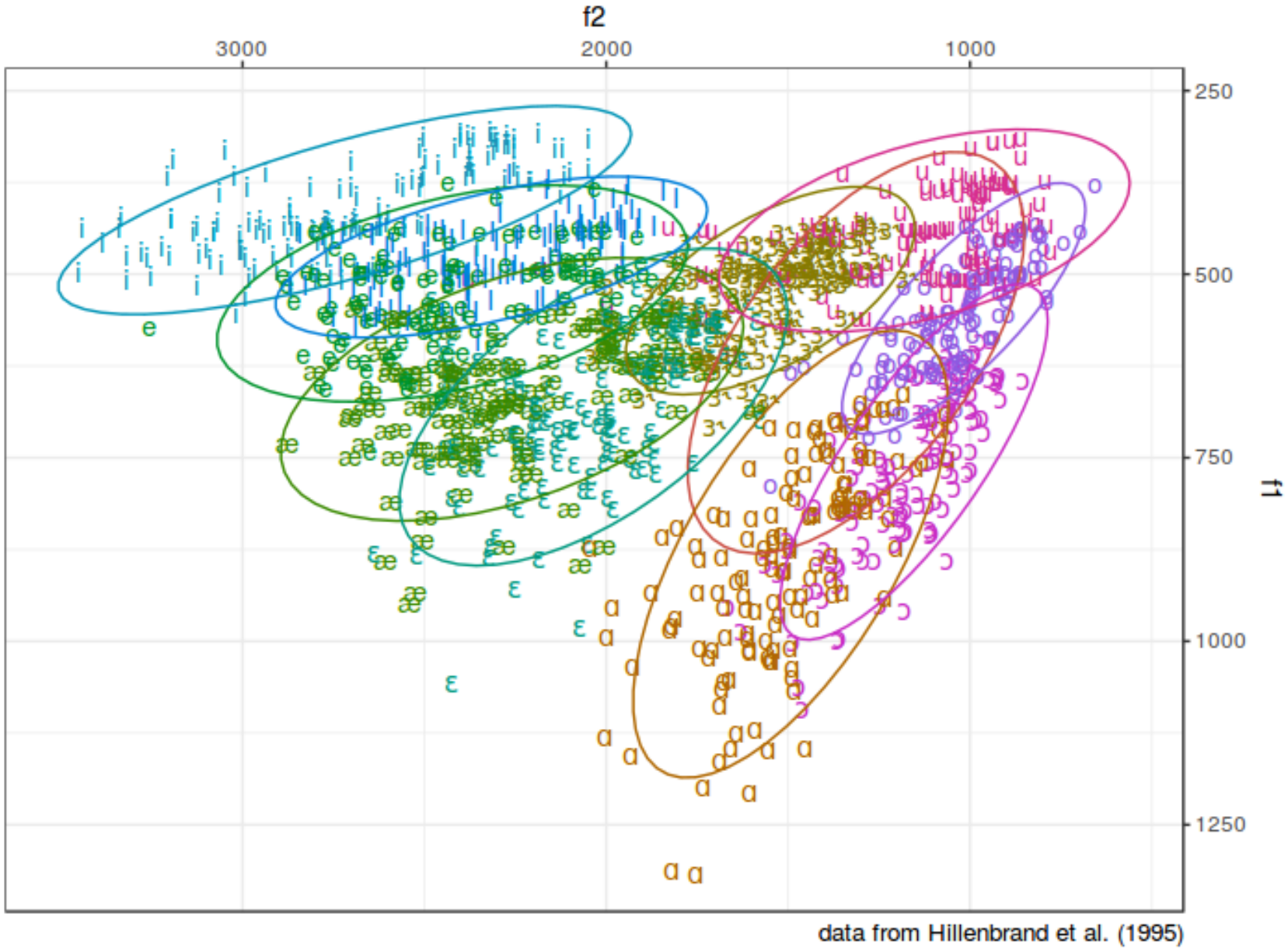
How shape of the vocal tract influences on vowels?



	i	a	u
F1	300	700	300
F2	2300	1400	800

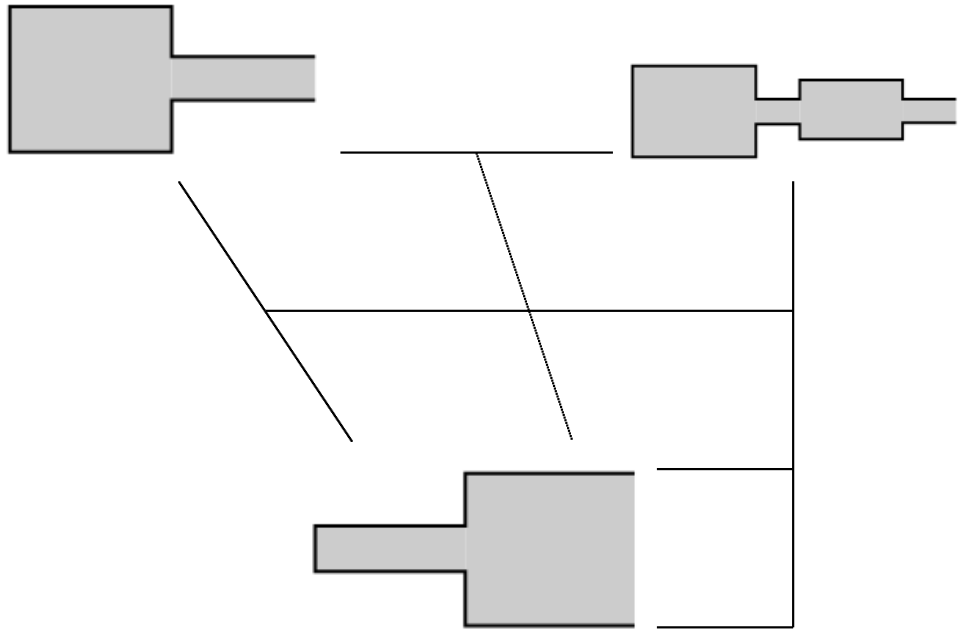
презентация доступна: **https://goo.gl/HUrRuk**

