# Introduction to Acoustic Phonetics

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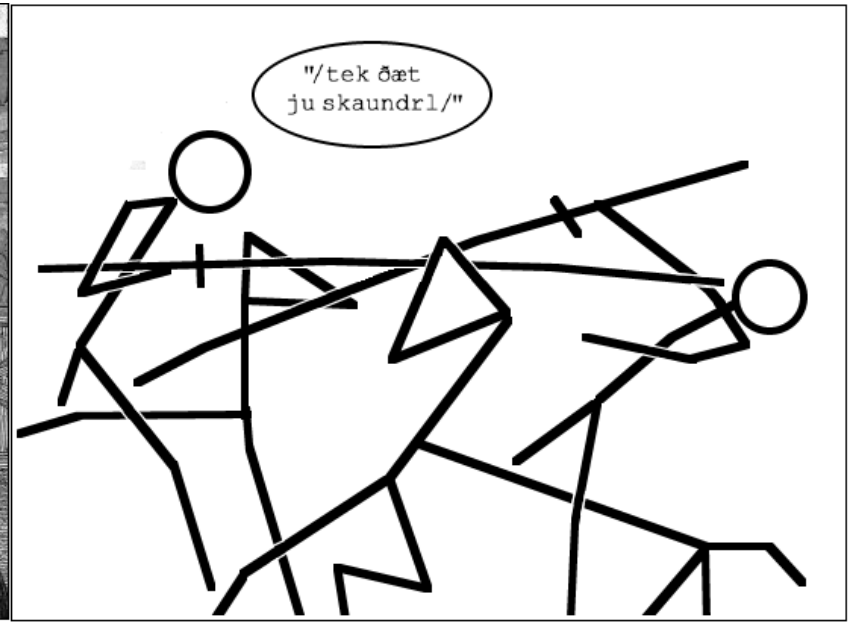
3 February, 2018

# About course

- Here is a course website.
- Here is a course program.
- We expect some theoretical knowledge
  - read 2. chapter from [Gussenhoven, Jacobs 2011]
  - be able to use IPA symbols
- We expect some basic R skills:
  - import .csv files to R
  - dplyr, ggplot2

# Phonetics?...


Phonetics

Phonology

from http://specgram.com/CLIII.1/09.parenchyma.cartoon.e.html

Phonetics is generally assumed to be a subfield that deals with **articulatory**, **acoustic** and **perceptional** aspects of phonological units. Phonology and phonetics together are supposed to describe organization of sounds in languages.

This course is about **acoustic phonetics**.

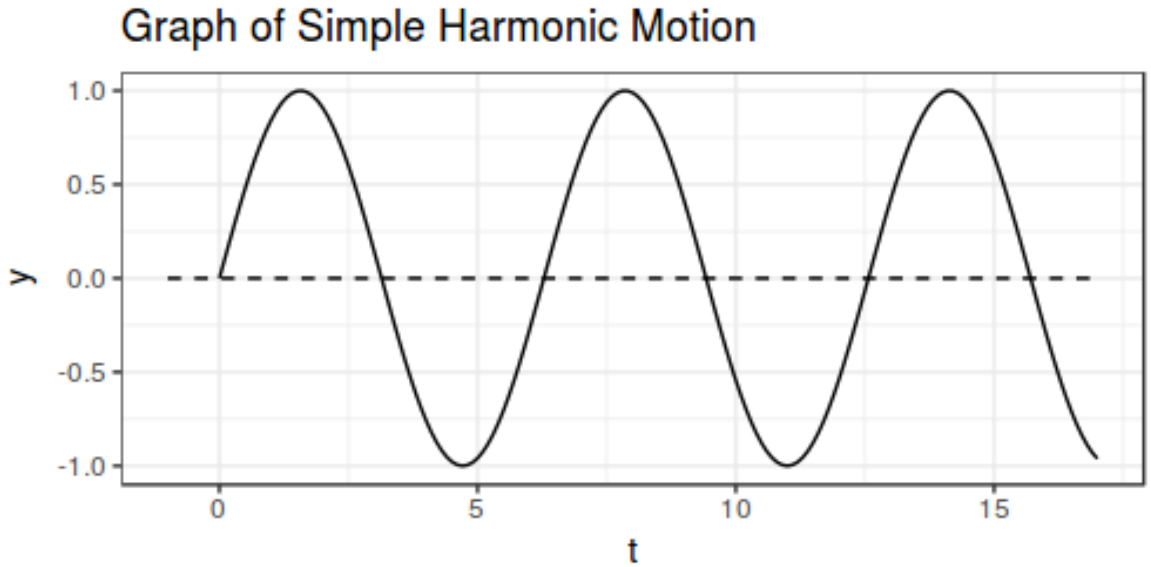
презентация доступна: **https://goo.gl/Rtu5Br**

# Simple Harmonic Motion

**Periodic Motion** is any type of motion that repeats itself after successuve equal time intervals.

**Simple Harmonic Motion** is specific type of periodic motion that arises from

- existence of some **equilibrium position** for a described object;
- **linear restoring force** that tending to pull the described object back to its equilibrium position.



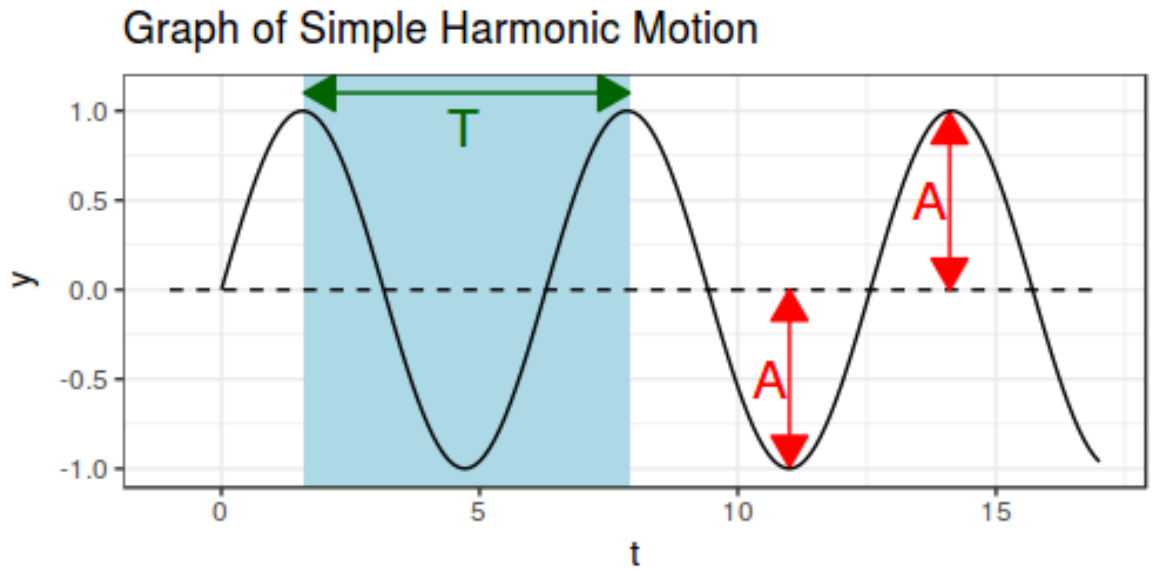
# Simple Harmonic Motion

**Amplitude** is the maximum displacement of the equilibrium position.

**Period (T)** is the duration of time of one cycle in a repeating event. (s)

**Frequency (f)** is the number of period (cycles) per second. (Hz)

$$f = \frac{1}{T} \qquad T = \frac{1}{f}$$



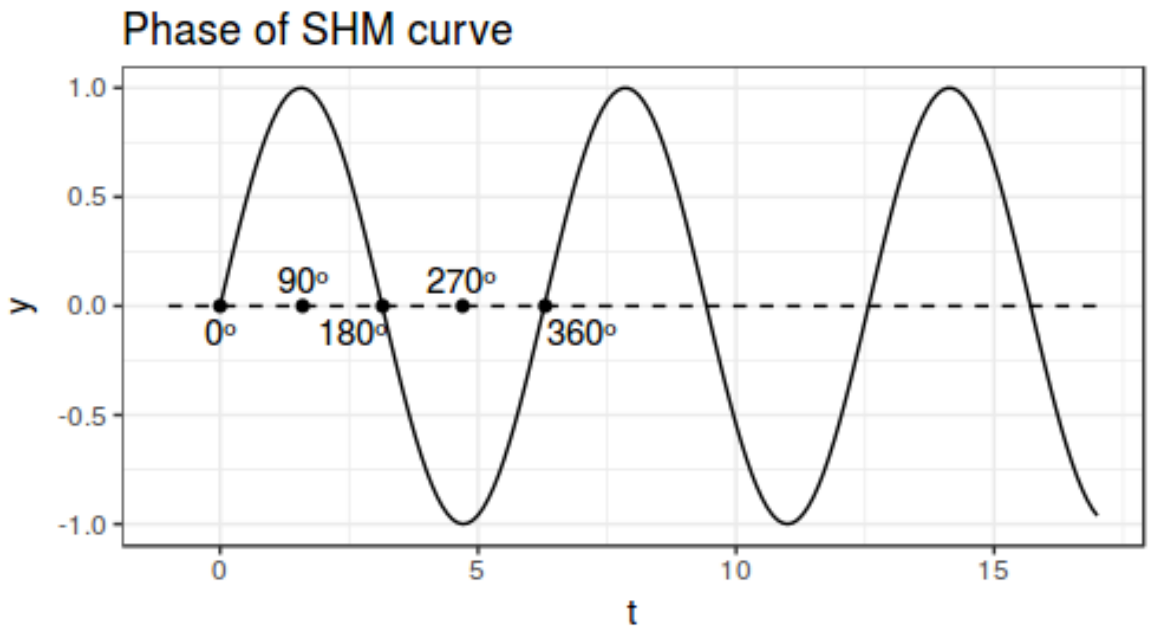
# Sound as SHM

We can correlate the physical properties of sound waves with our perception:

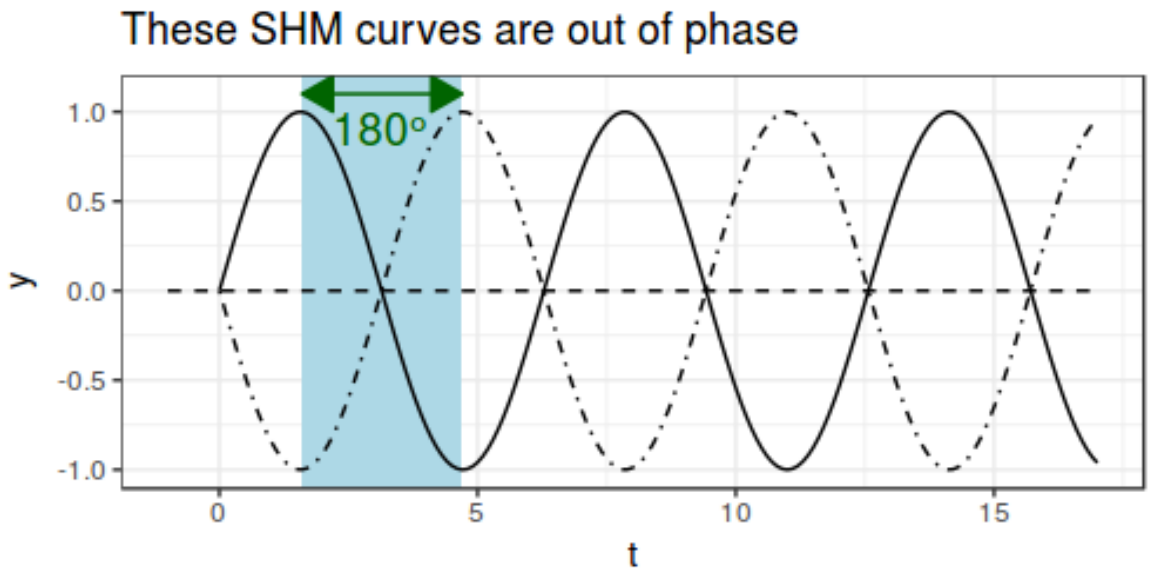
- We perceive changes in frequency as **pitch**
- We perceive changes in amplitude as **loudness**

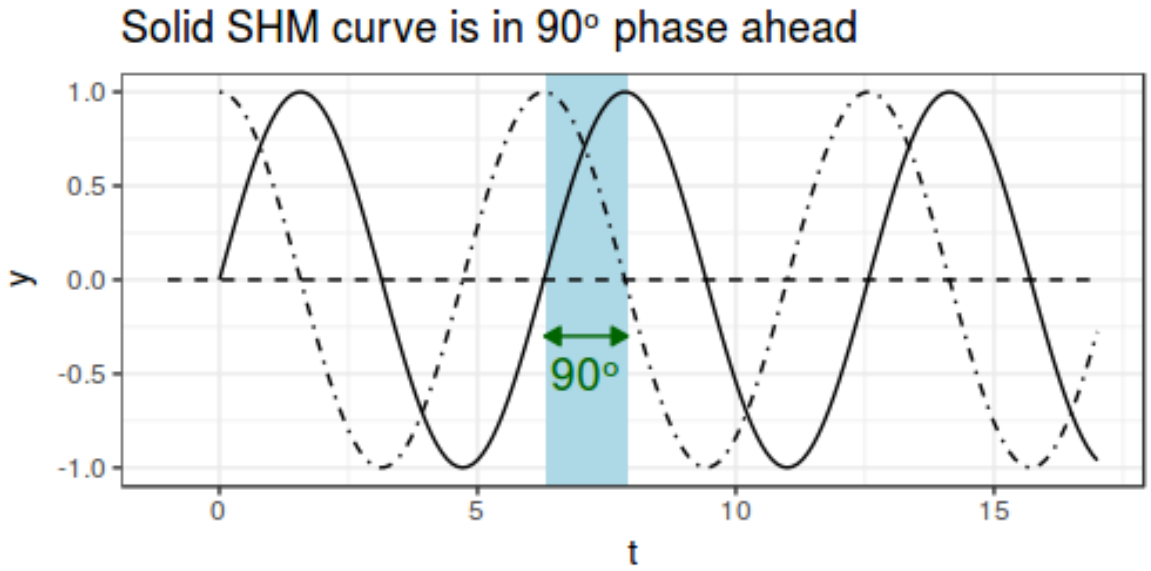
# Phase of SHM

One period of SHM can be devided into $360^0$ of **phase $\varphi$.**



# SHMs comparison



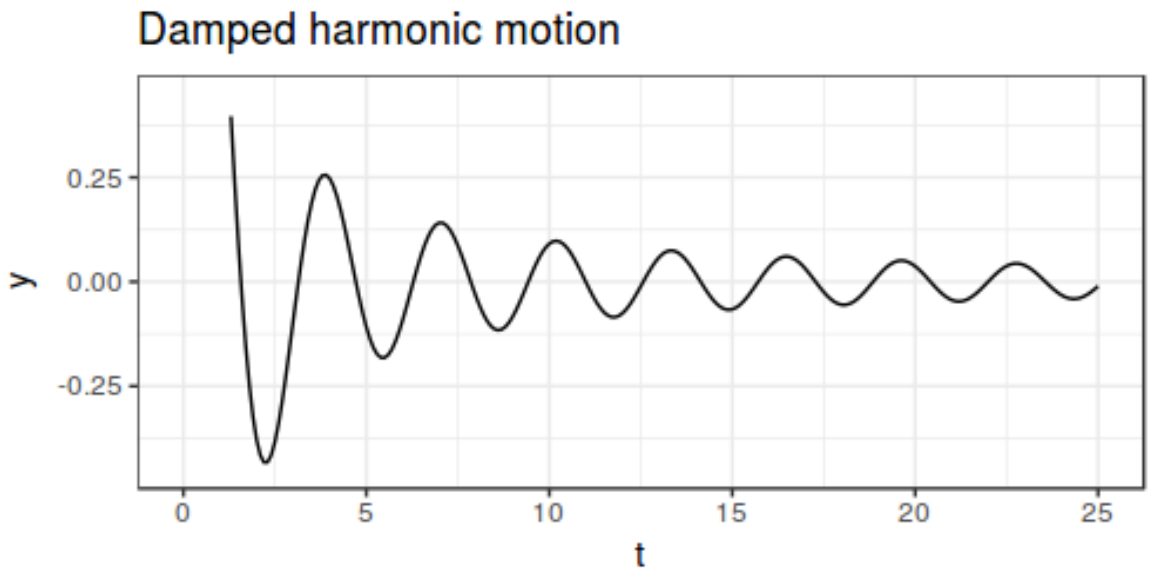
# Wave representation

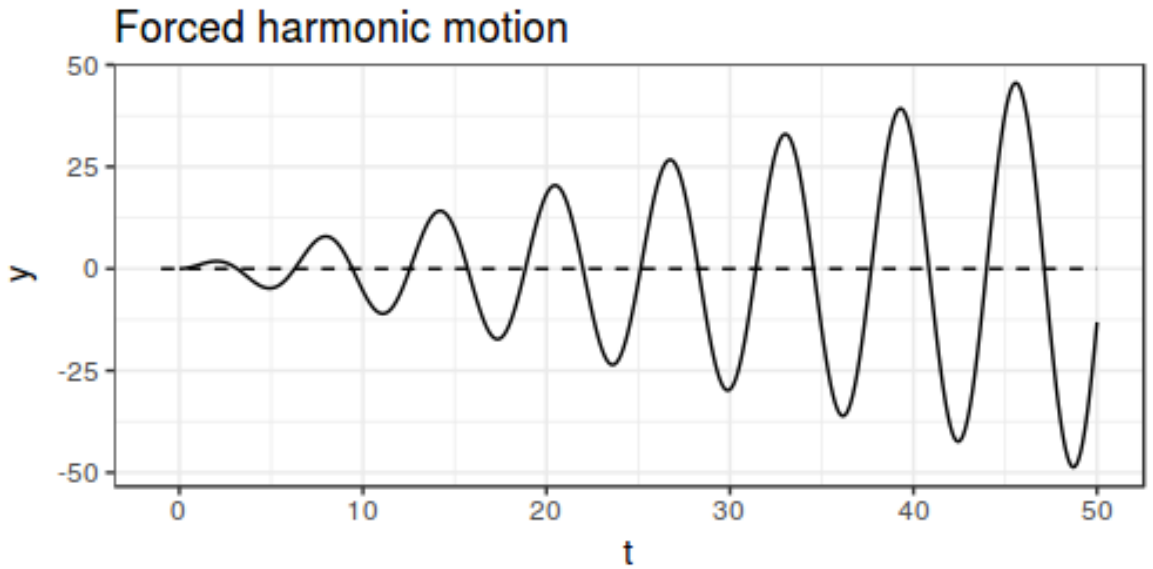
Waves can be represented by formula:

$$s(t) = A \times \cos(2\pi ft + \phi)$$

- $A$ — amplitude
- $f$ — is the fundamental frequency
- $\phi$ — phase
- $t$ — time

# Harmonic motion

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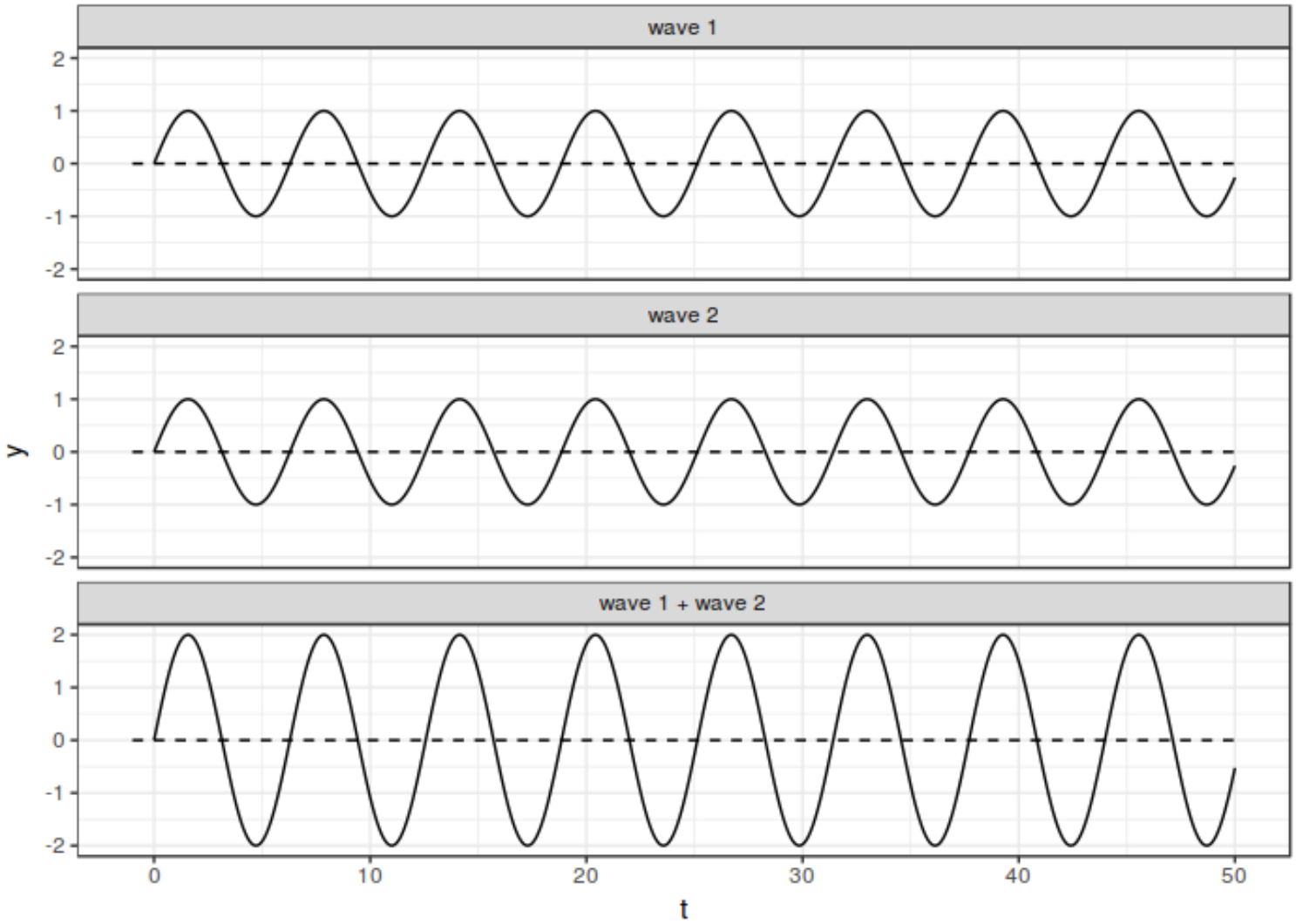
# Harmonic motion

Harmonic motions are closely related with the phenomena of **resonance** and **antiresonance**.

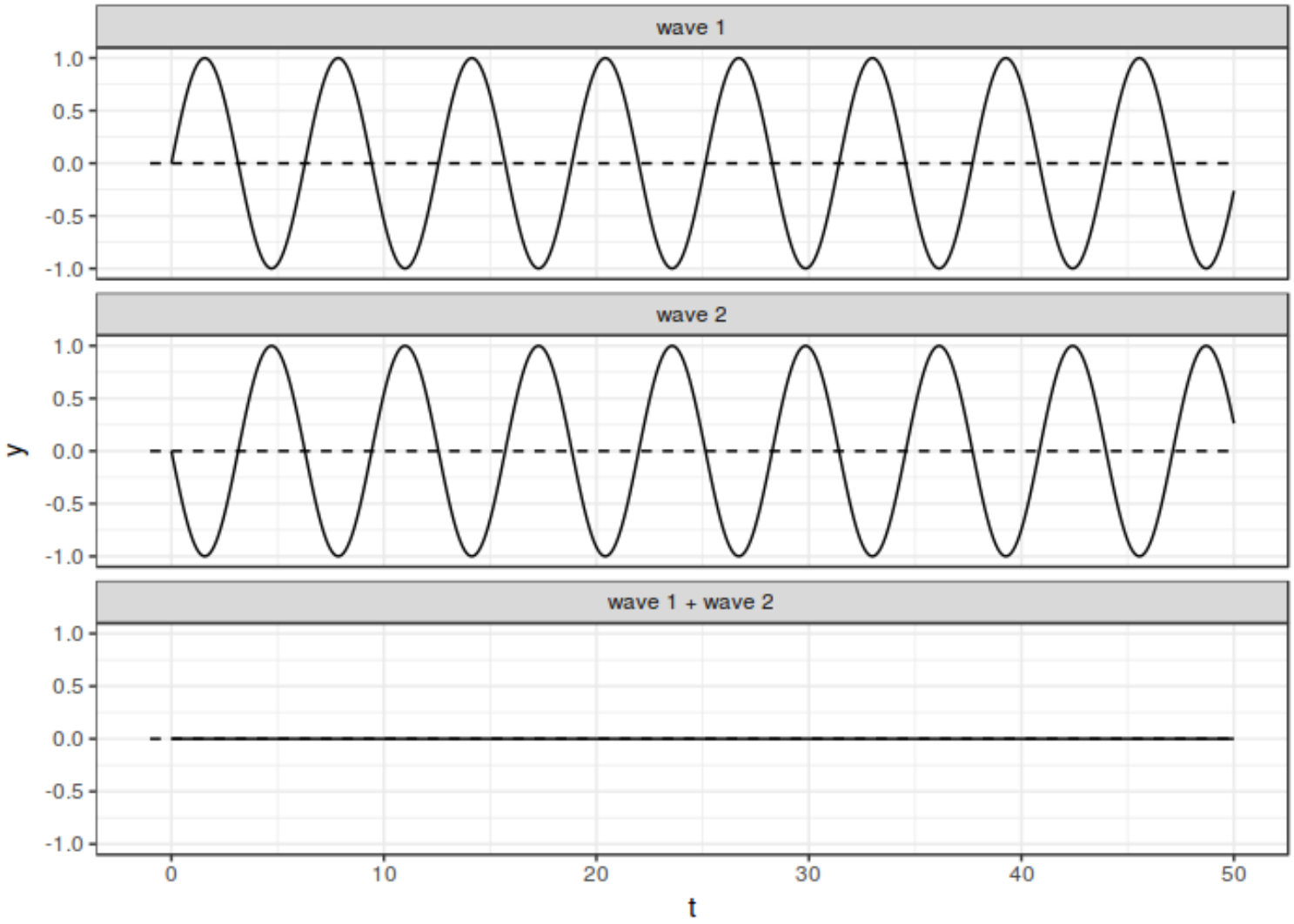
**Resonance** is a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies.

