LYDANALYSE II: PERCEPTION & KOGNITION

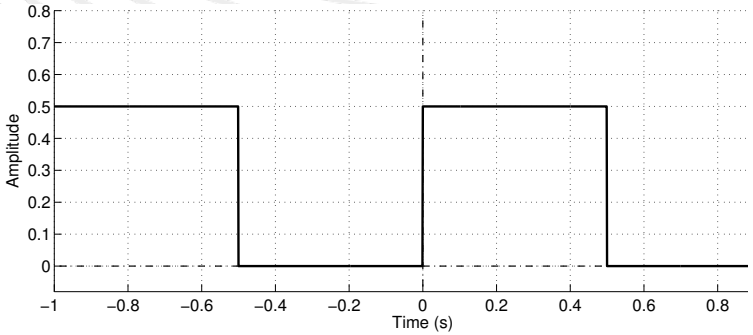
SOFIA DAHL
DEPT. OF ARCHITECTURE, DESIGN AND MEDIA TECHNOLOGY

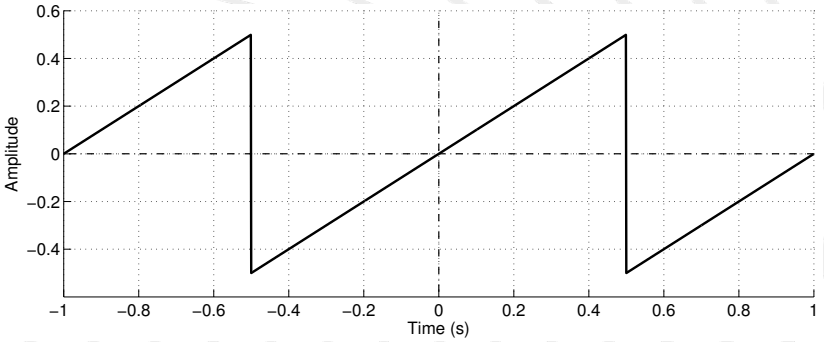
AALBORG UNIVERSITY
DENMARK

PERIODIC SIGNALS

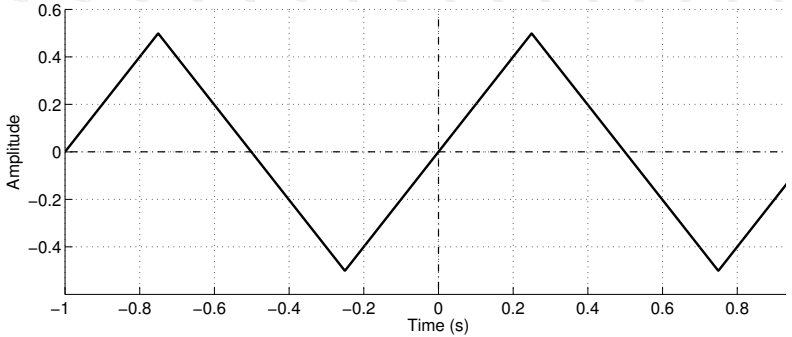
Waveforms that repeat the same pattern over and over and over and over….

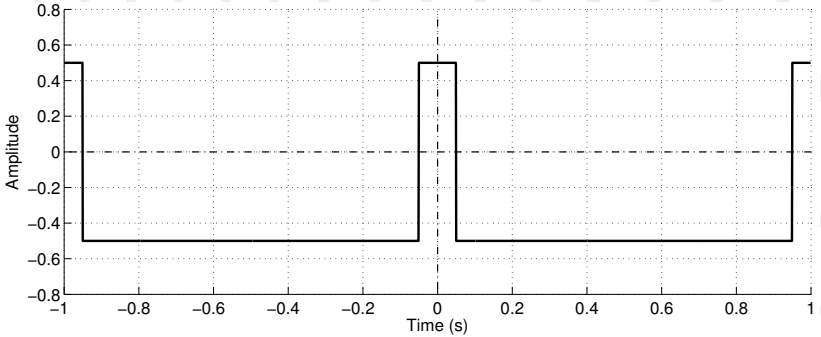
Consider these *periodic* signals





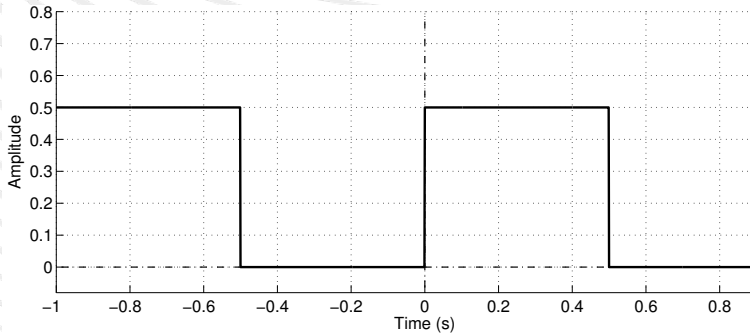
Each one has a period of 1 second, and amplitude of 0.5.