Vowel chart



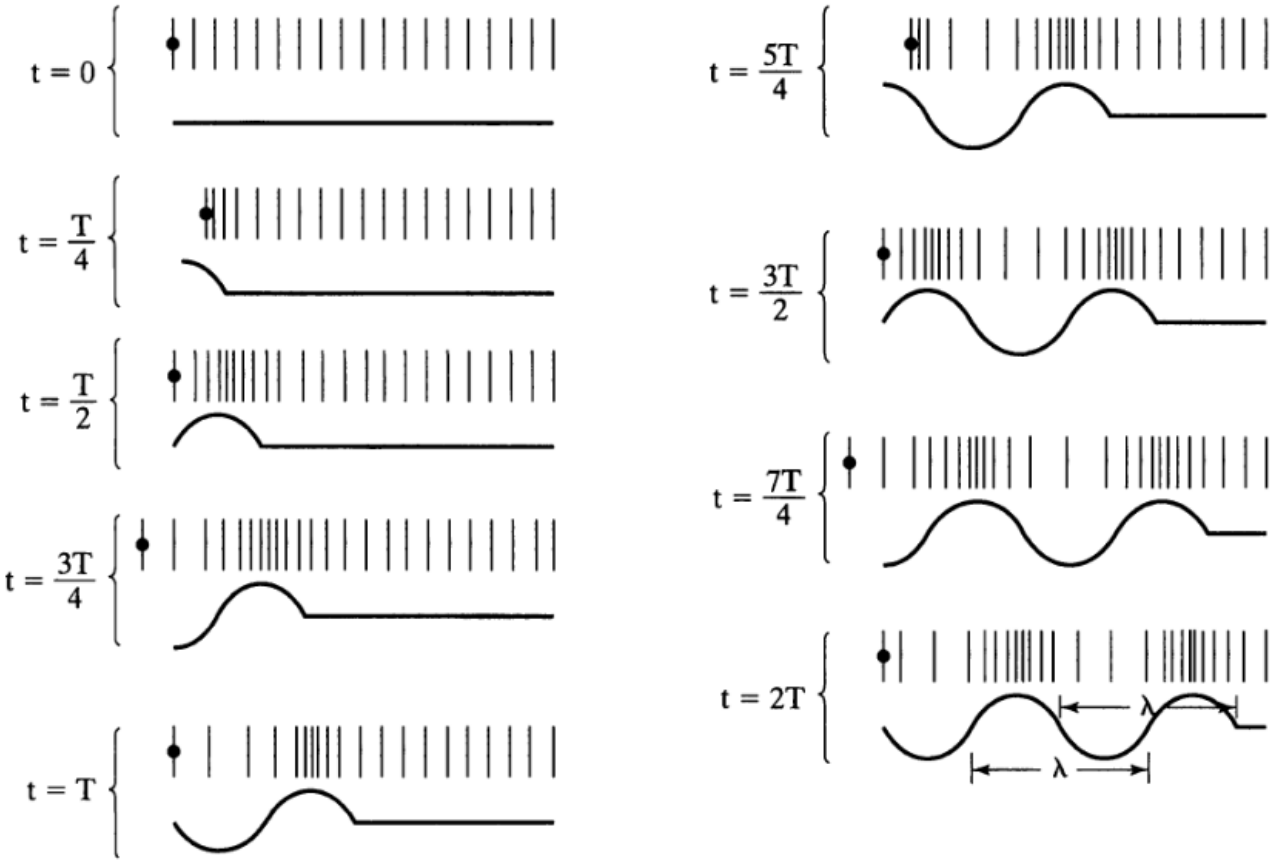
презентация доступна: **https://goo.gl/HUrRuk**

How shape of the vocal tract influences on vowels?



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

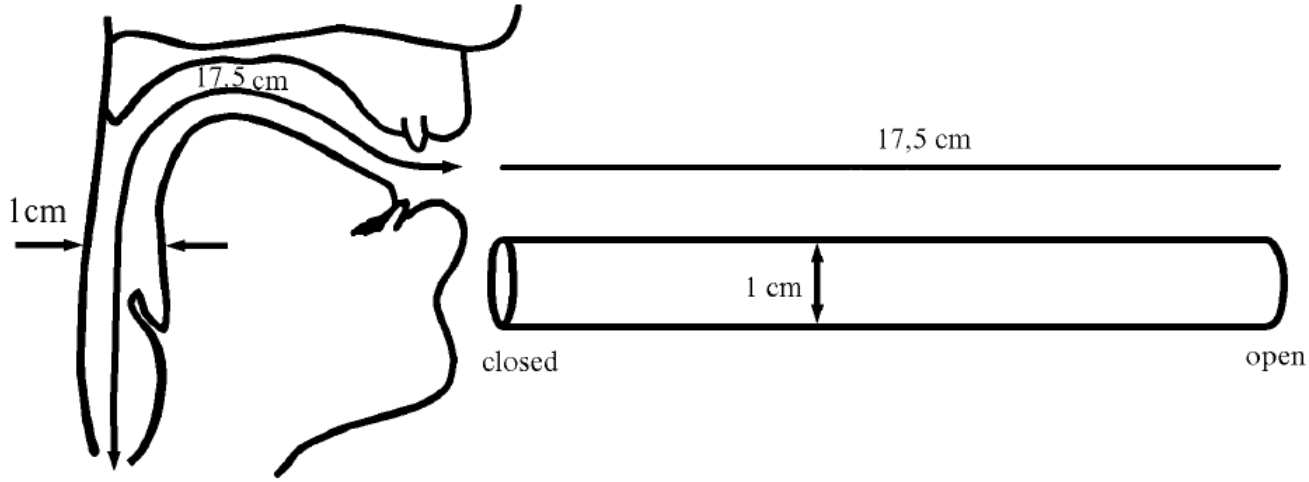
Wavelength



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

c — speed of sound; λ — wavelength; f — sound frequency; T — period

Neutral vocal tract in the position for the vowel ə

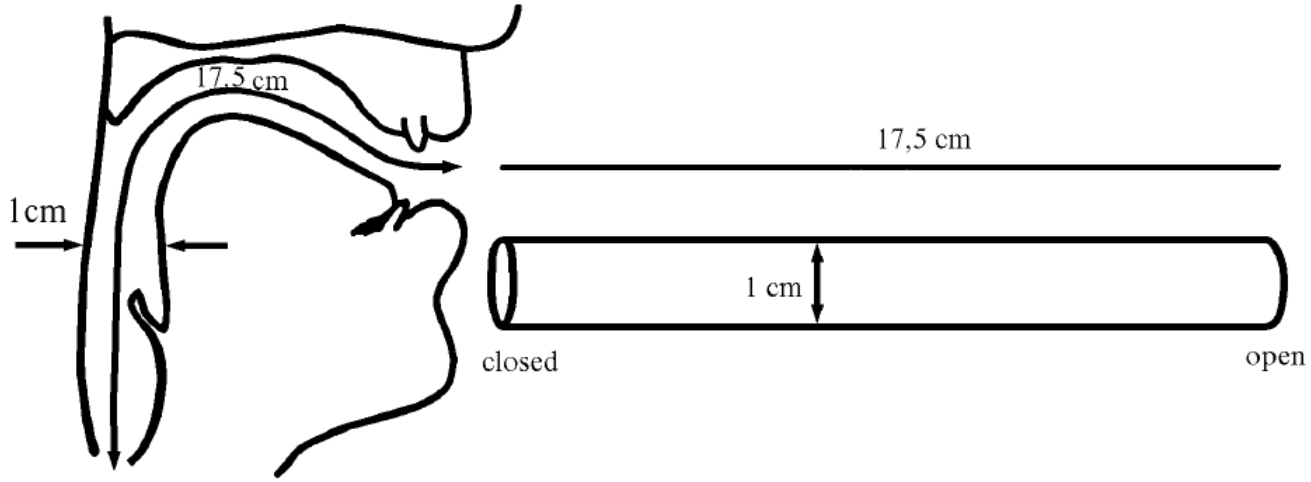


Resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies. The lowest natural frequency at which such a tube resonates will have a wavelength (λ) **four times the length** of the tube (L).

