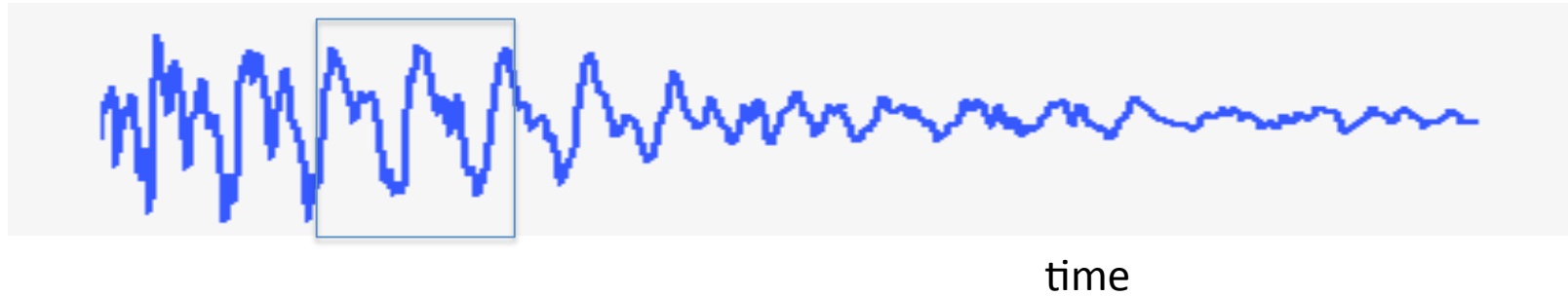
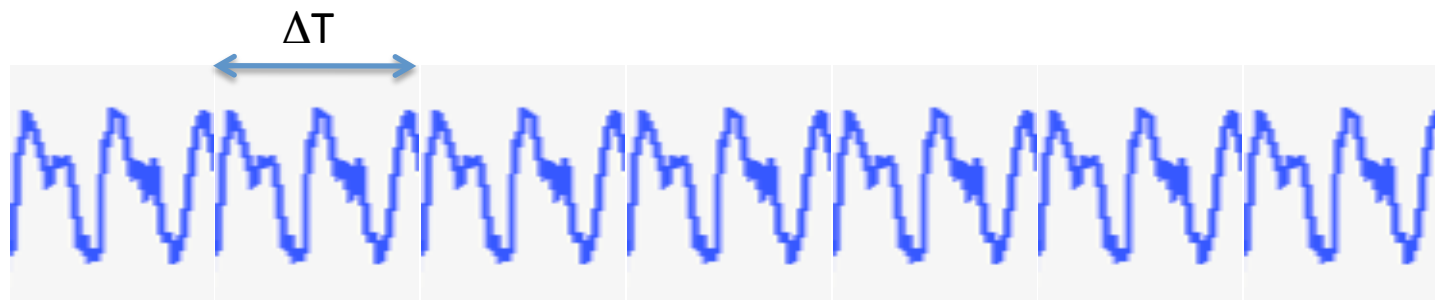
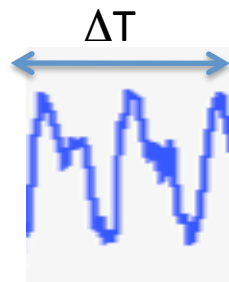


signal is typically changing in time (non-stationary)

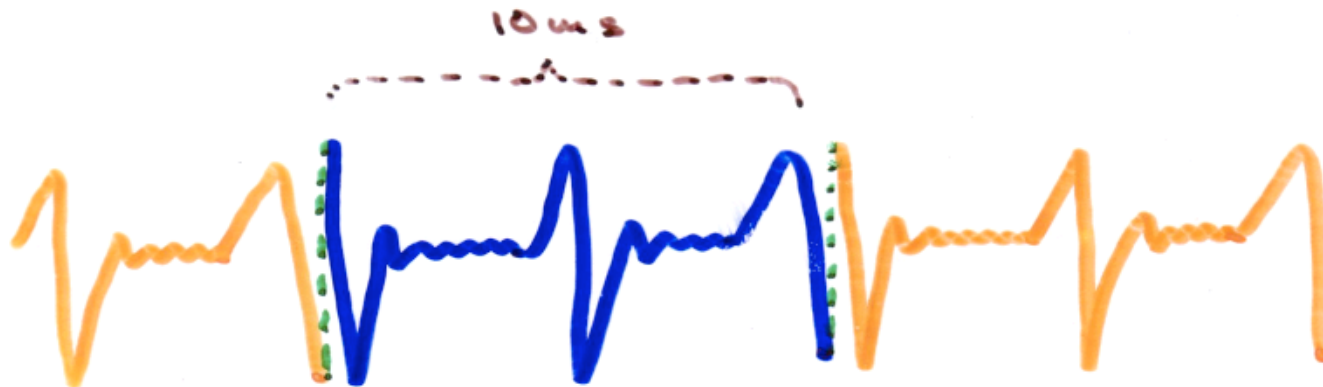


short-term analysis: consider only a short segment of the signal at any given time



to analysis the signal appear to be periods with the period ΔT

Non-stationary turns into periodic



Discrete Fourier Transform

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) \cdot e^{j\frac{2\pi kn}{N}} \quad X(k) = \frac{1}{N} \sum_{n=0}^{N-1} x(n) \cdot e^{-j\frac{2\pi kn}{N}}$$