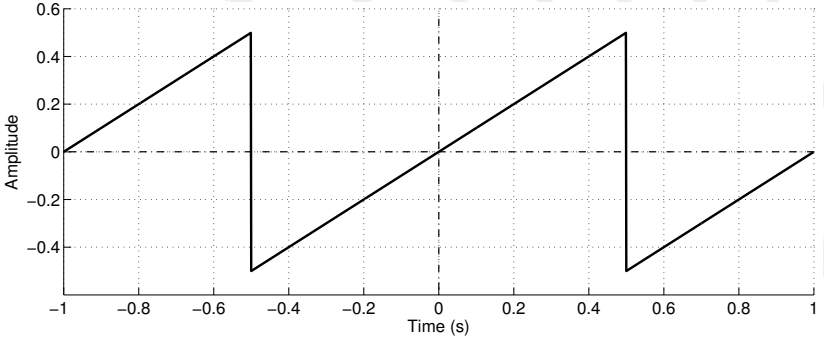


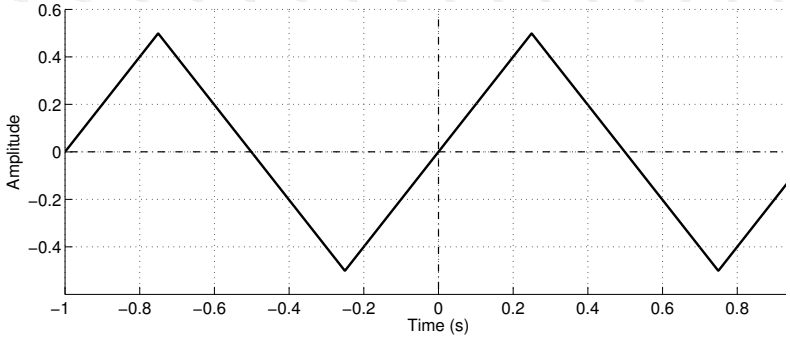


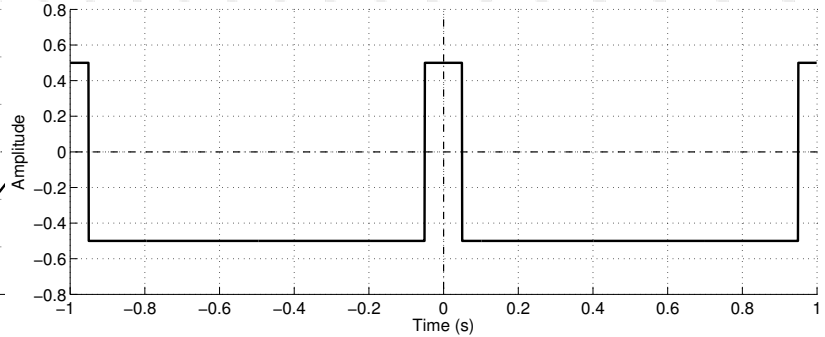
Bob Sturm's slides

Can you hear the shapes?