**Antiresonance** is a phenomenon in which a vibrating system or external force drives another system to oscillate with smaller amplitude at specific frequencies.

# Addition of waves



# Addition of waves



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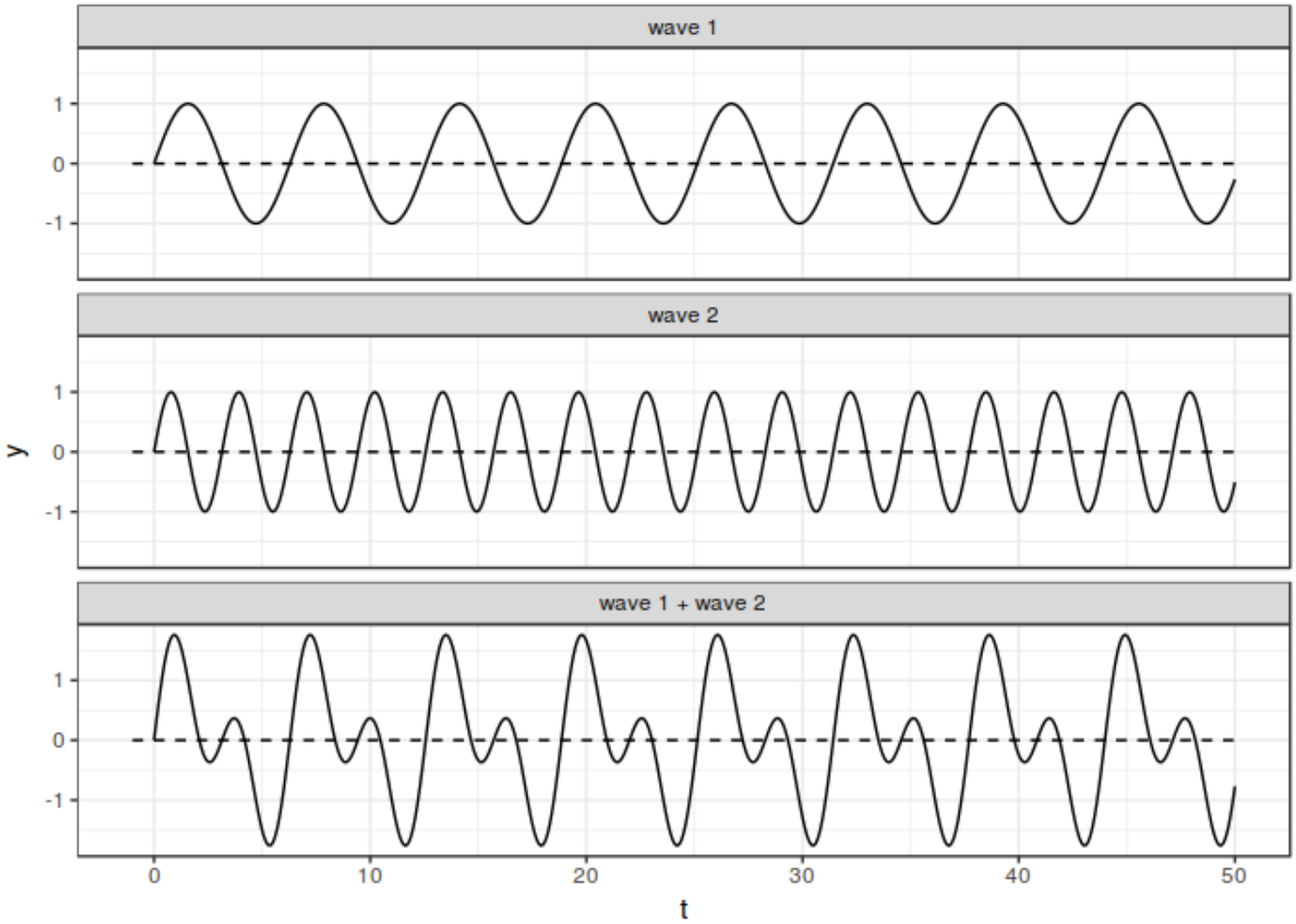