Discrete and periodic in both domains (time and frequency)

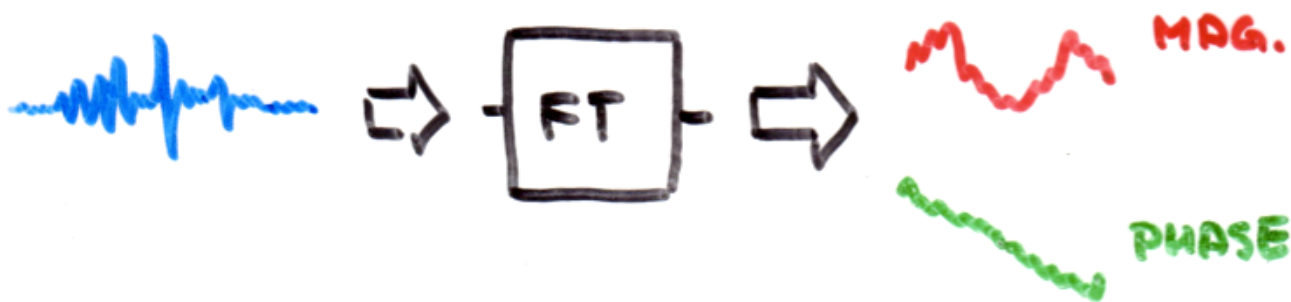
Short-term Discrete Fourier Transform

$$S_n(e^{j\omega}) = \sum_{m=-\infty}^{\infty} s(m) \cdot w(n-m) \cdot e^{-j\omega m}$$

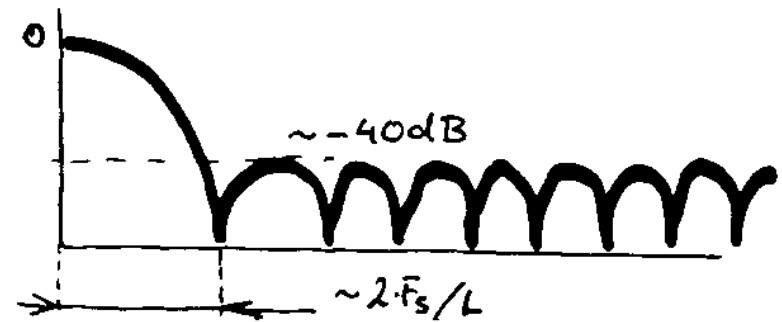
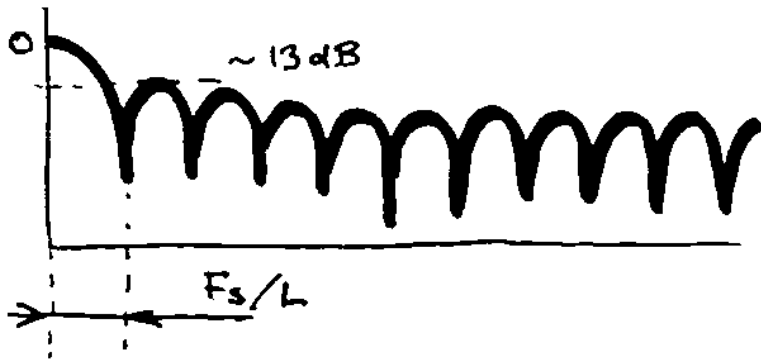
n-fixed (FIXED WINDOW POSITION)