Bob Sturm's slides

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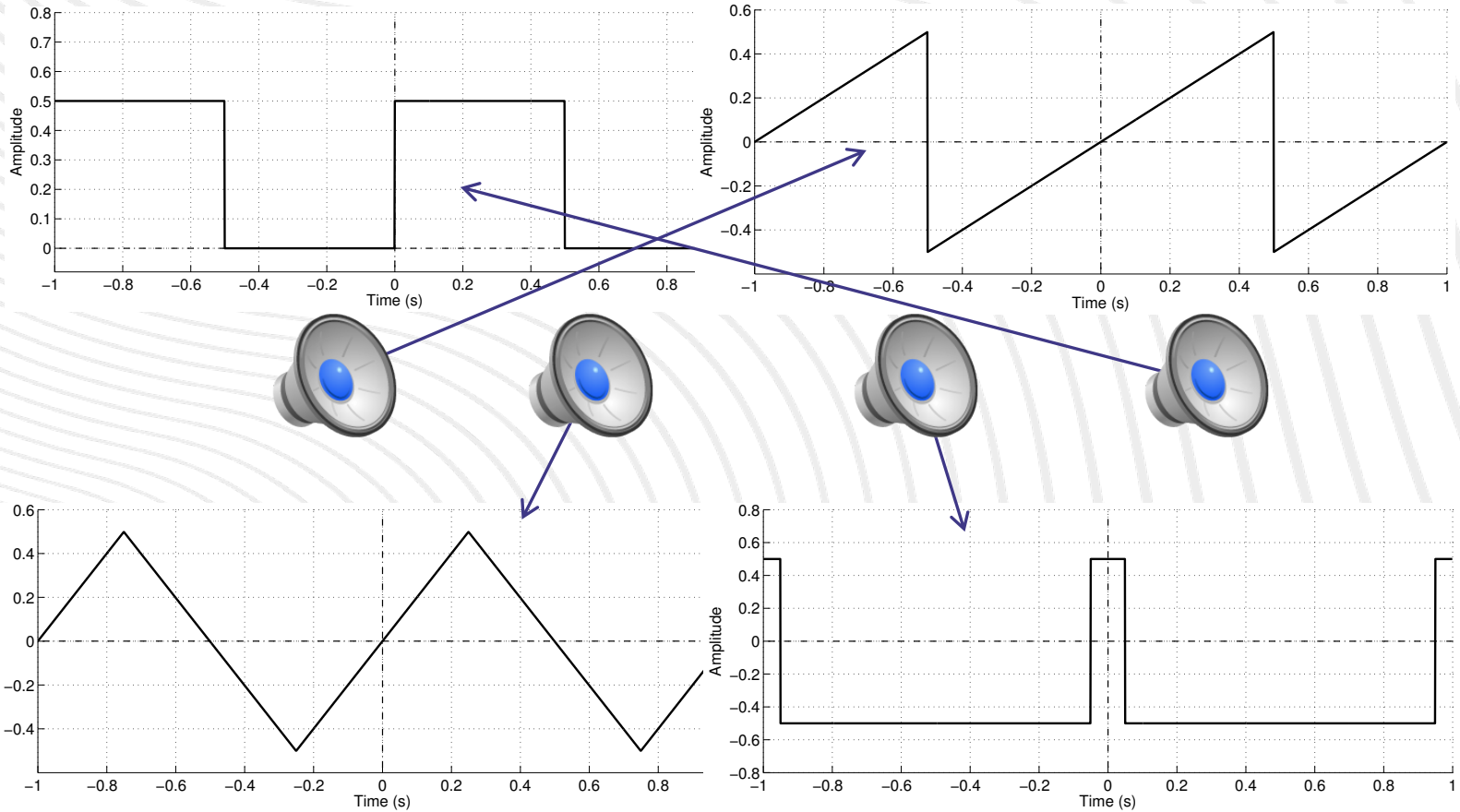