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

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

Neutral vocal tract in the position for the vowel ə

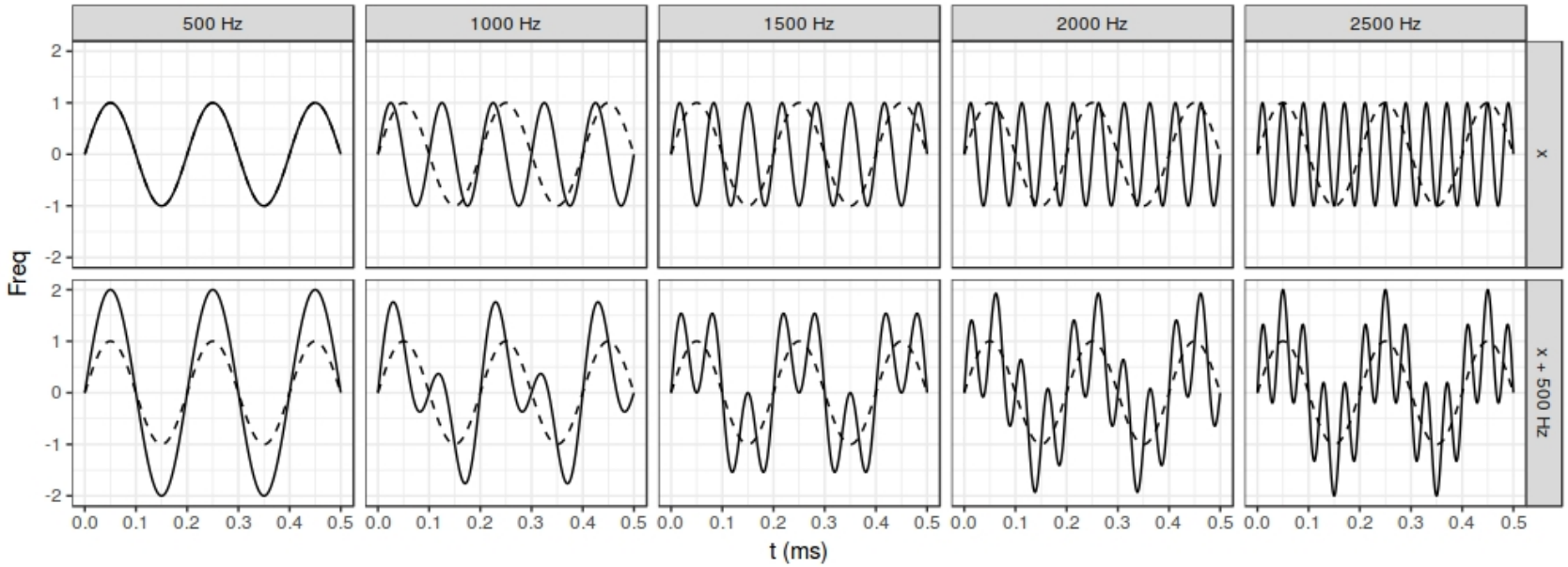


Resonance is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies. The lowest natural frequency at which such a tube resonates will have a wavelength (λ) **four times the length** of the tube (L).

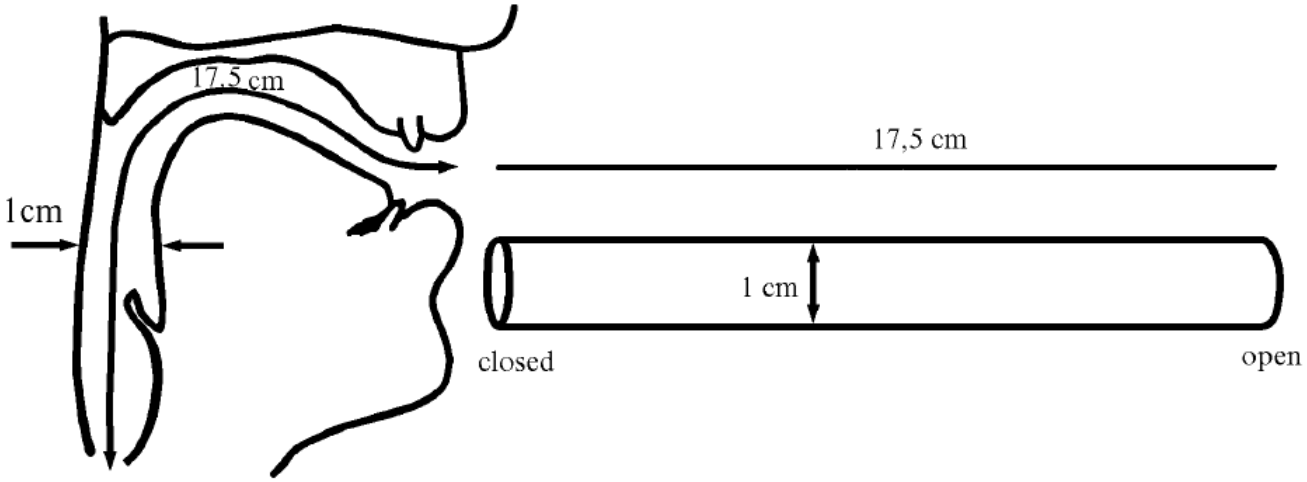
$$f = \frac{c}{\lambda} = \frac{c}{4 \times L} \approx \frac{33400}{17.5 \times 4} \approx 477\,\text{Hz} \approx 500\,\text{Hz}$$