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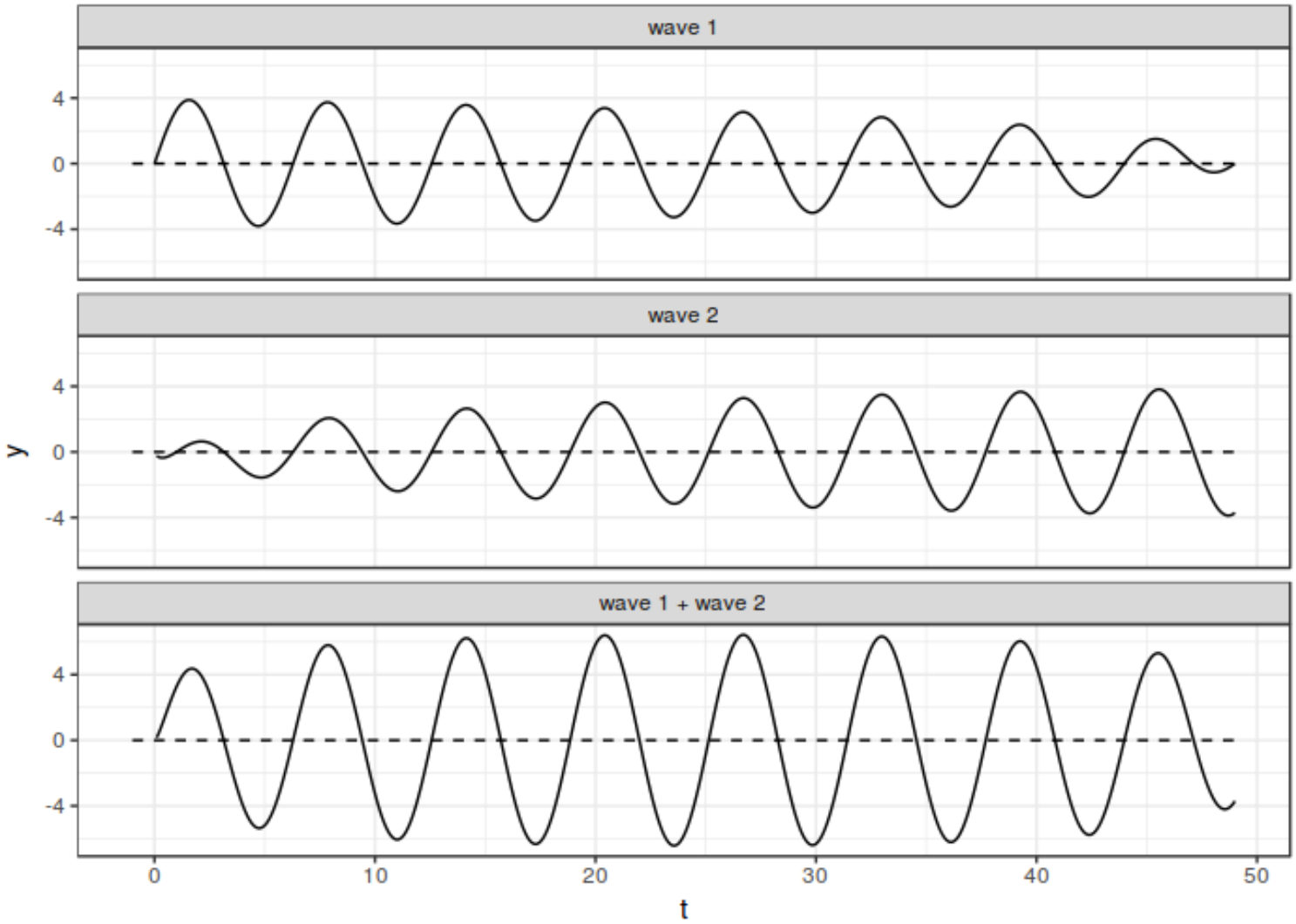
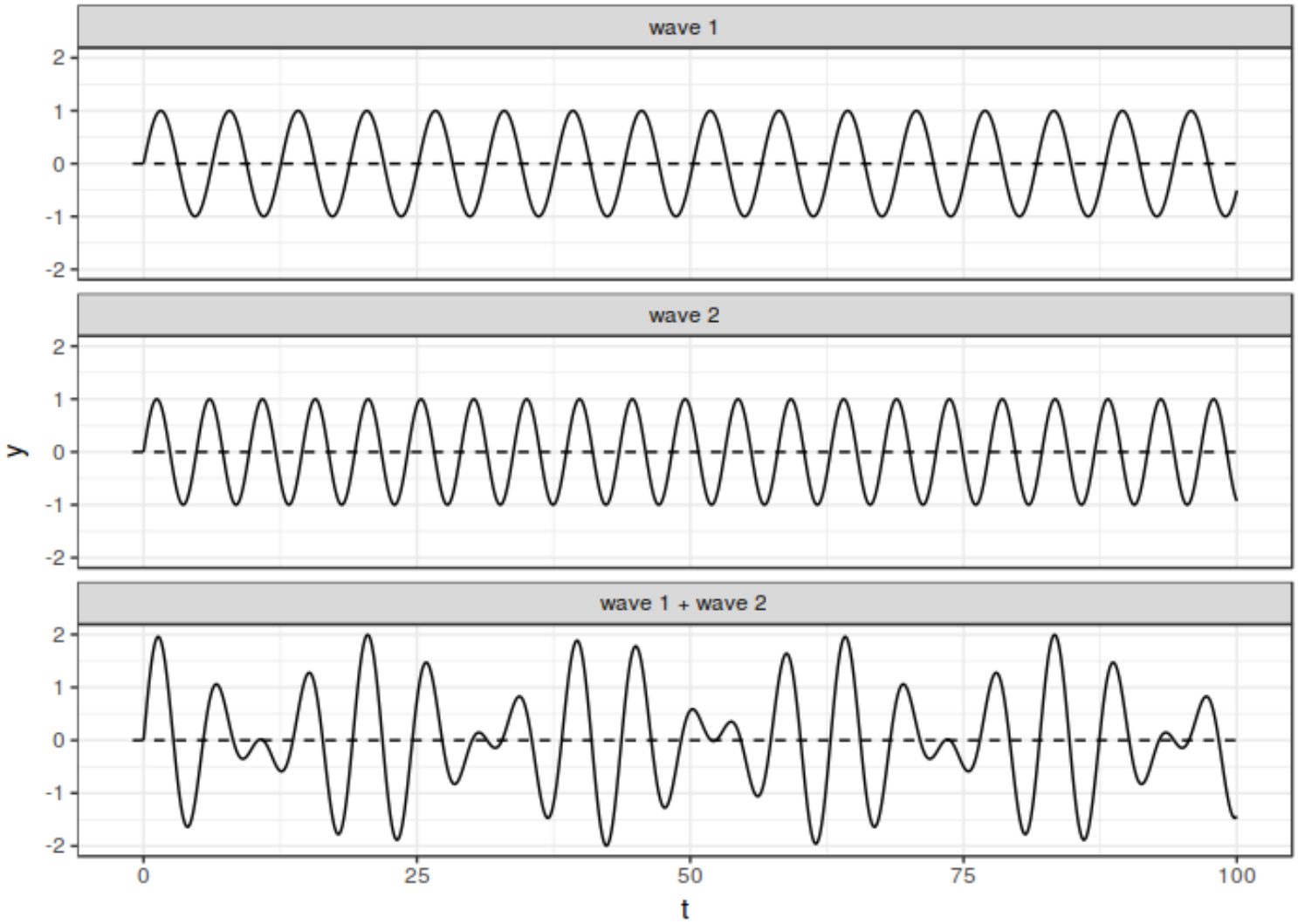
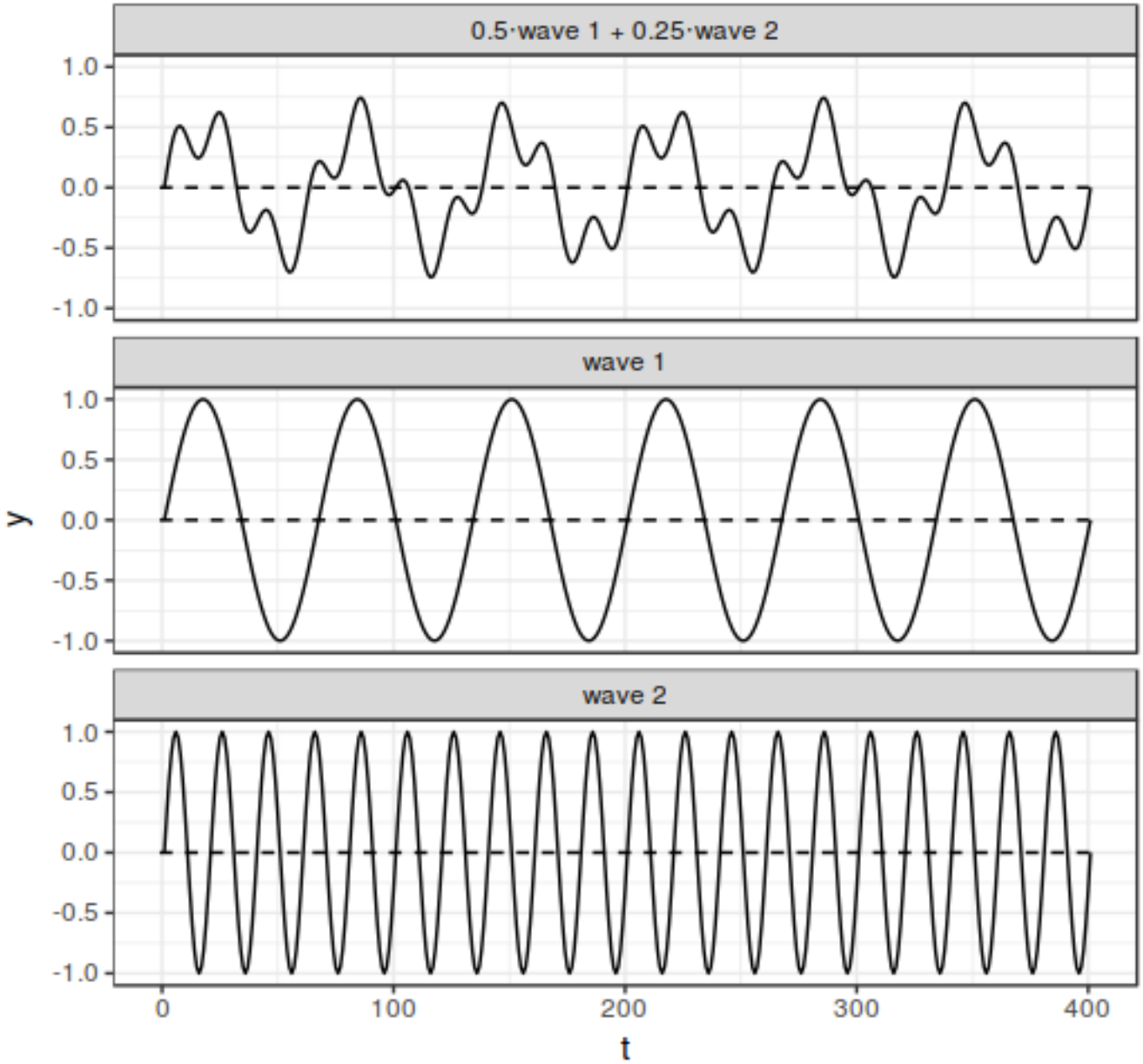


# Beats

**Beats** is a phenomenon of the change in amplitude of the sum of two waves with slightly different frequencies.



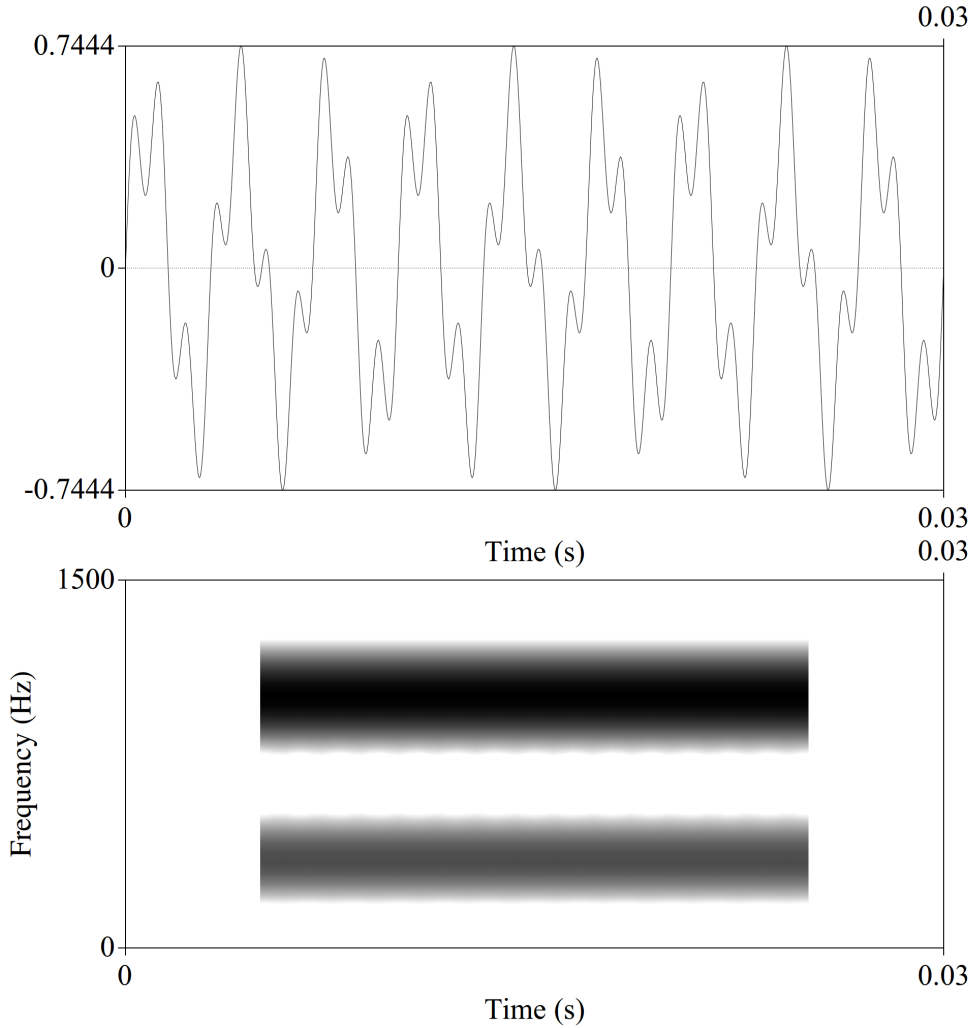
**Fourier Transform** allows to extract components of the complex wave.