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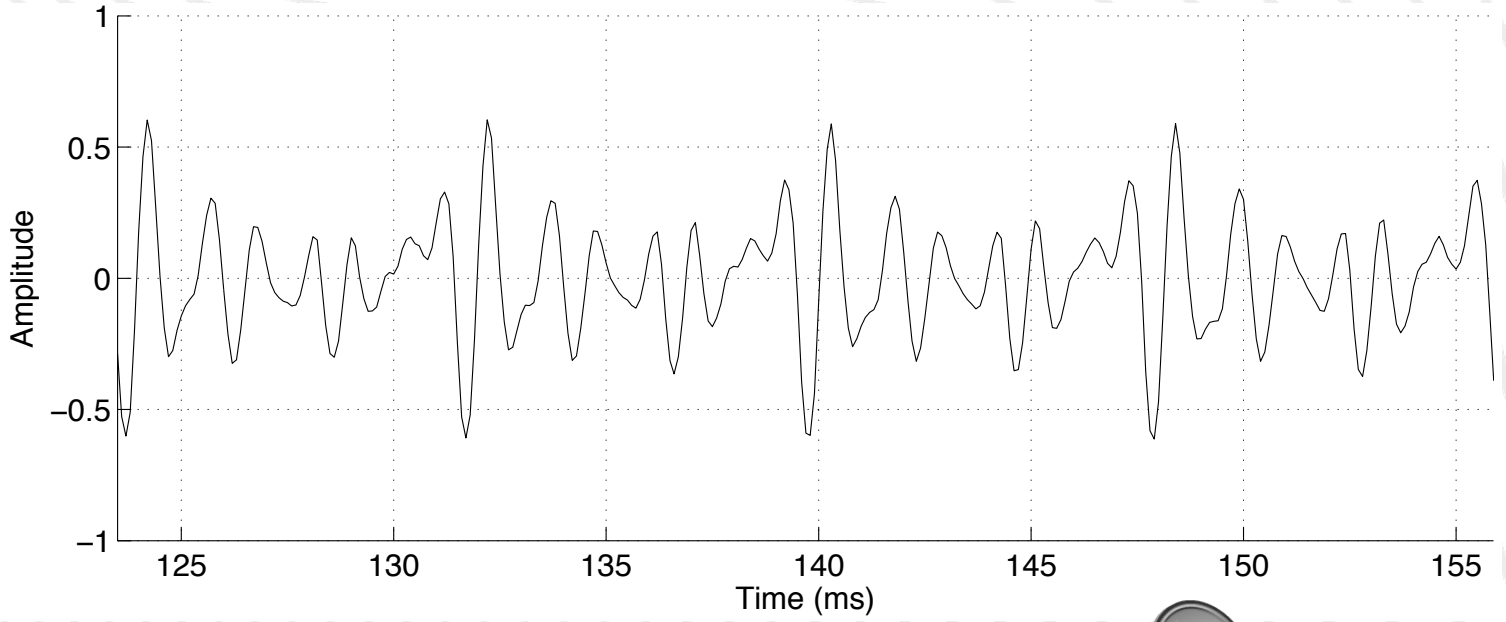
Periodicity in speech signals



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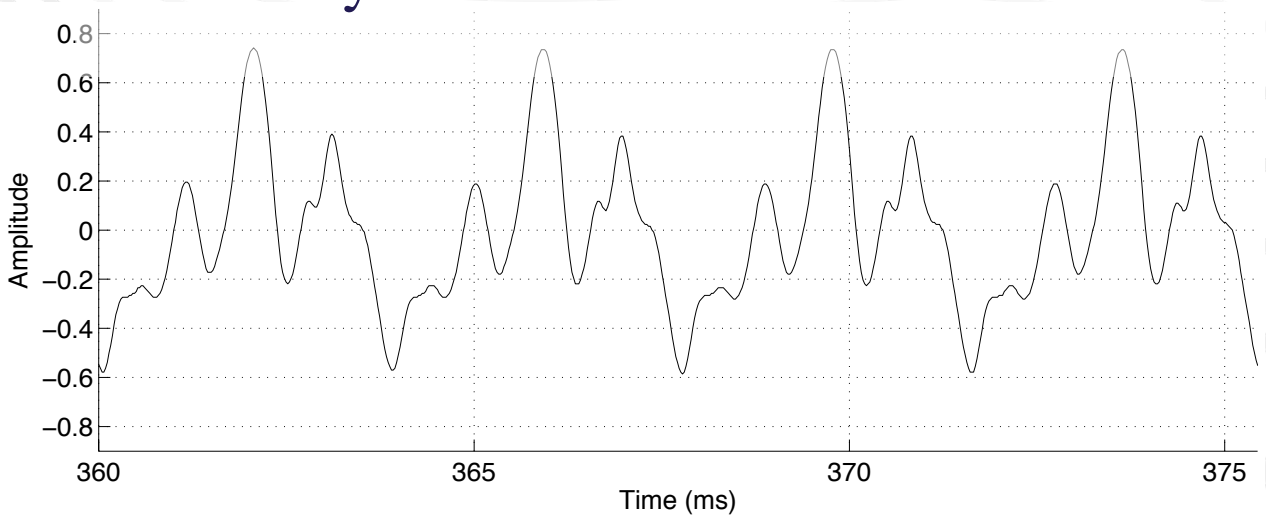
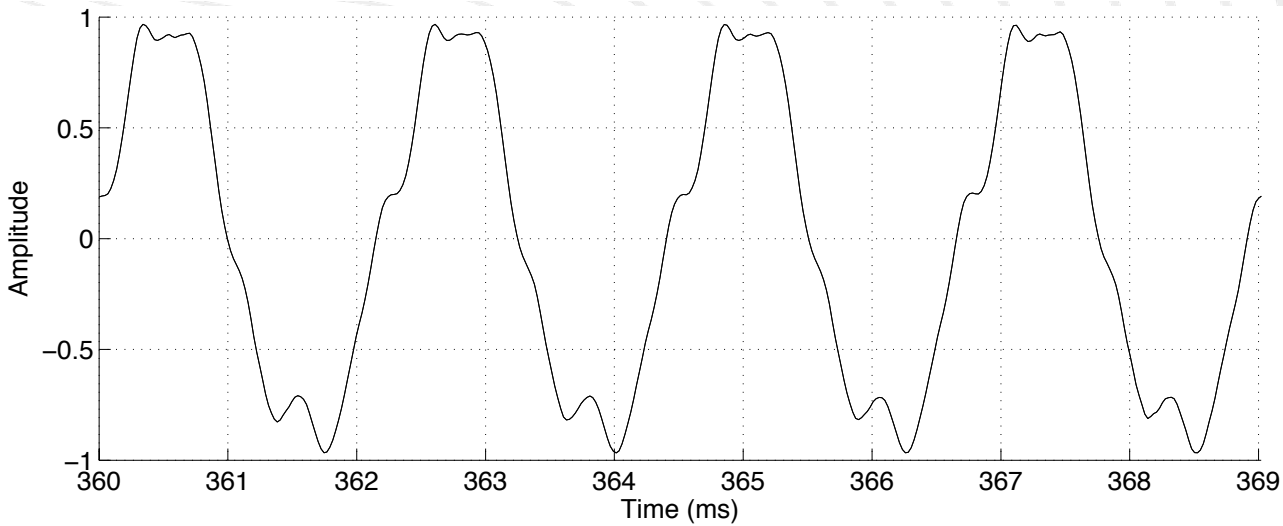
Periodicity in instrument sounds