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

Wave addition



Neutral vocal tract in the position for the vowel ə



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

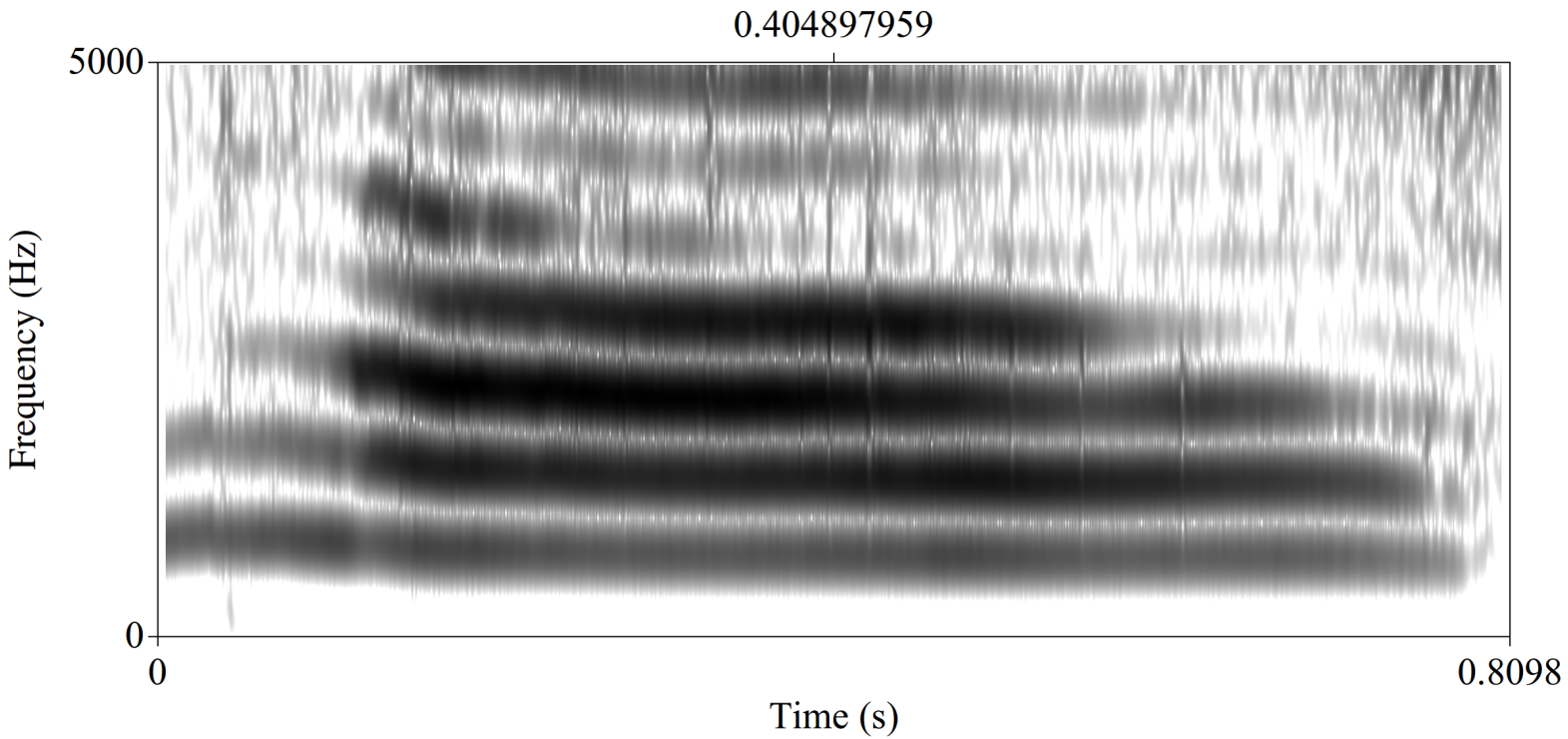
$$F_2 = \frac{c}{\lambda} = \frac{c}{\frac{4}{3} \times L} = \frac{3 \times c}{4L} \approx 1500 \text{ Hz}$$

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

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

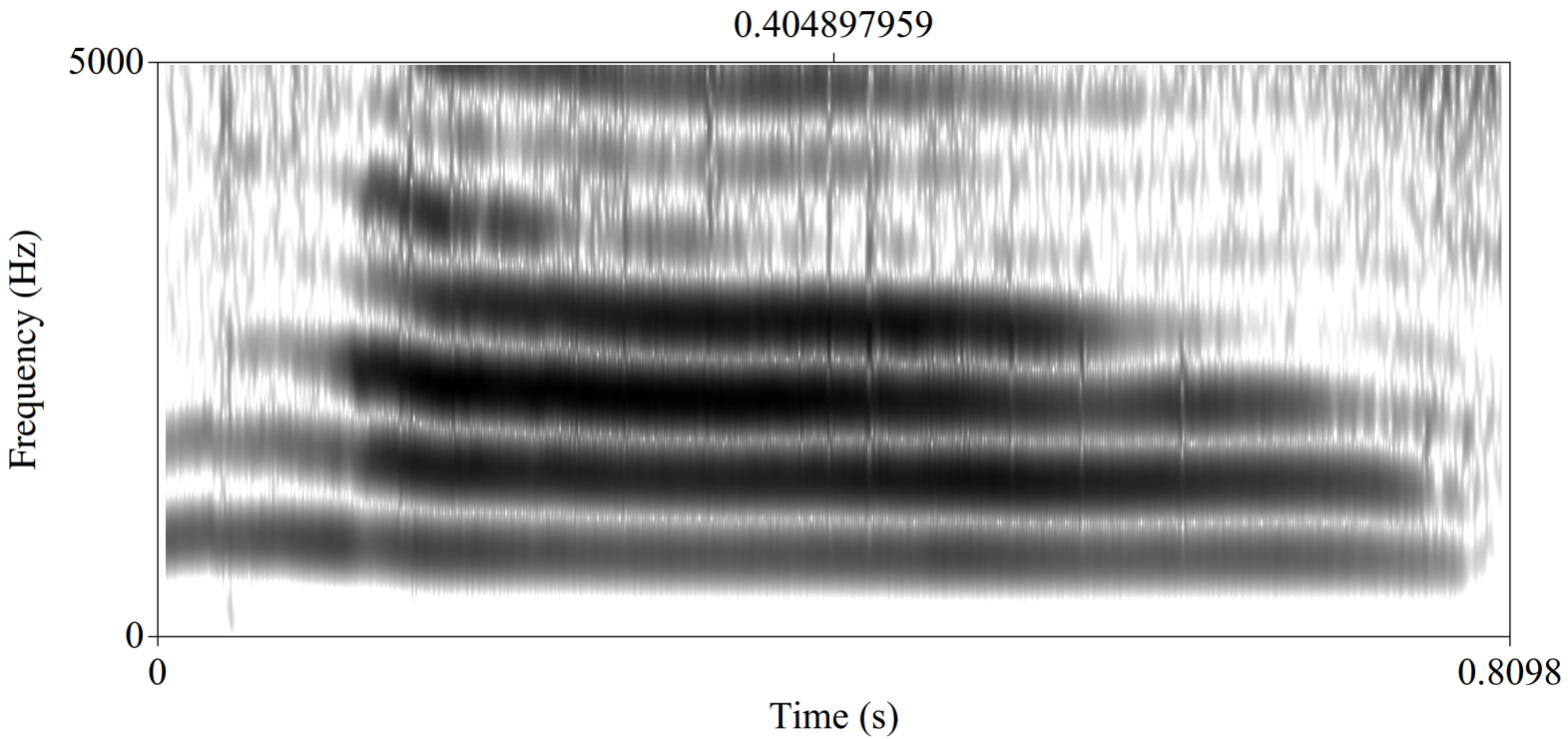
презентация доступна: **https://goo.gl/HUrRuk**

???