- FOURIER TRANSFORM OF

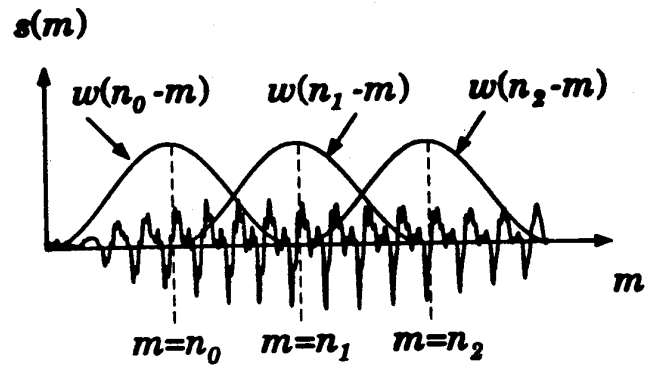
$s(m) \cdot w(n-m)$



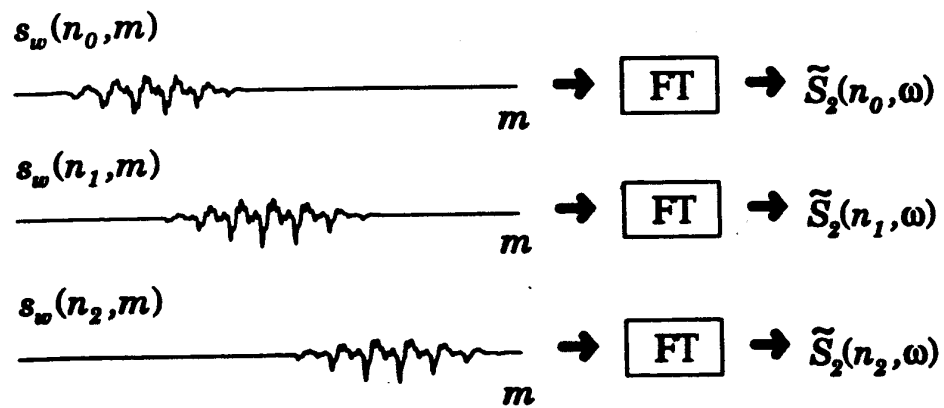
Signal multiplied by the window



Spectrum of the signal convolves with the spectrum of the window

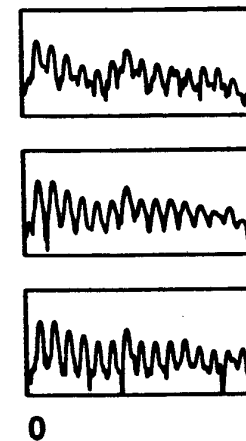