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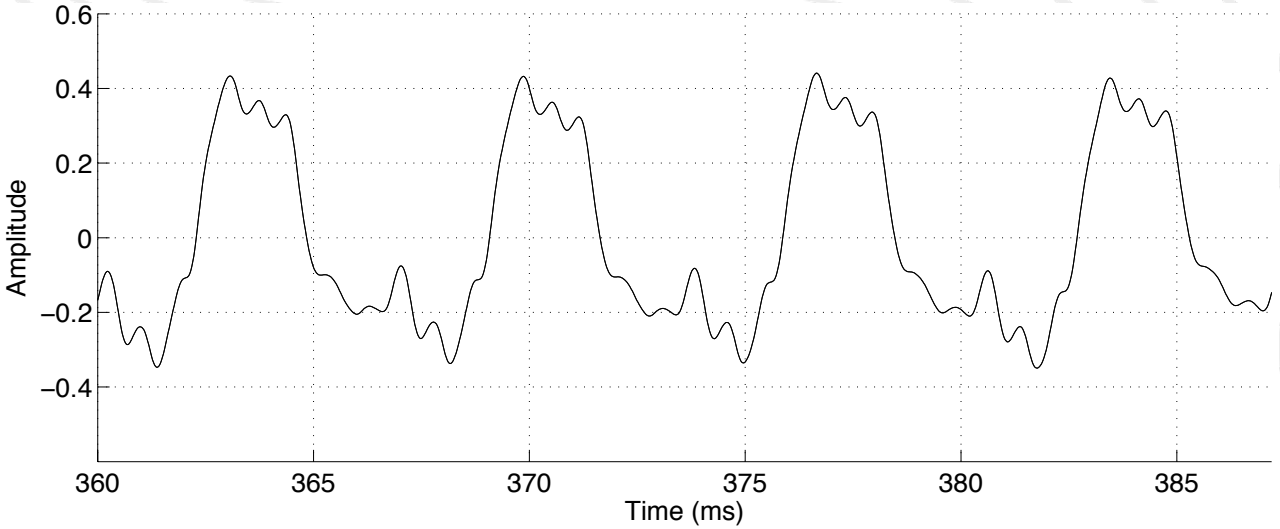
Periodic signals in instruments