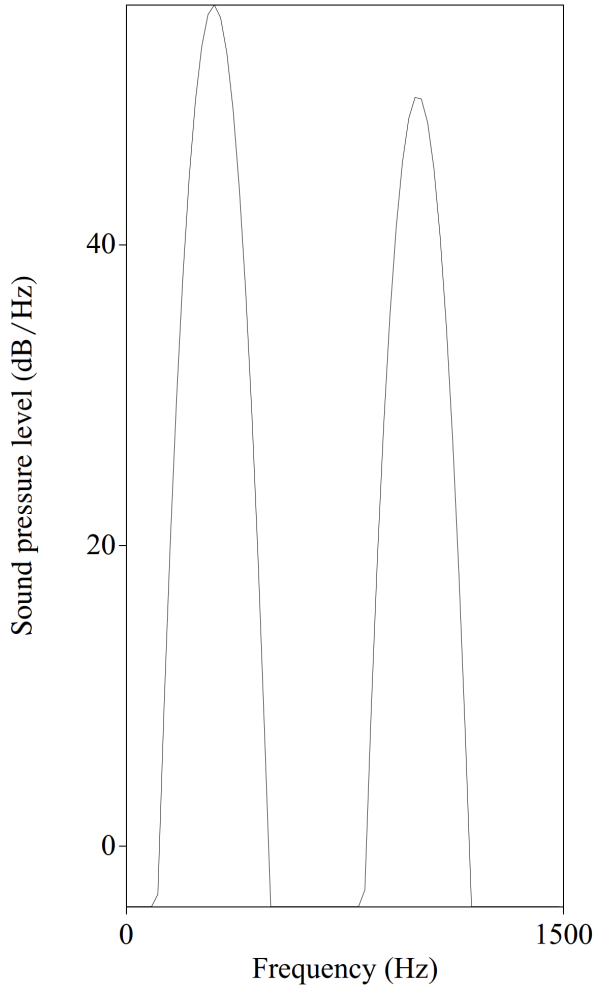


**Fourier Transform** allows to extract components of the complex wave.

| smoothie | complex wave |
|---|---|
| ↓ | ↓ |
| 1 banana, cut in chunks | 300 Hz |
| 1 cup grapes | 1000 Hz |
| vanilla yogurt | |
| 1/2 apple, cored and chopped | |
| 1.5 cup fresh spinach leaves | |