1D
 ↓
 2D



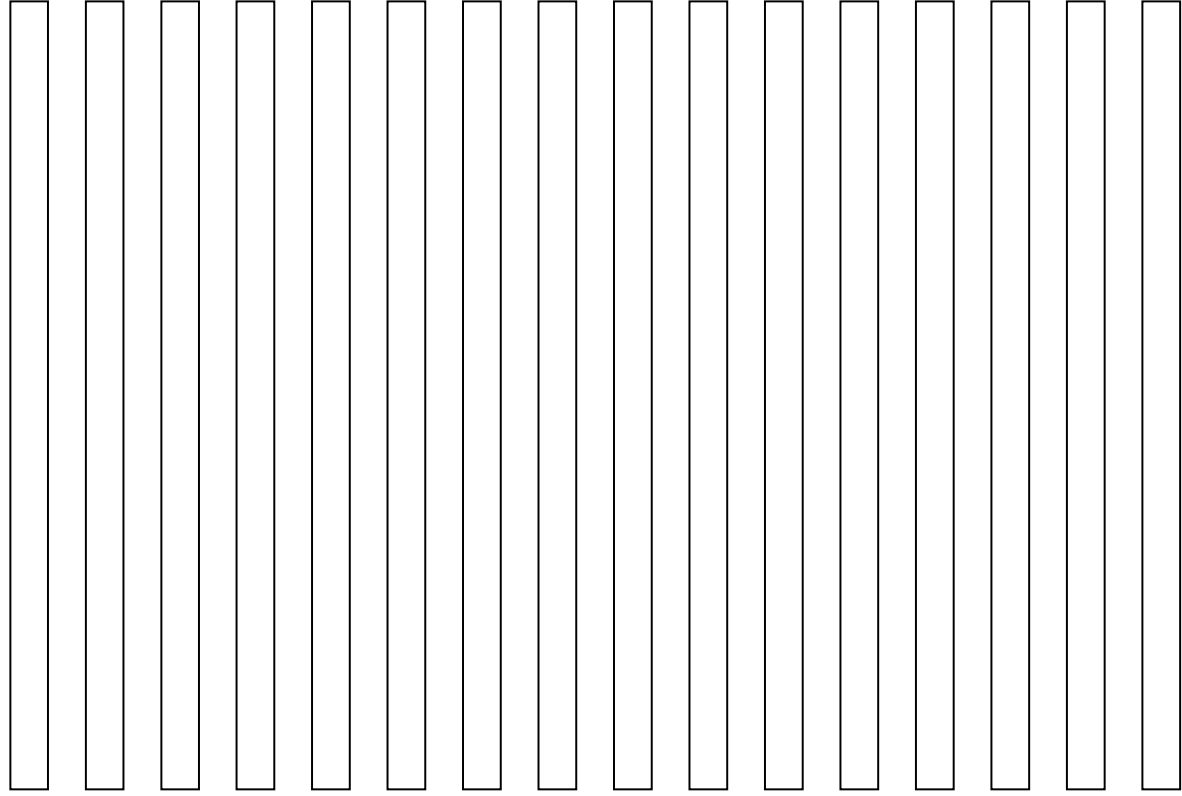
**Time-frequency
 representation**

frequency



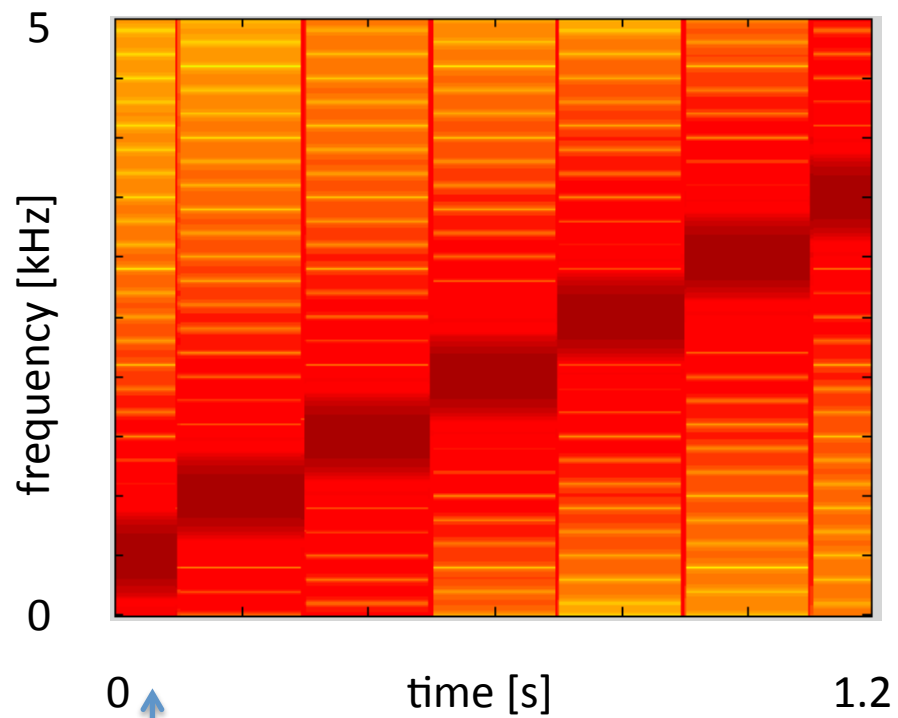
time

frequency

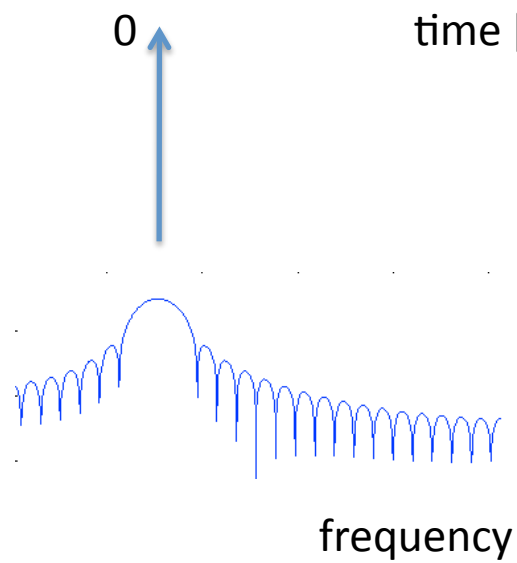
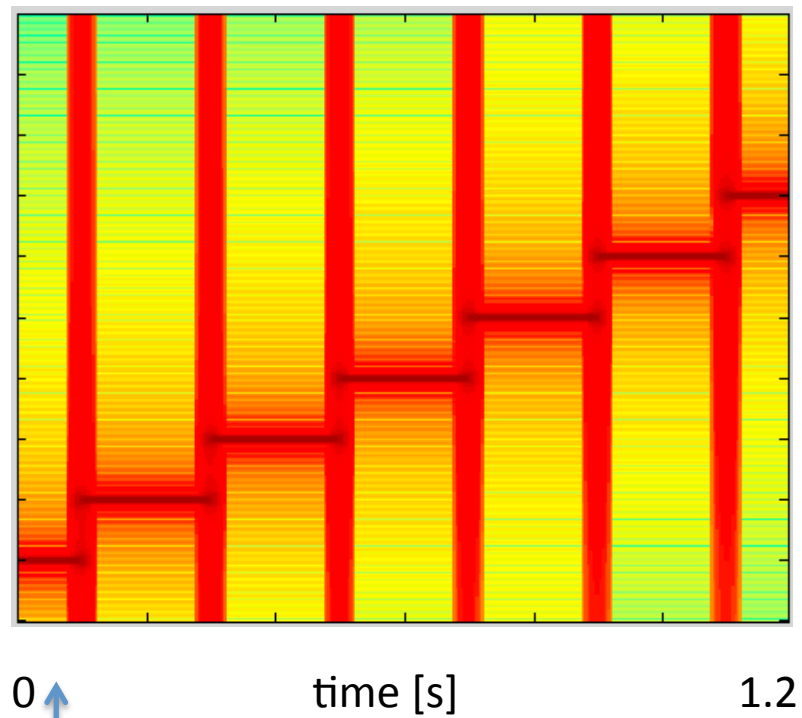