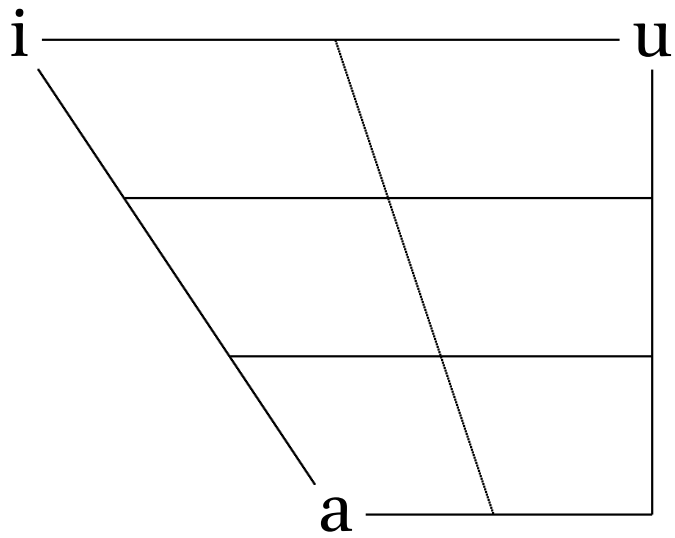
listen

Cat meow

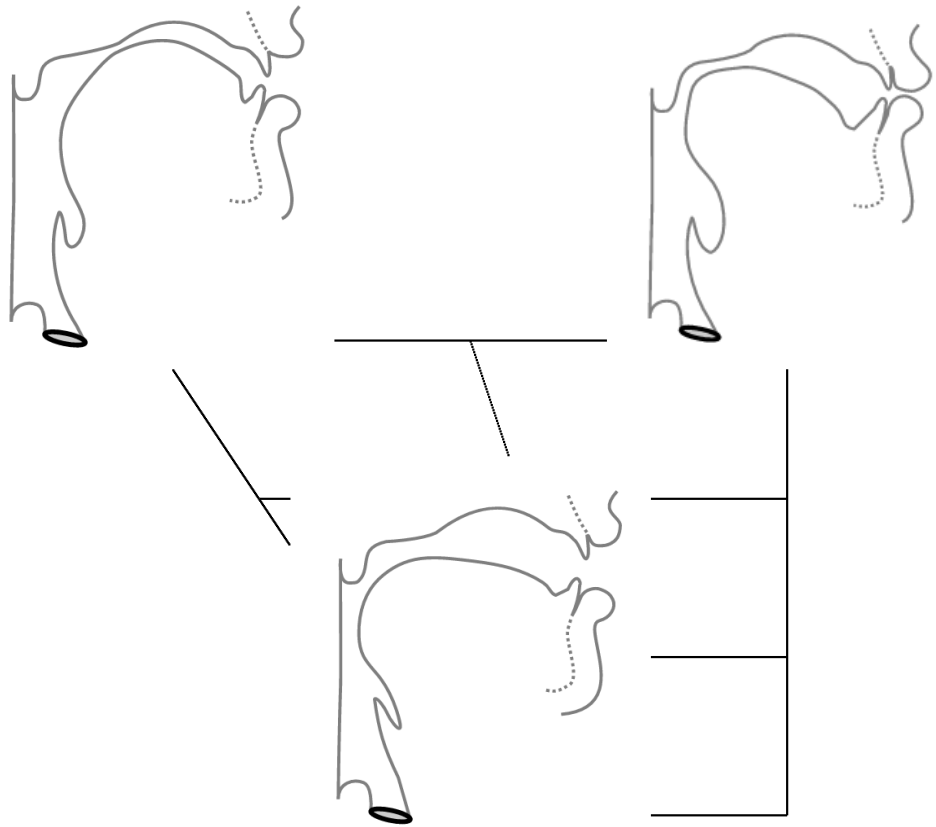


listen

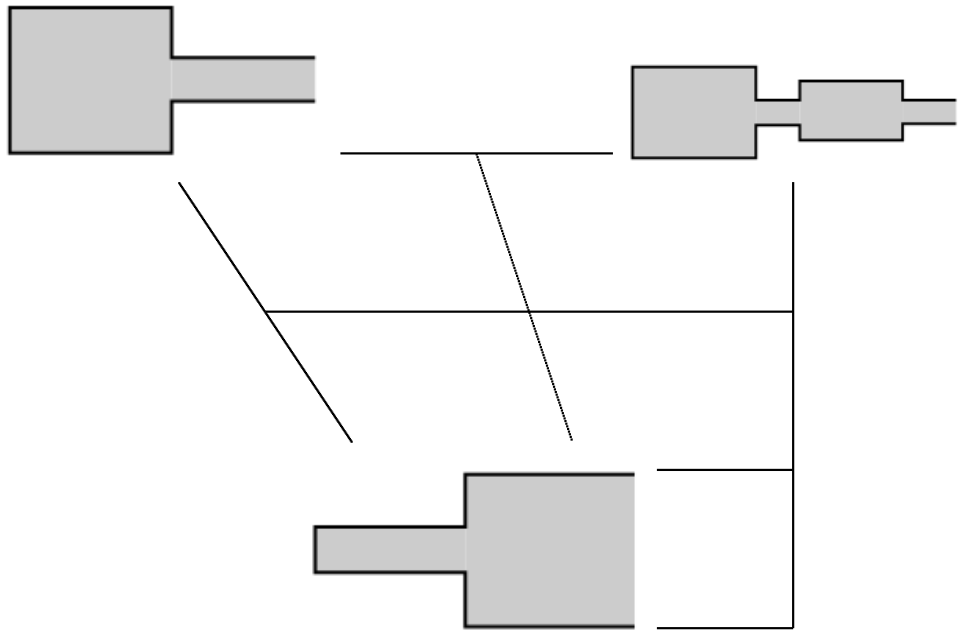
How shape of the vocal tract influences on vowels?



How shape of the vocal tract influences on vowels?



How shape of the vocal tract influences on vowels?