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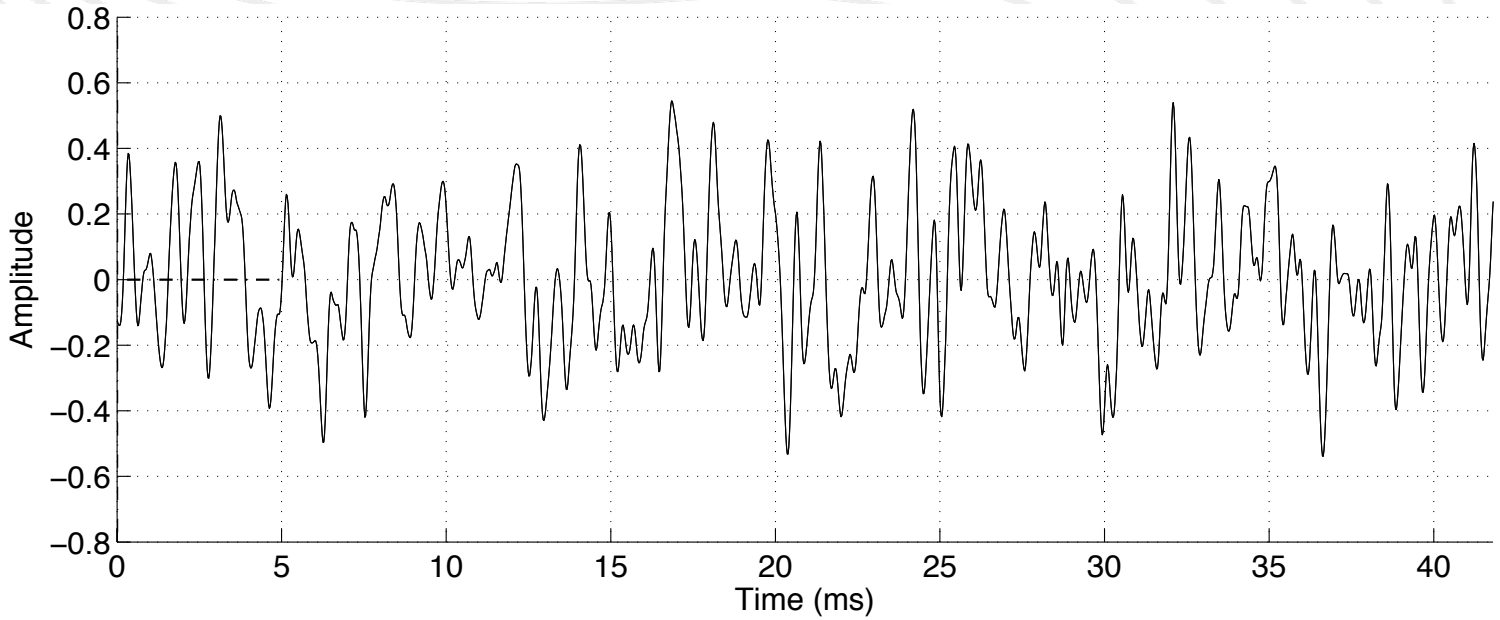
Non-periodic signals in instruments



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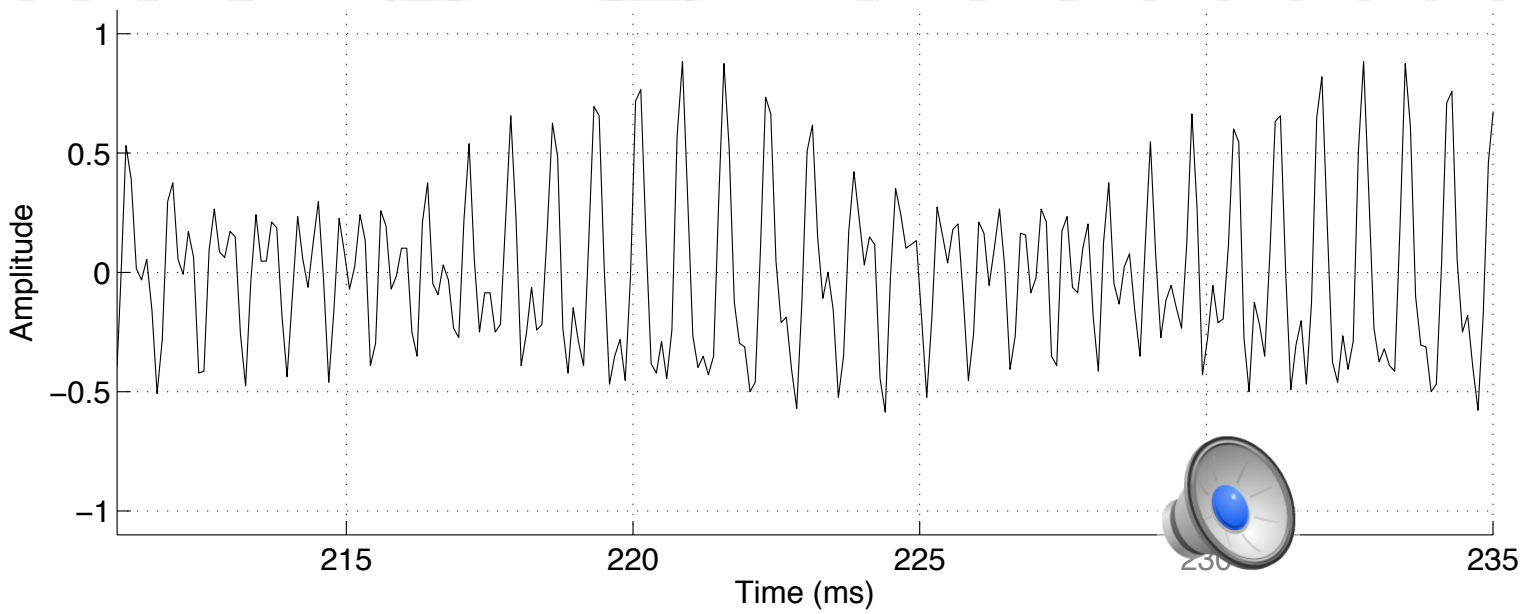
Periodicity in nature sounds