time

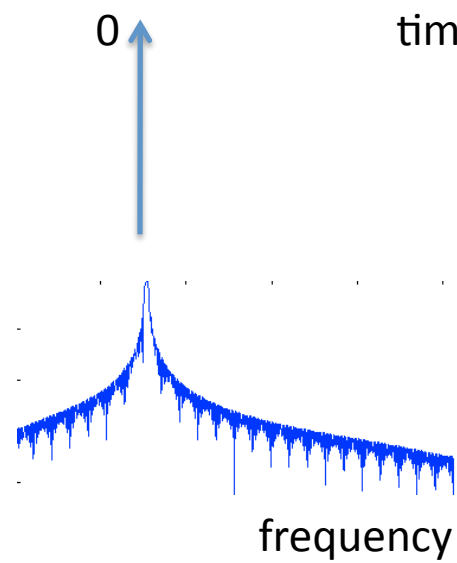
Analysis window 5 ms

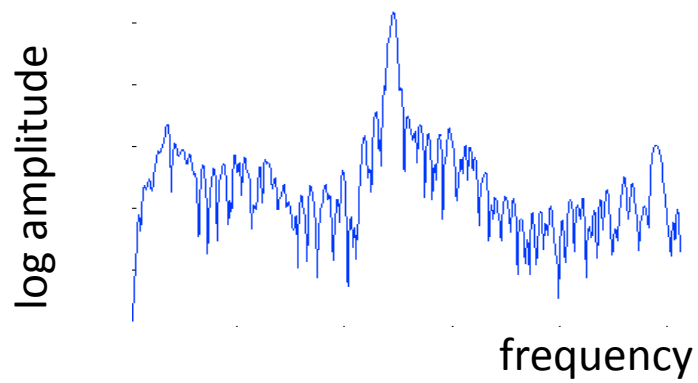
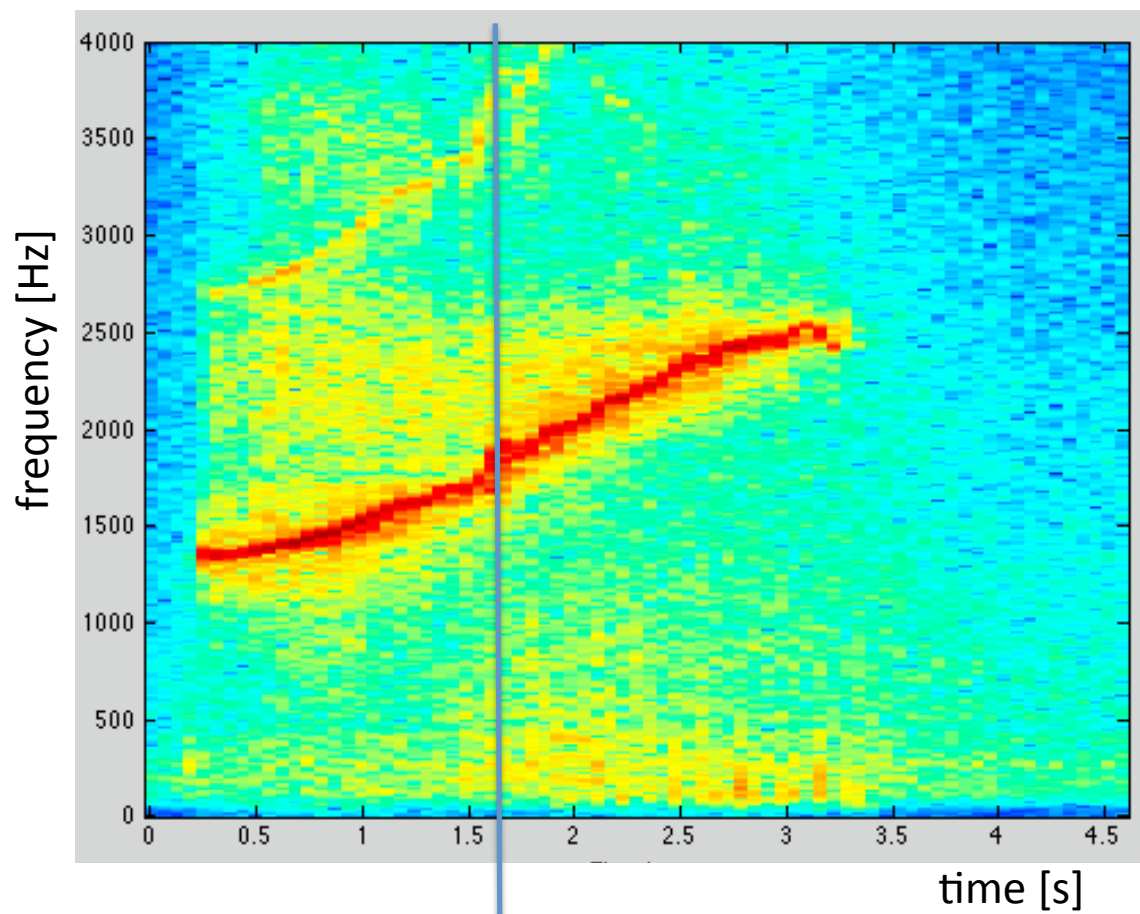