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

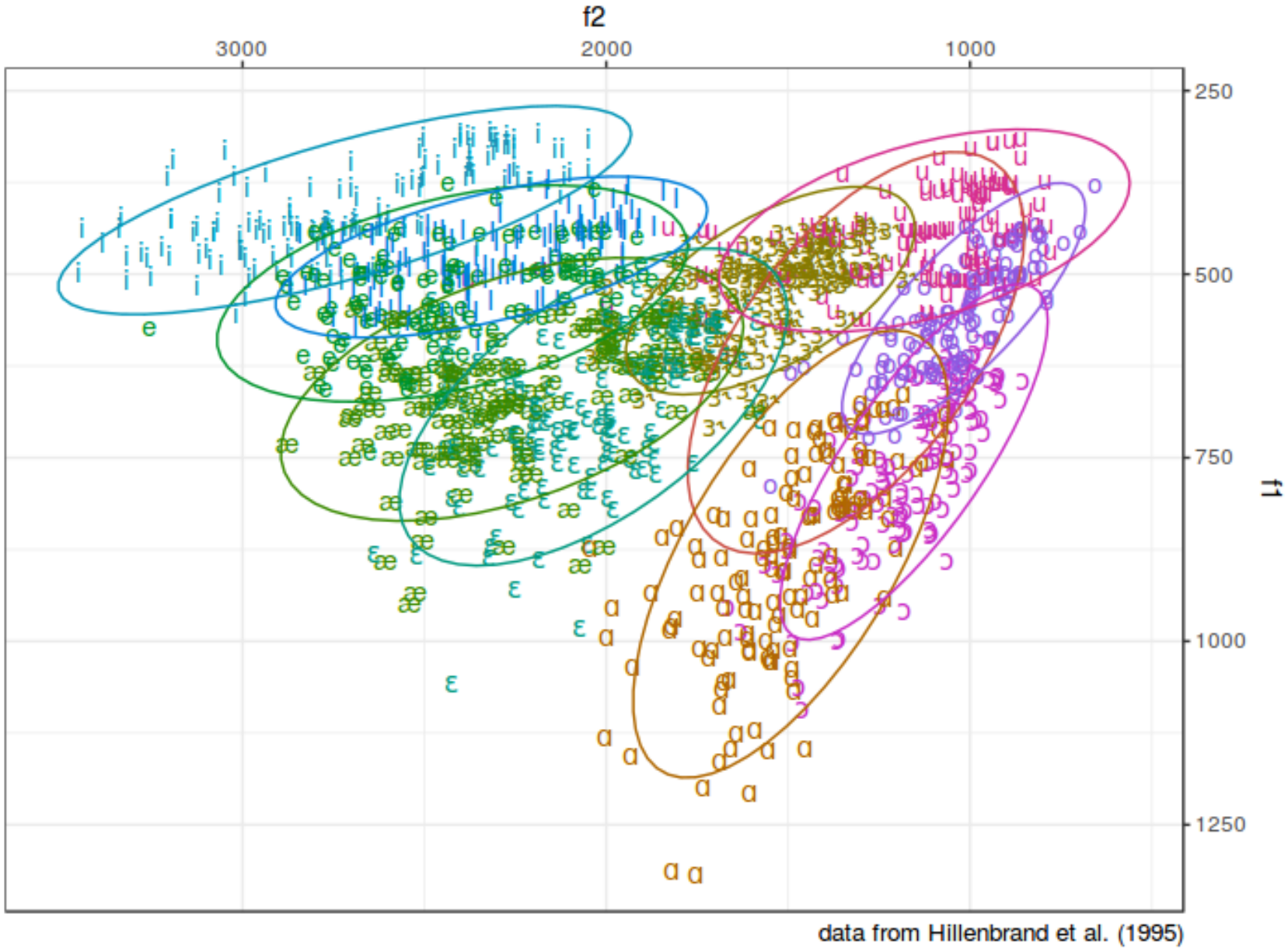
$$f = \frac{c}{2\pi} \times \sqrt{\frac{A}{V \times L}}$$

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

Other models

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

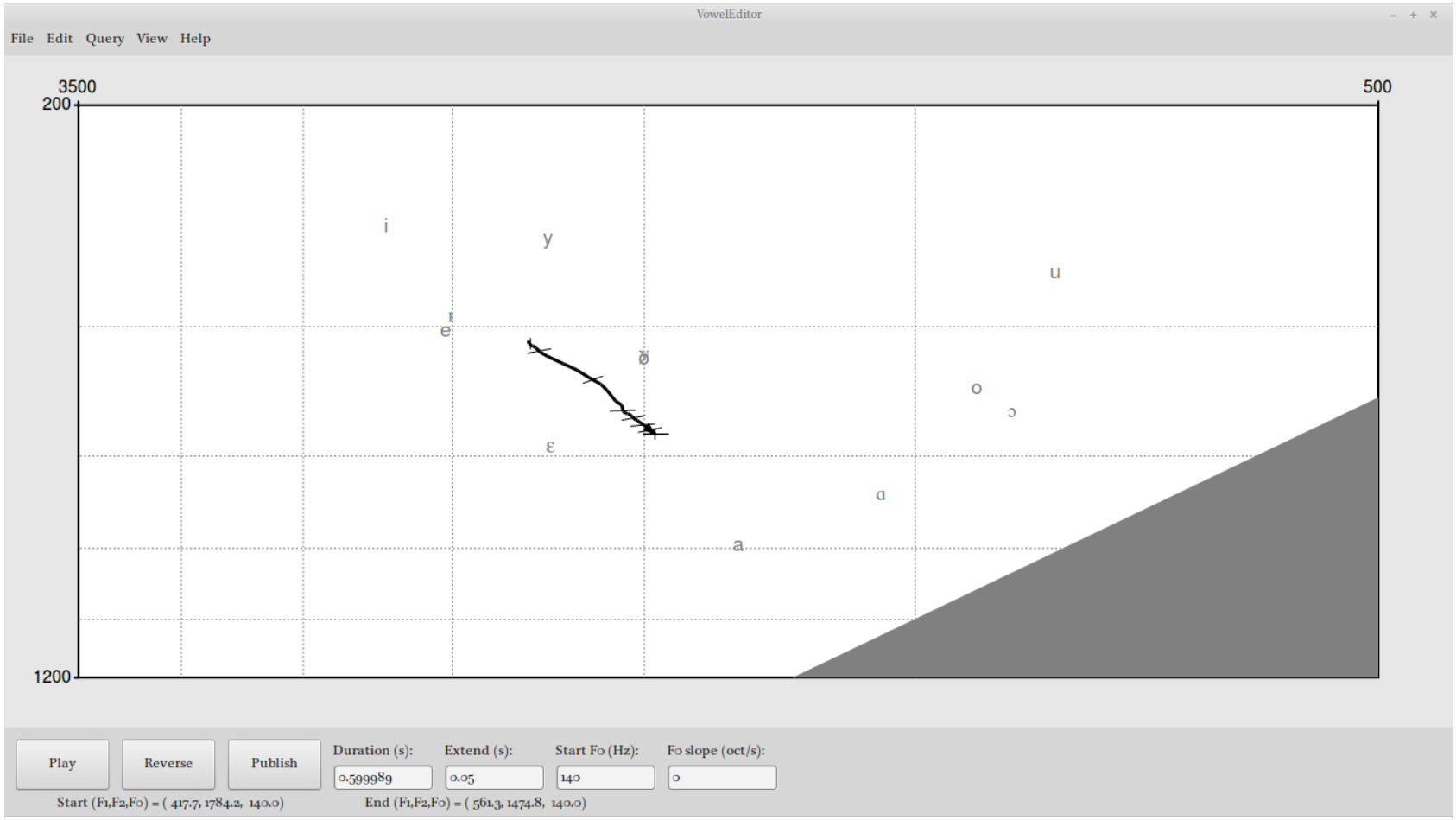
How to get something like that?