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Three Wattled Bellbird

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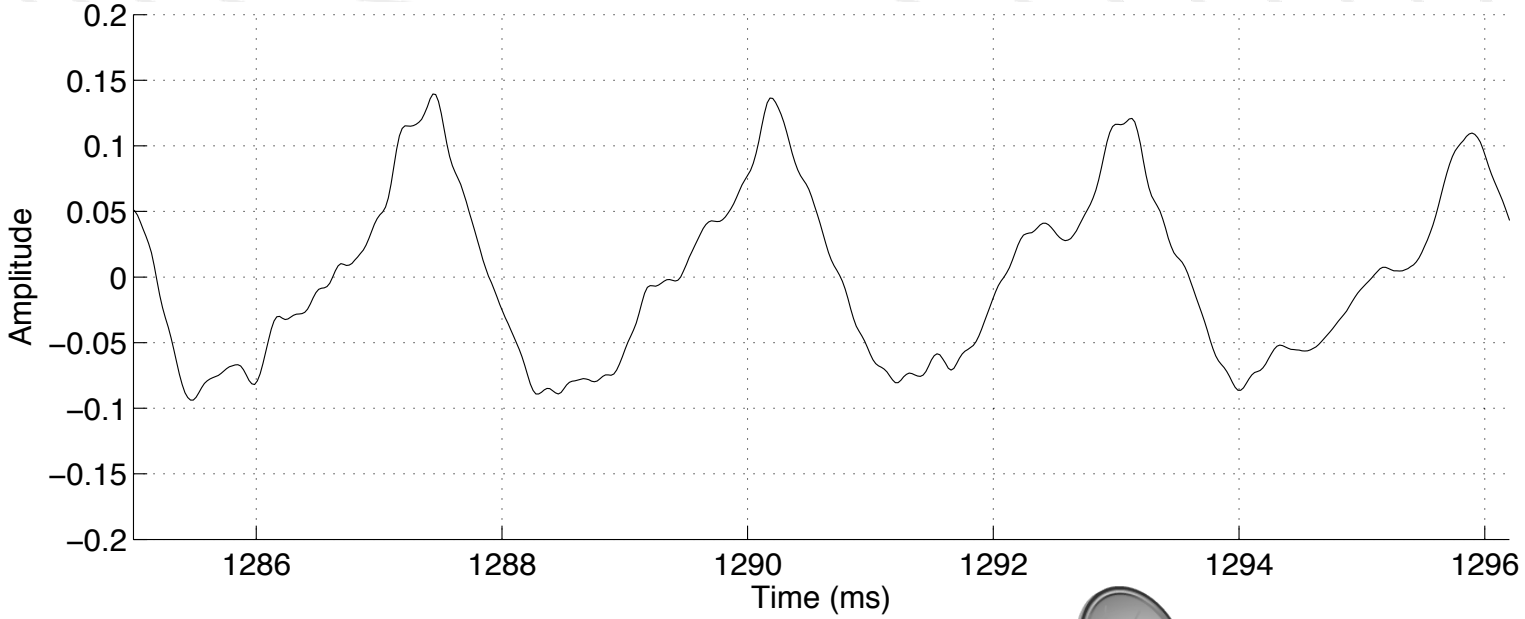
Periodicity in Eefing & Hamboning



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Eefing & Hamboning: A Lost Art