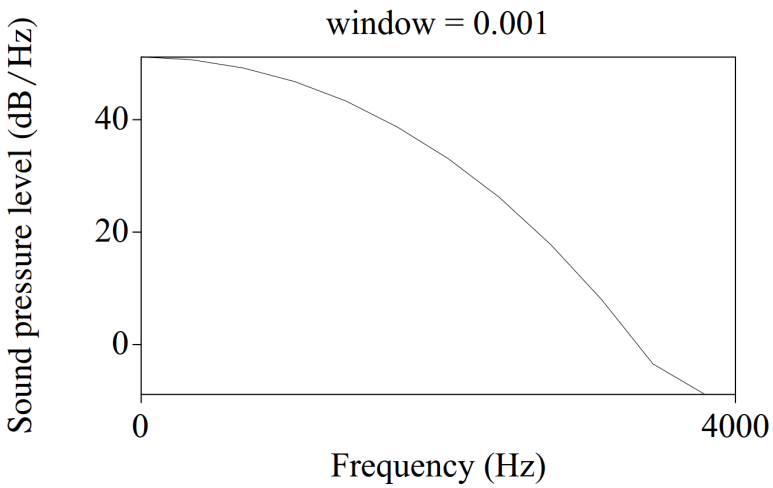
# Spectrogram

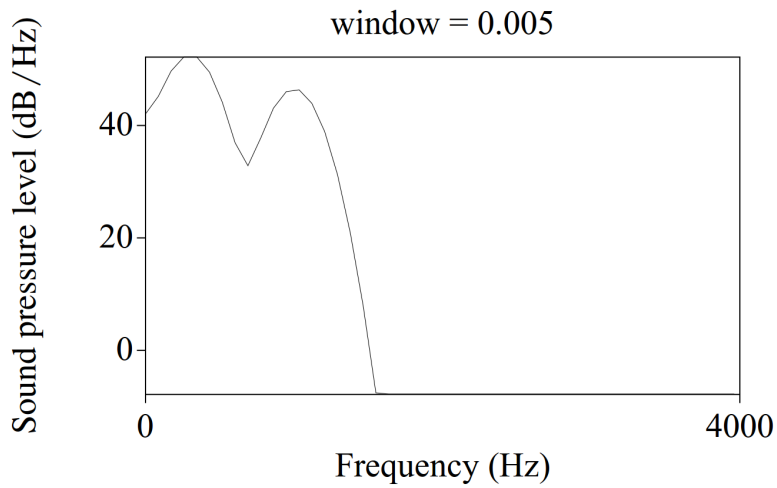


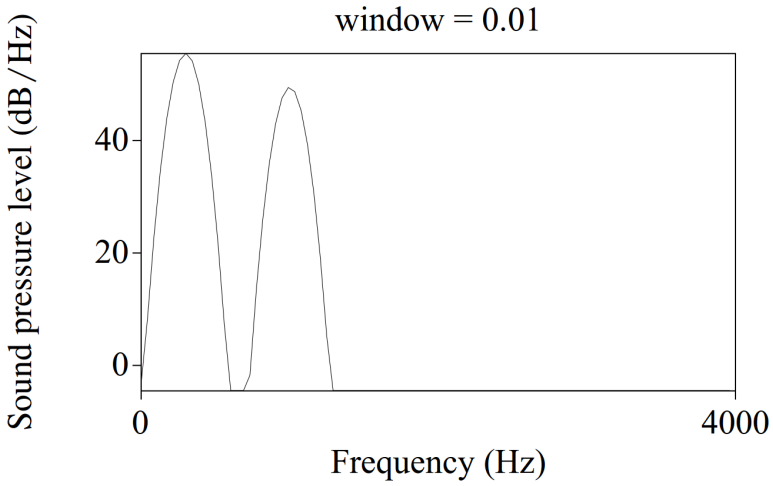



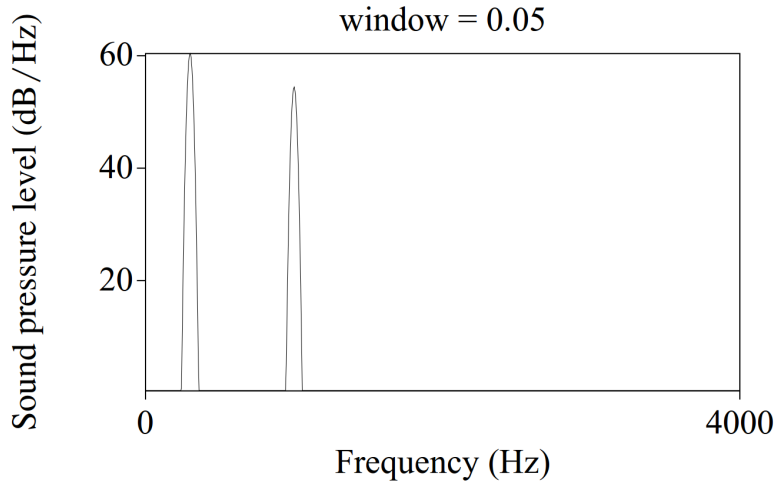
# Spectral slices

## Spectrograms are differ in window length



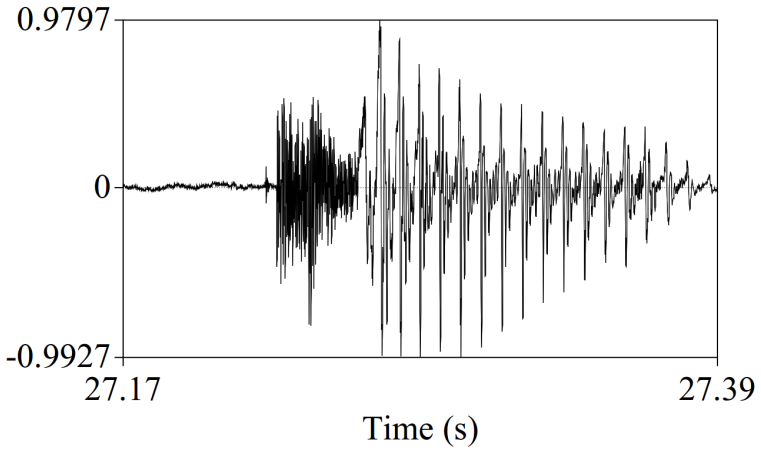



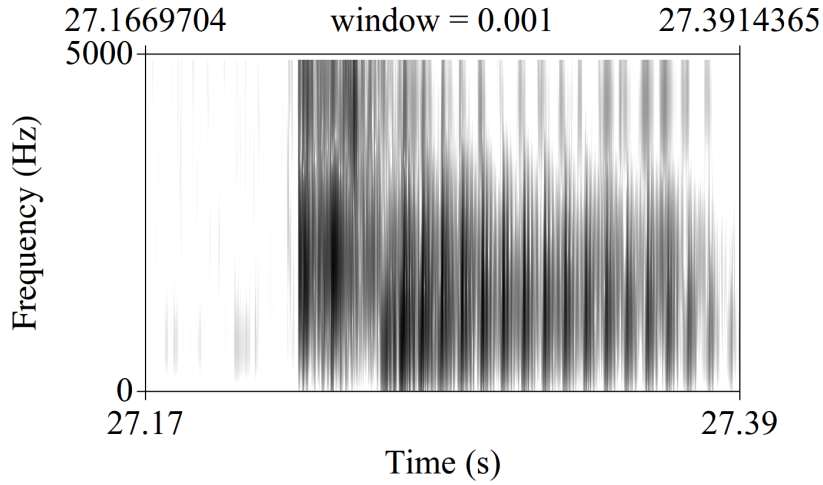



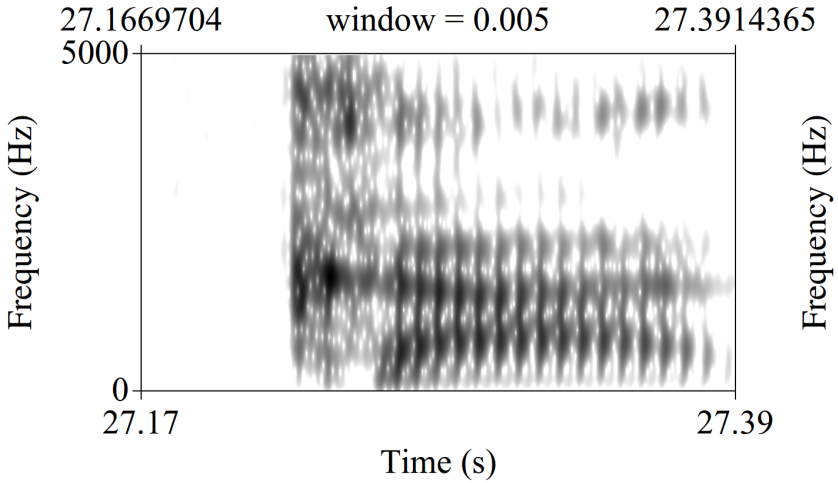



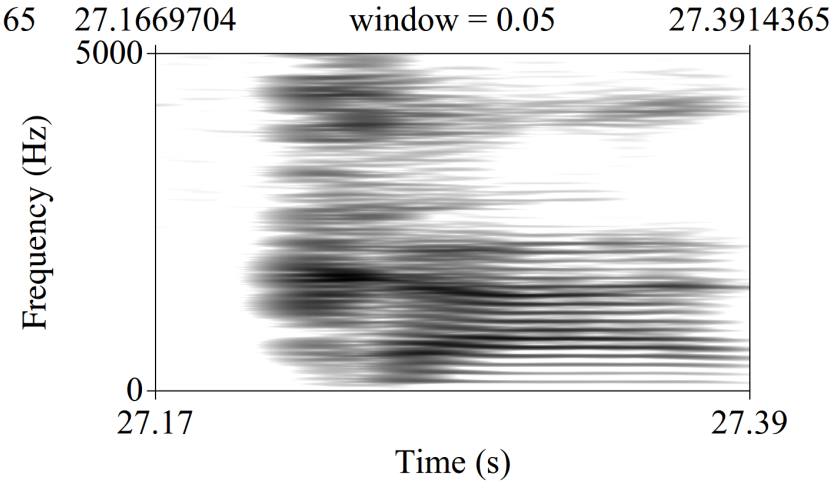
# Spectrograms

## Syllable [ka]



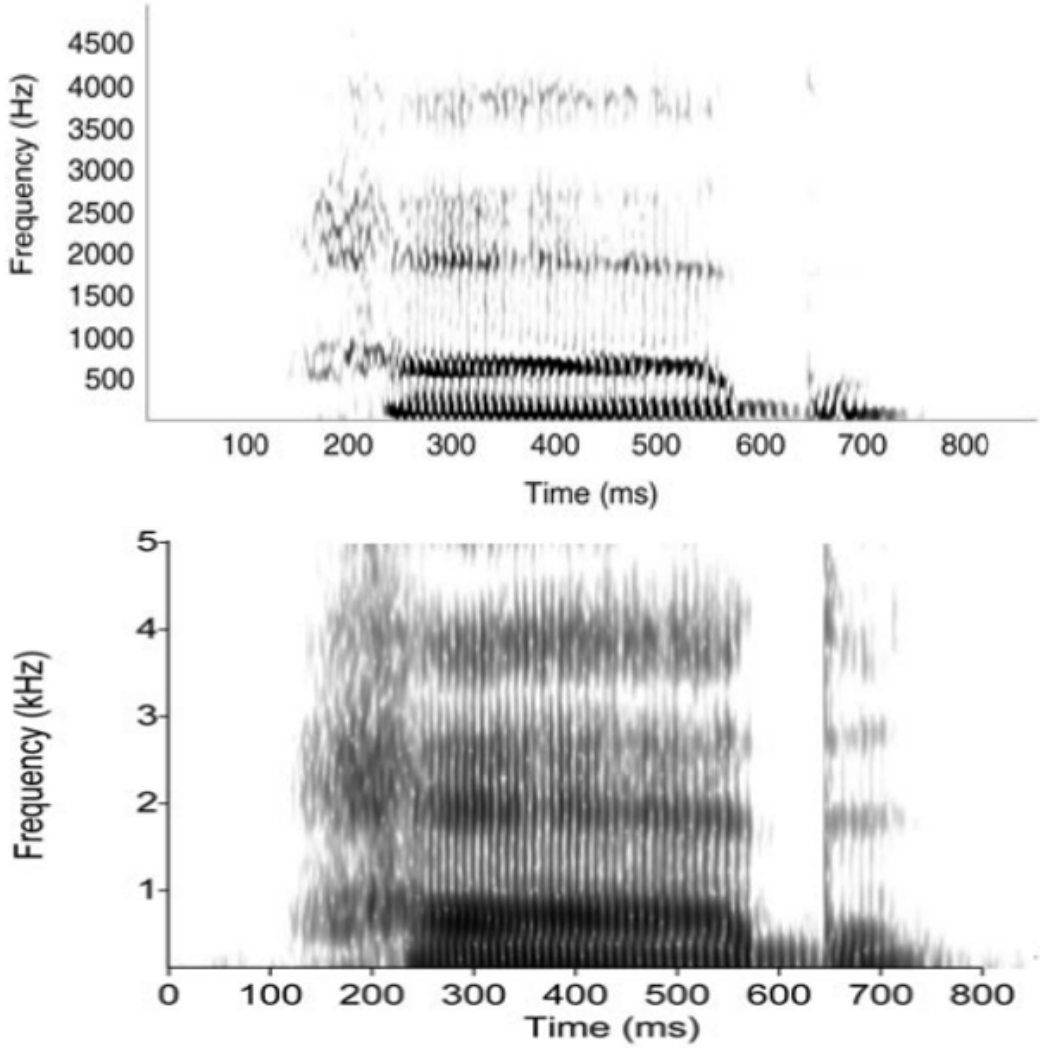



# Not by Fourier alone

Conventional spectrogram and Zhao-Atlas-Marks distribution of the English word *had*, computed using a Kaiser tapering function.