презентация доступна: **https://goo.gl/HUrRuk**

Vowel editor

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



How to analyse vowels?

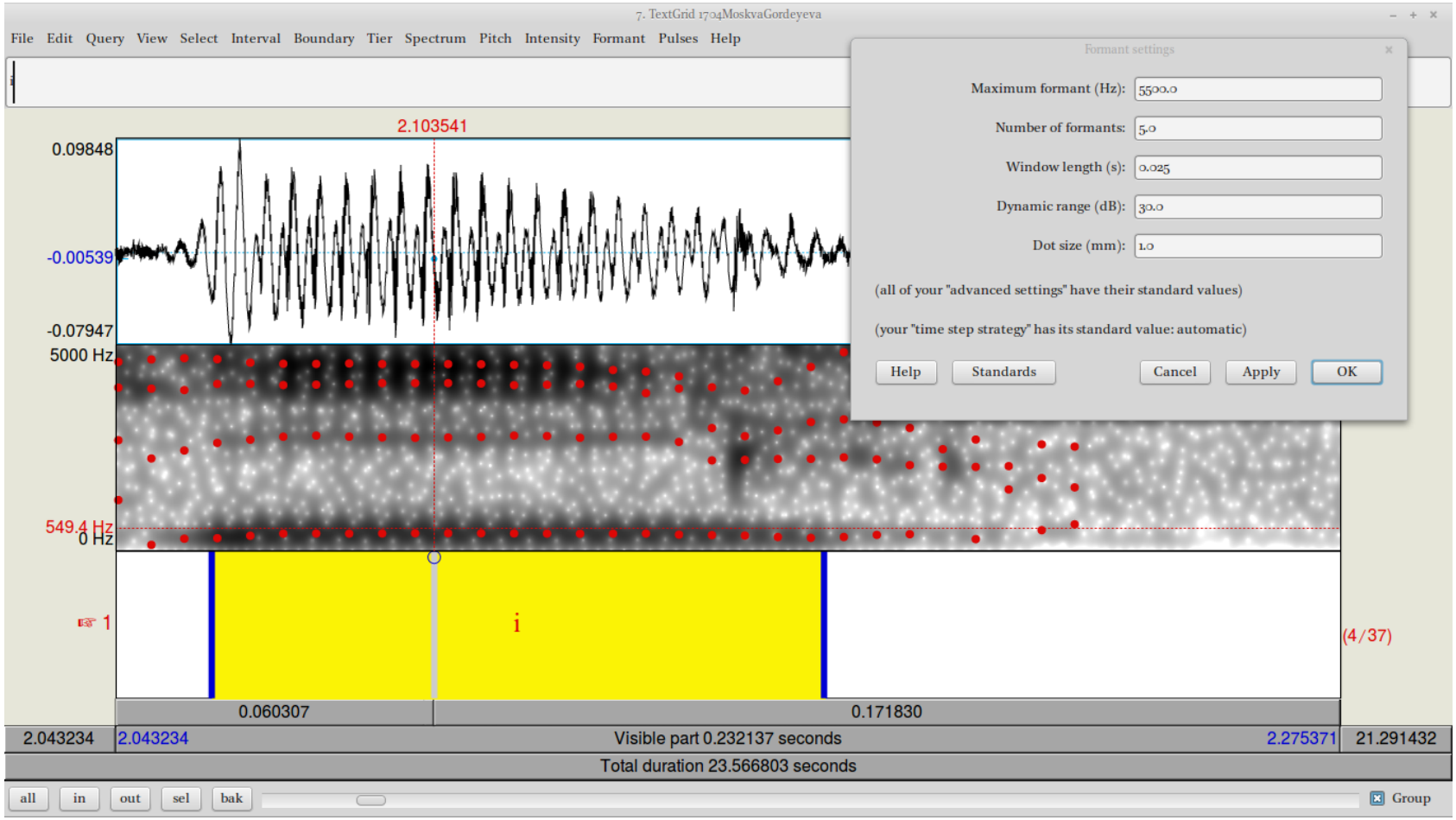
- record sounds
- annotate sounds
- make an exploratory analysis
- extract duration and formant information from your data
- create the plot

How to analyse vowels?