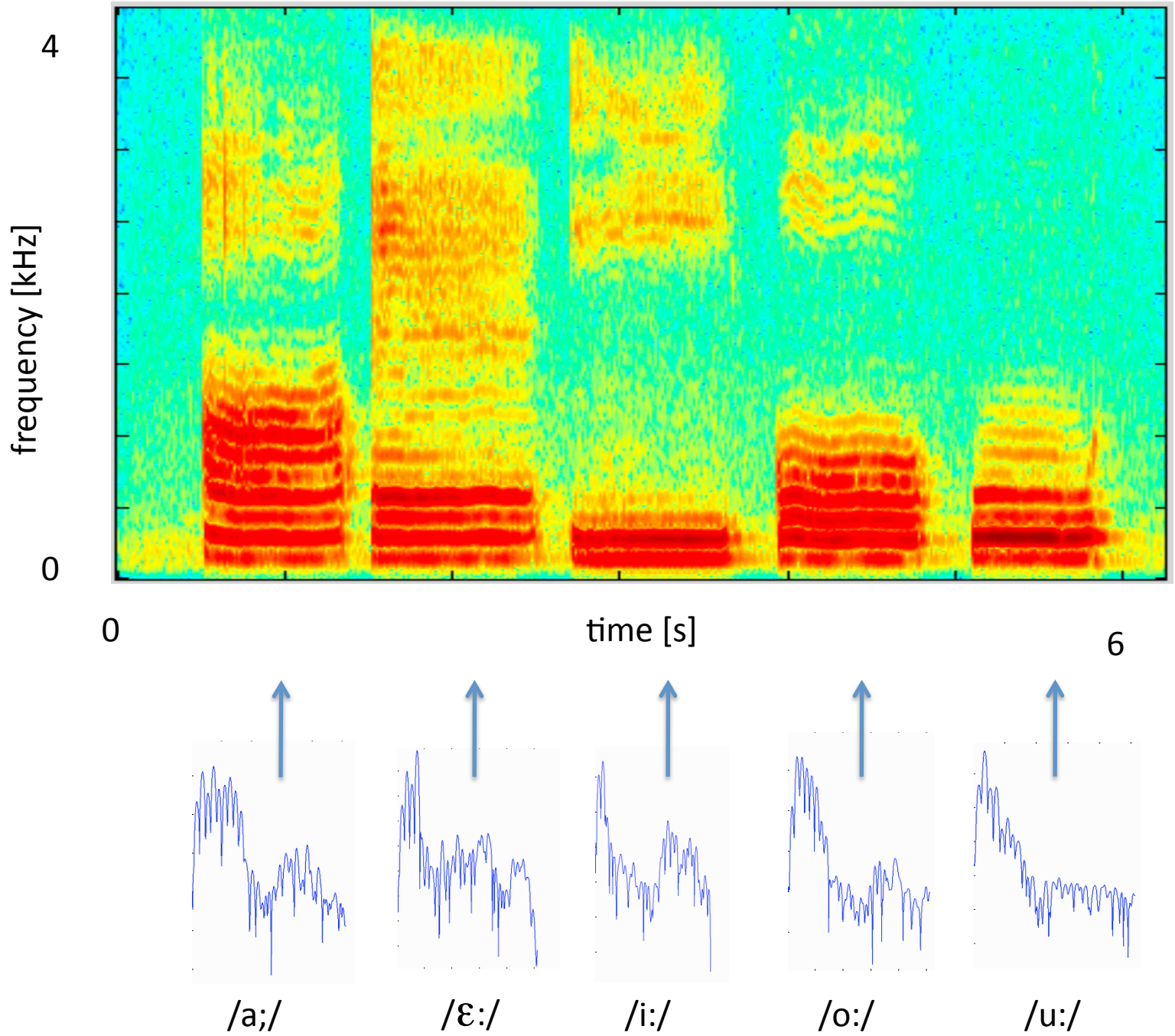
Analysis window 50 ms



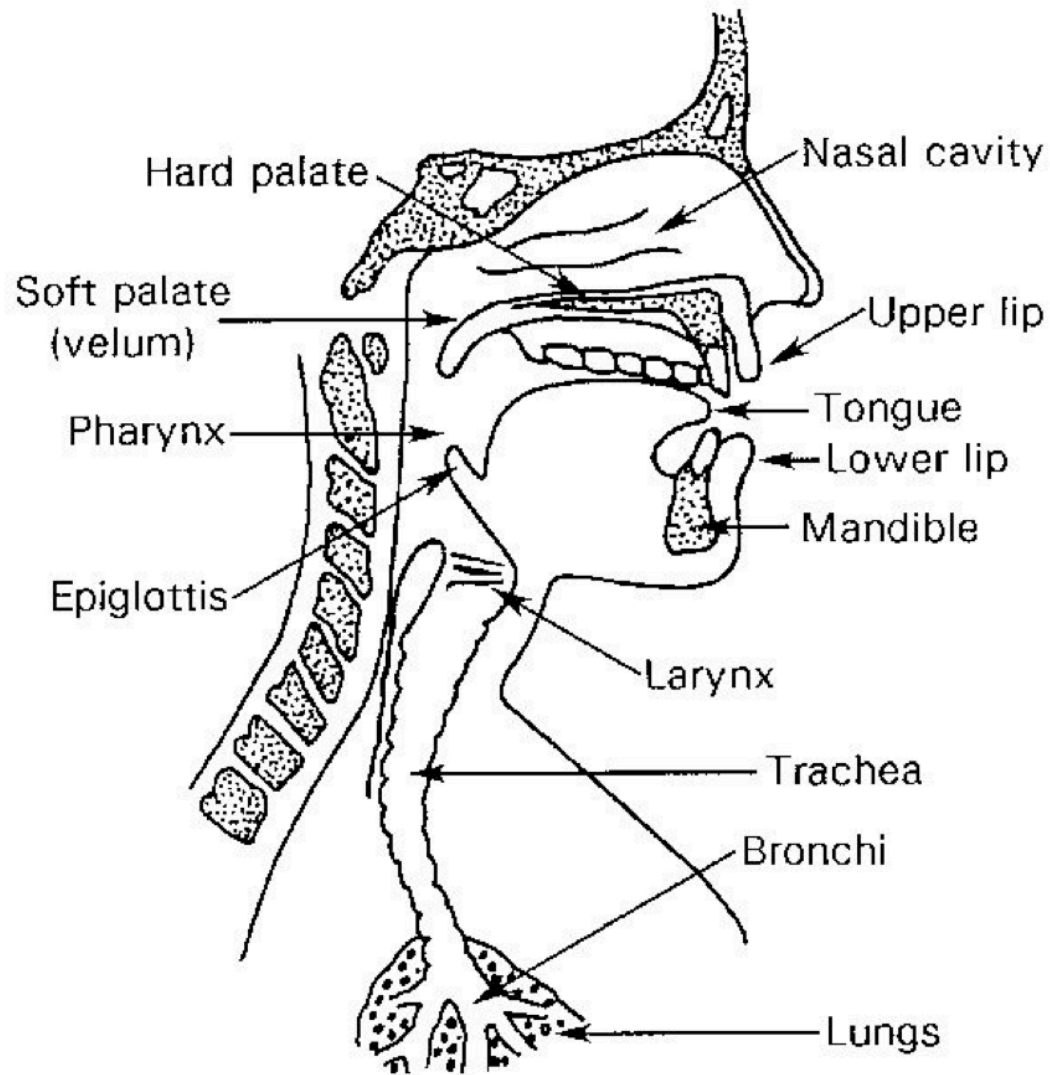
log amplitude

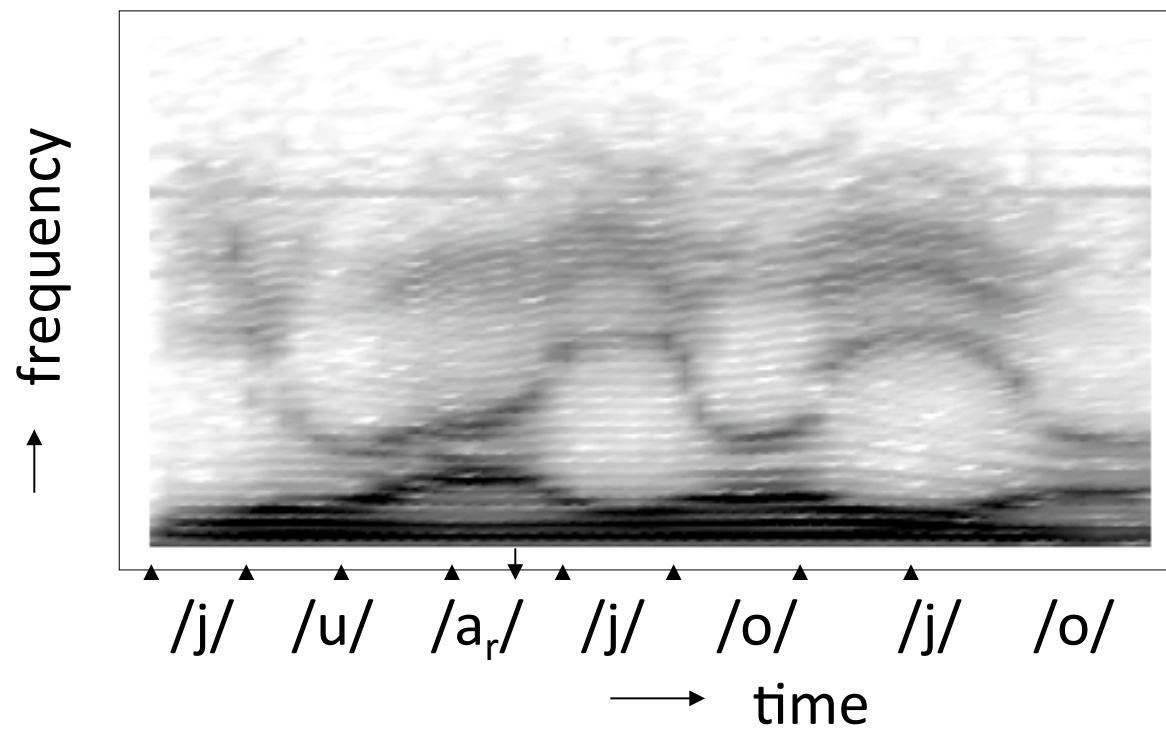






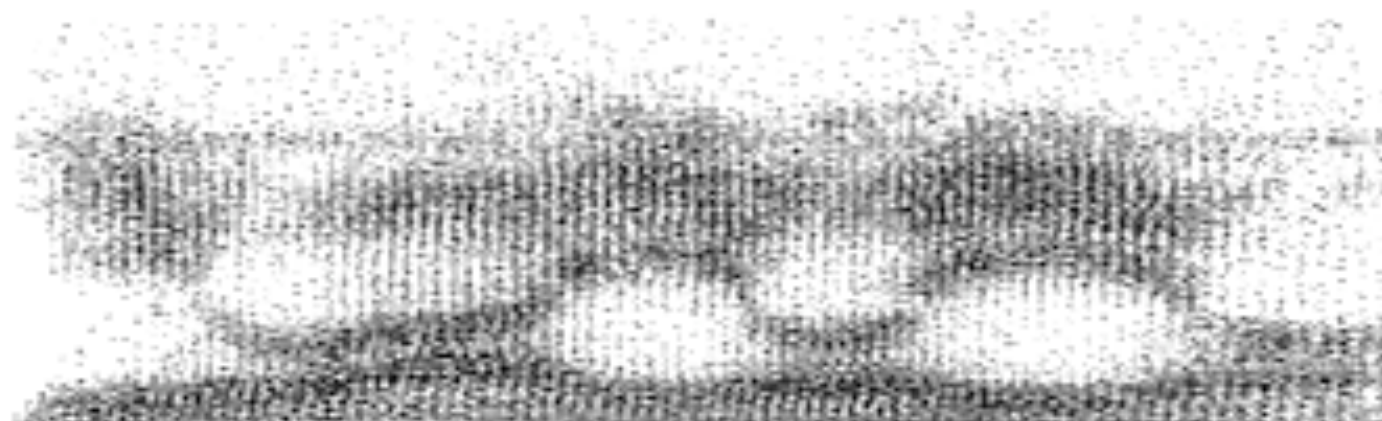
Speech production





SPECTROGRAMS

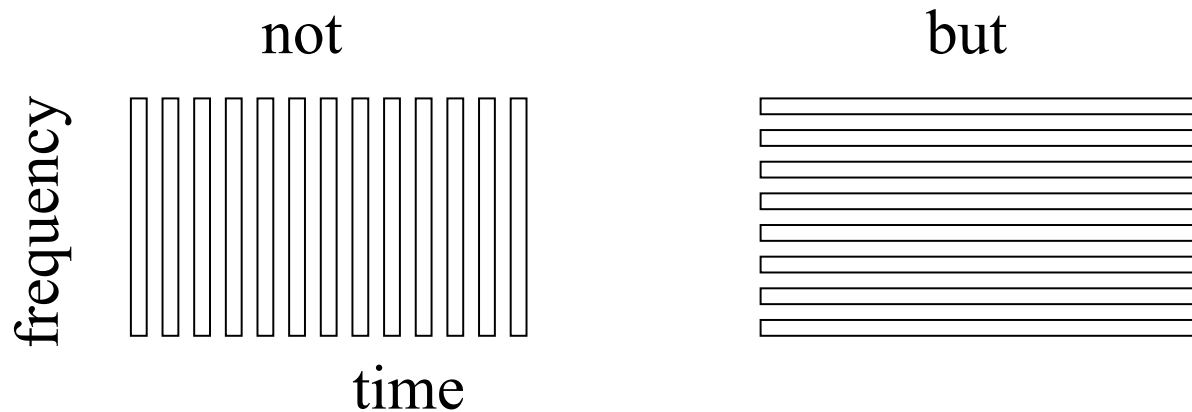
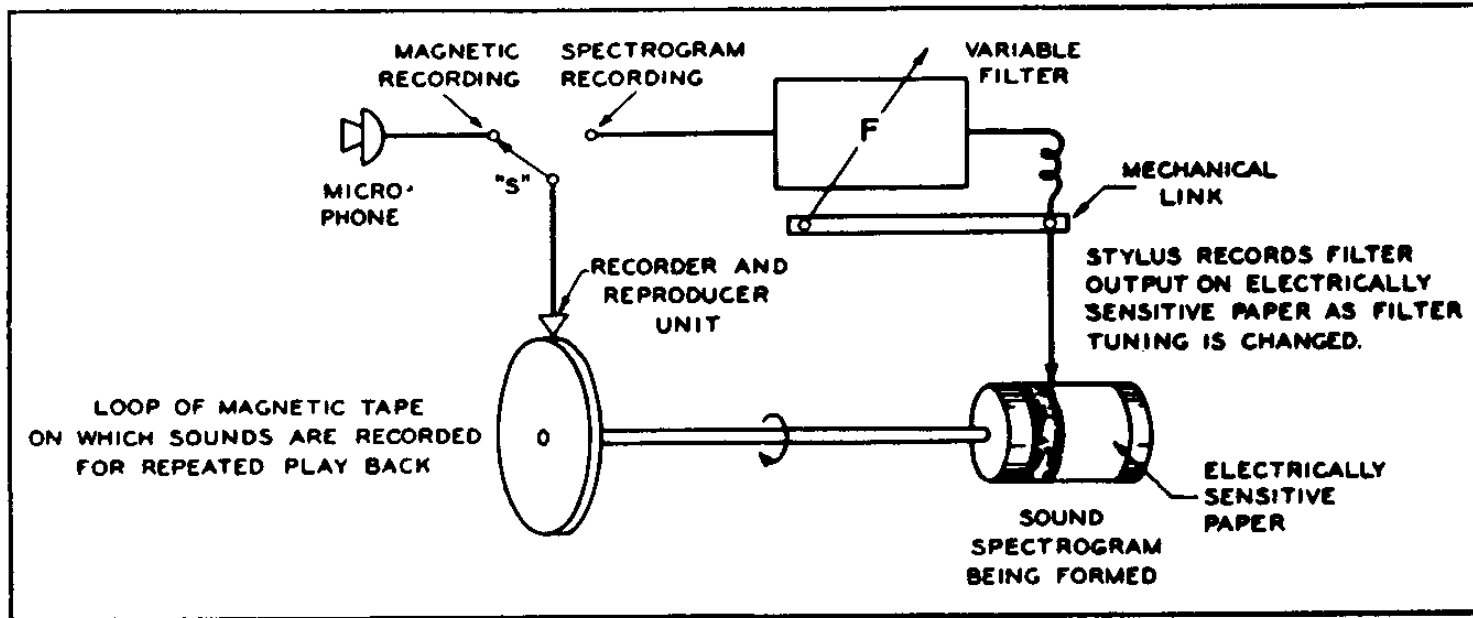
ADULT MALE



CHILD



Sound Spectrograph (2nd WW)



Homework

1. What is the difference between quantization and sampling? What are the potential distortions produced by these operations?
2. What are properties of the spectrum of the following signals
 - (a) Continuous periodic signal
 - (b) Discrete non-periodic signal.
3. You are given a mixture of two signals and the goal is to separate the mixture. The composite signal begins at $t=0$ and has a duration of 10s. What types of windows would you choose for the following cases.
 - (a) two sine waves at frequency 500 Hz and 520 Hz.
 - (b) two narrow square pulses of width 50ms occurring at $t=1$ s and $t=1.1$ s.Justify your choice in a few words.