from [Fulop 2011: 119]

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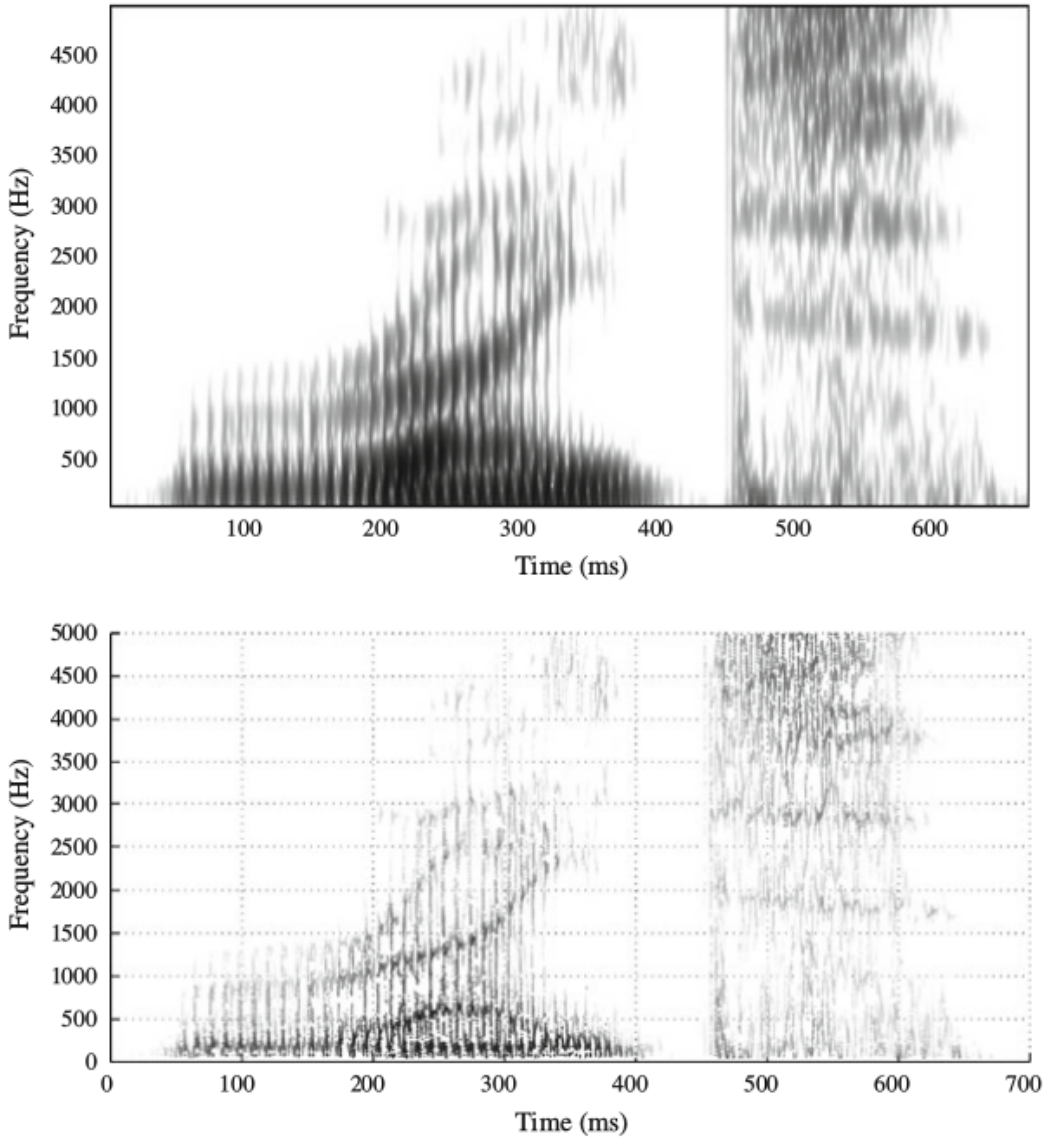
# Not by Fourier alone

Conventional and reassigned spectrograms of the English word *right*

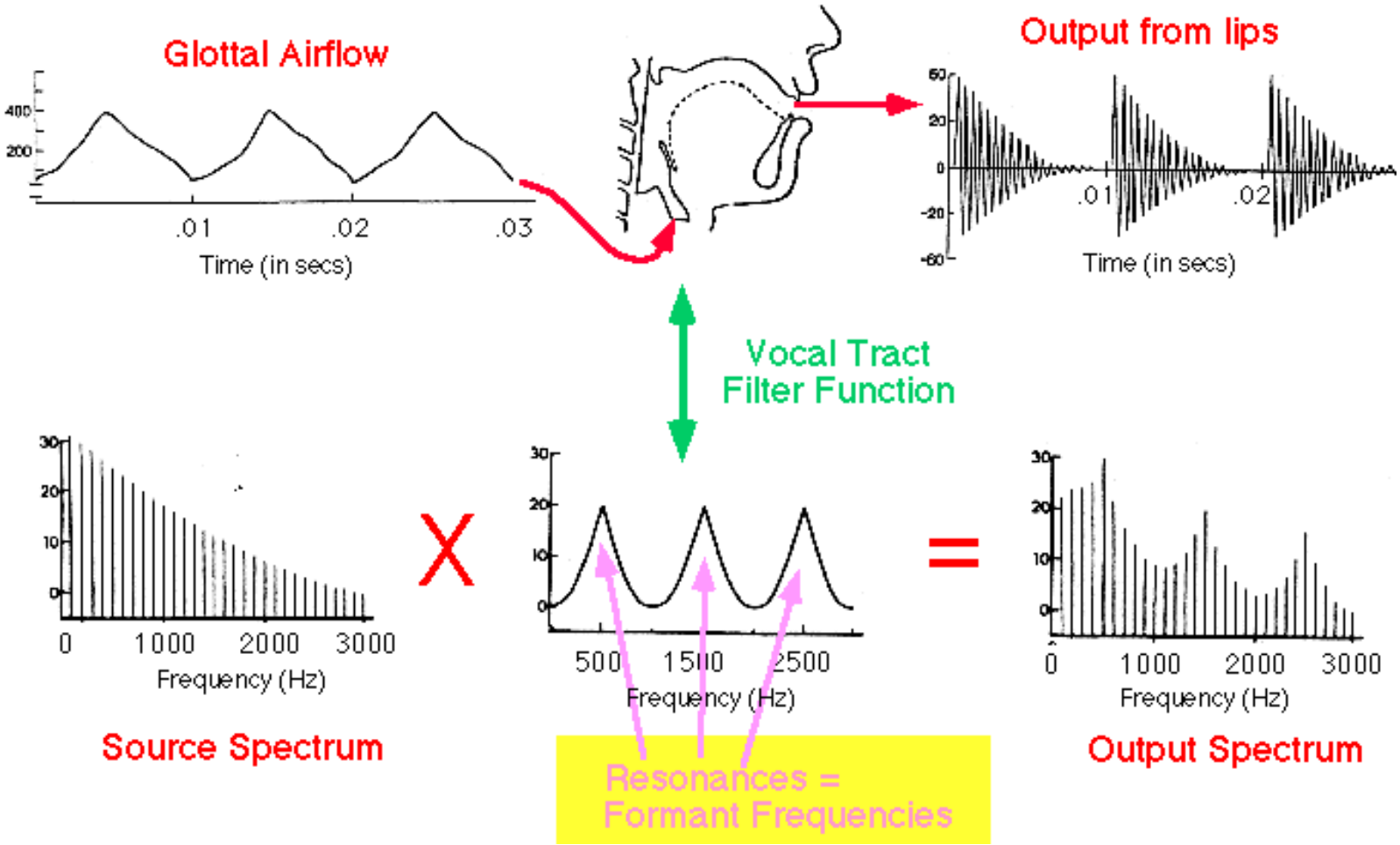



from [Fulop 2011: 142]

презентация доступна: **https://goo.gl/Rtu5Br**

# Source-Filter Model of Speech Production

The output energy (at the mouth) for a given frequency is equal to the amplitude the source harmonic, multiplied by the magnitude of the filter function for that the frequency.



# Summary

- sounds are waves (with amplitude, frequency and phase)
- simple waves can be combined to the complex one
- Fourier transform allows to extract components of the complex wave
- It is not only Fourier transform that allows to extract components of the complex wave
- Source-Filter Model: vocal tract is a resonator that filters some frequencies of the wave produced by vocal folds vibration.

# Thank you!

Please, don't hesitate to write me

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# Reference

Berg, R. E., Stork D. G. (2005). The physics of sound. Pearson Education.

Fulop, S. (2011). Speech spectrum analysis. Springer Science & Business Media.

Gussenhoven, Carlos, Haike Jacobs (2011). Understanding Phonology Hodder Education. USA.