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

Formants in Praat

Praat Analyser > Formant > Show Formants



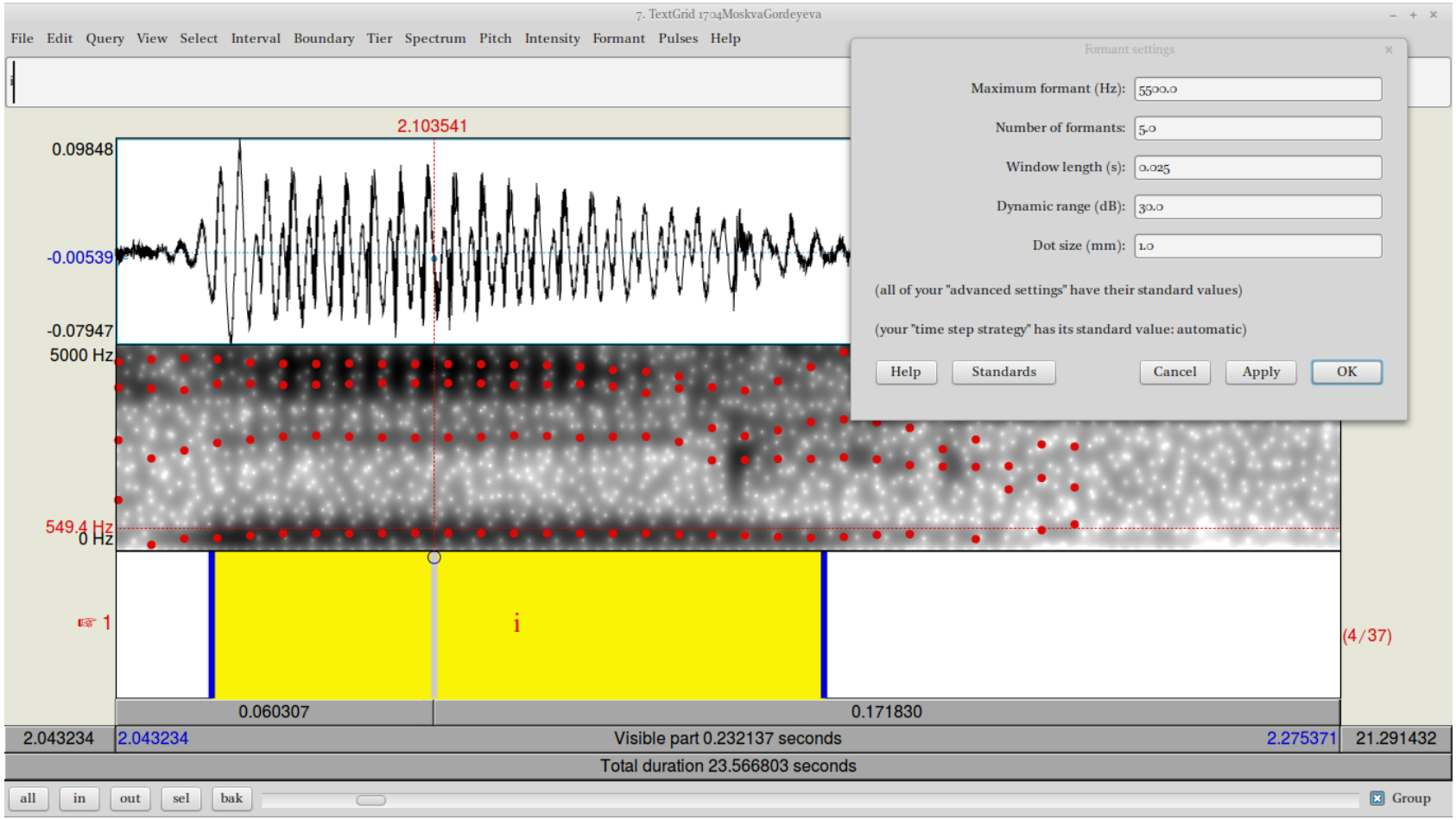
F1 select the nearest first formant value or mean value for selection

F2 select the nearest second formant value or mean value for selection

F3 select the nearest third formant value or mean value for selection

Formants in Praat

Praat Analyser > Formant > Formant Settings...



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

How to analyse vowels?

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

Change writing preferences to UTF-8!

Praat Objects > Preferences > Text writing preferences...

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.

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

- 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

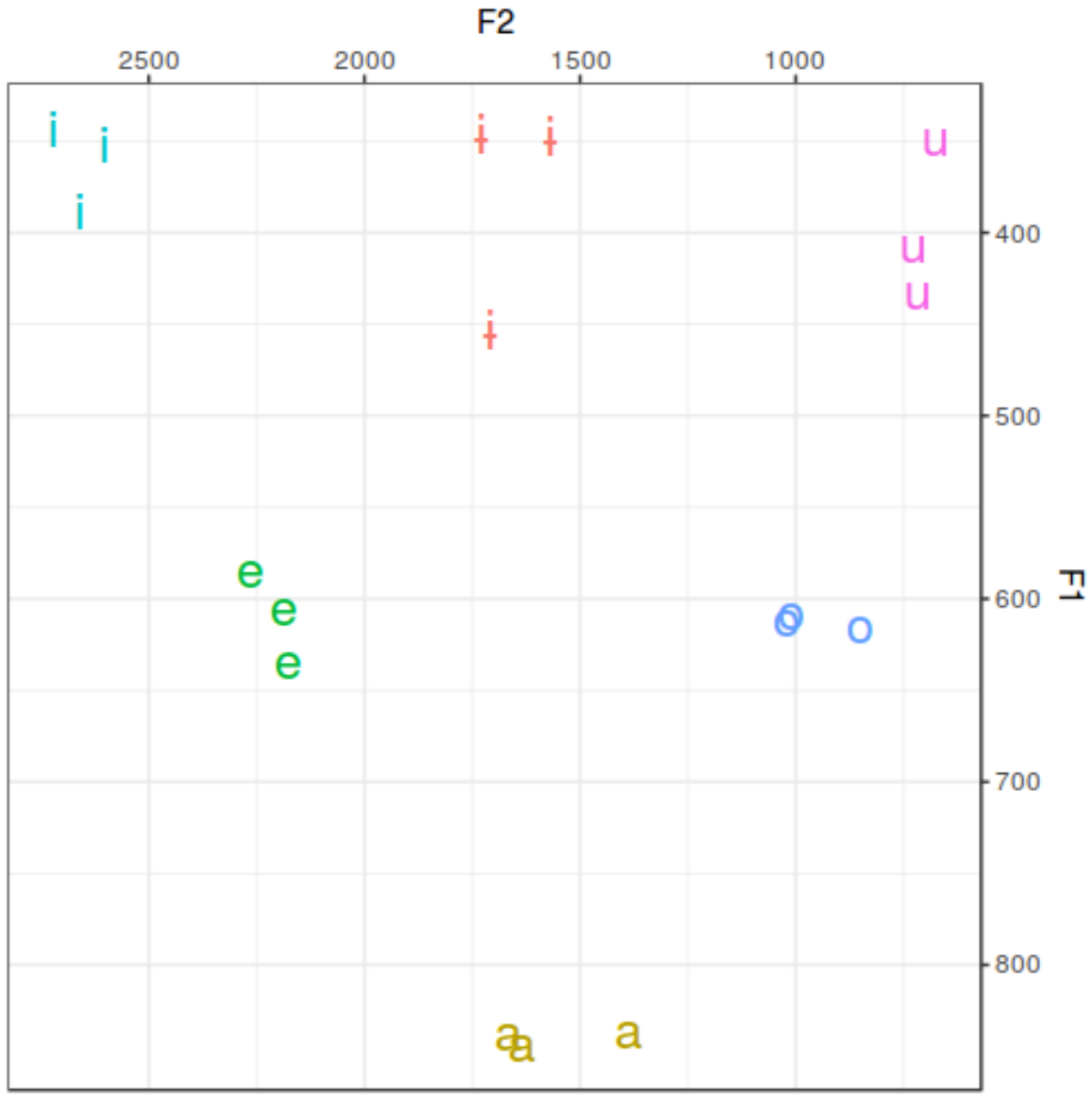
How to analyse vowels?

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

Plotting formant values with ggplot2

```
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



презентация доступна: **https://goo.gl/HUrRuk**

How to analyse vowels?

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

vowels

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

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

phonTools

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

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

Thank you!

Please, don't hesitate to write me

agricolamz@gmail.com

презентация доступна: **https://goo.gl/HUrRuk**

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.