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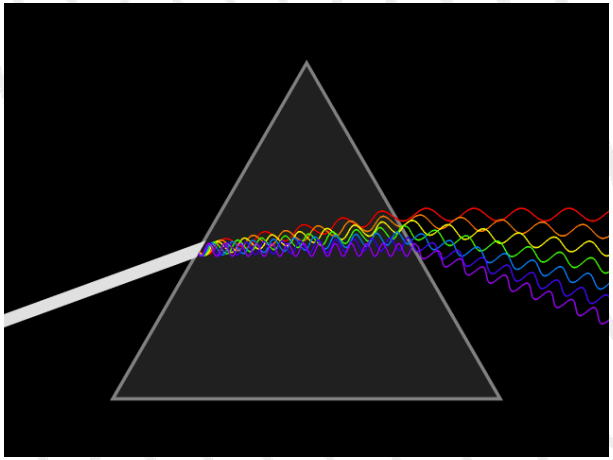
Joseph Fourier (1768-1830)

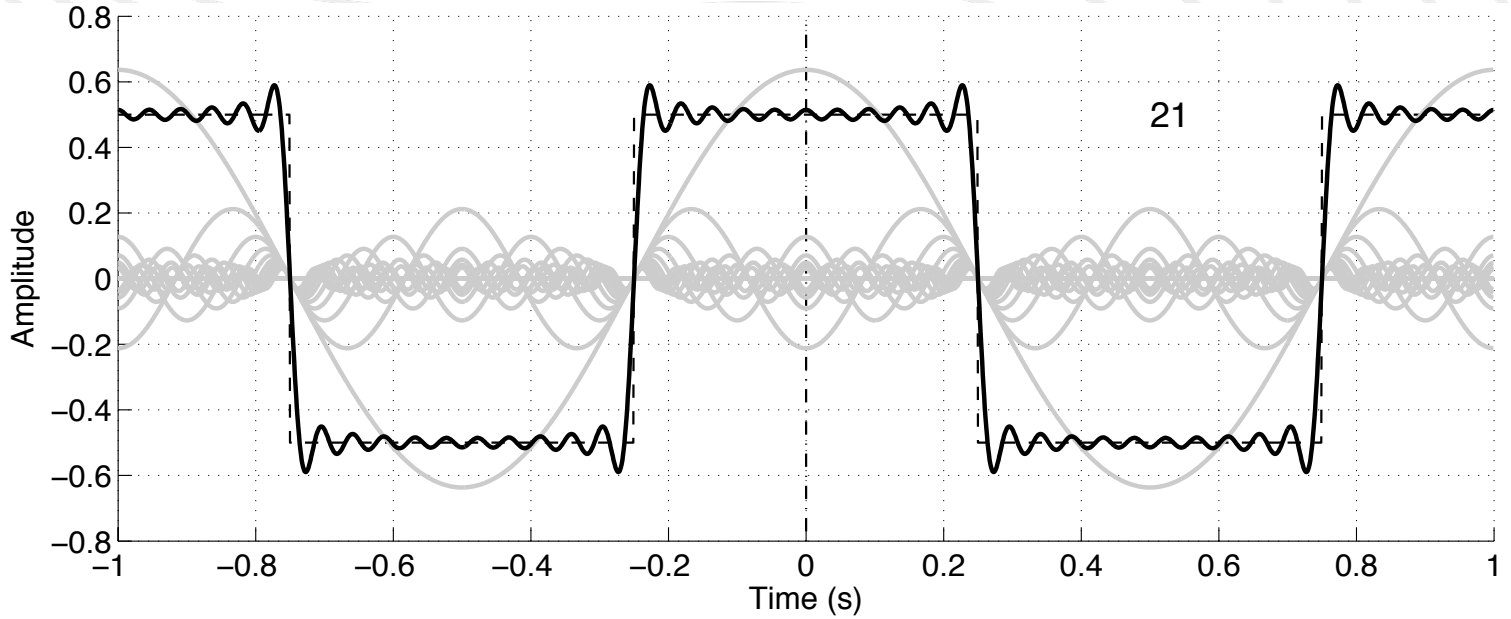
Any periodic waveform can be described as a combination of periodic signals!



The frequency spectrum

- Shows the amplitudes of the frequencies contained in the waveform.
- One could think of a spectrum as a “recipe” of how much of each frequency needed to cook up a particular signal.

Example: Building up a square wave by adding (odd!) multiples of the fundamental frequencies



The amplitudes of the higher frequencies decline.

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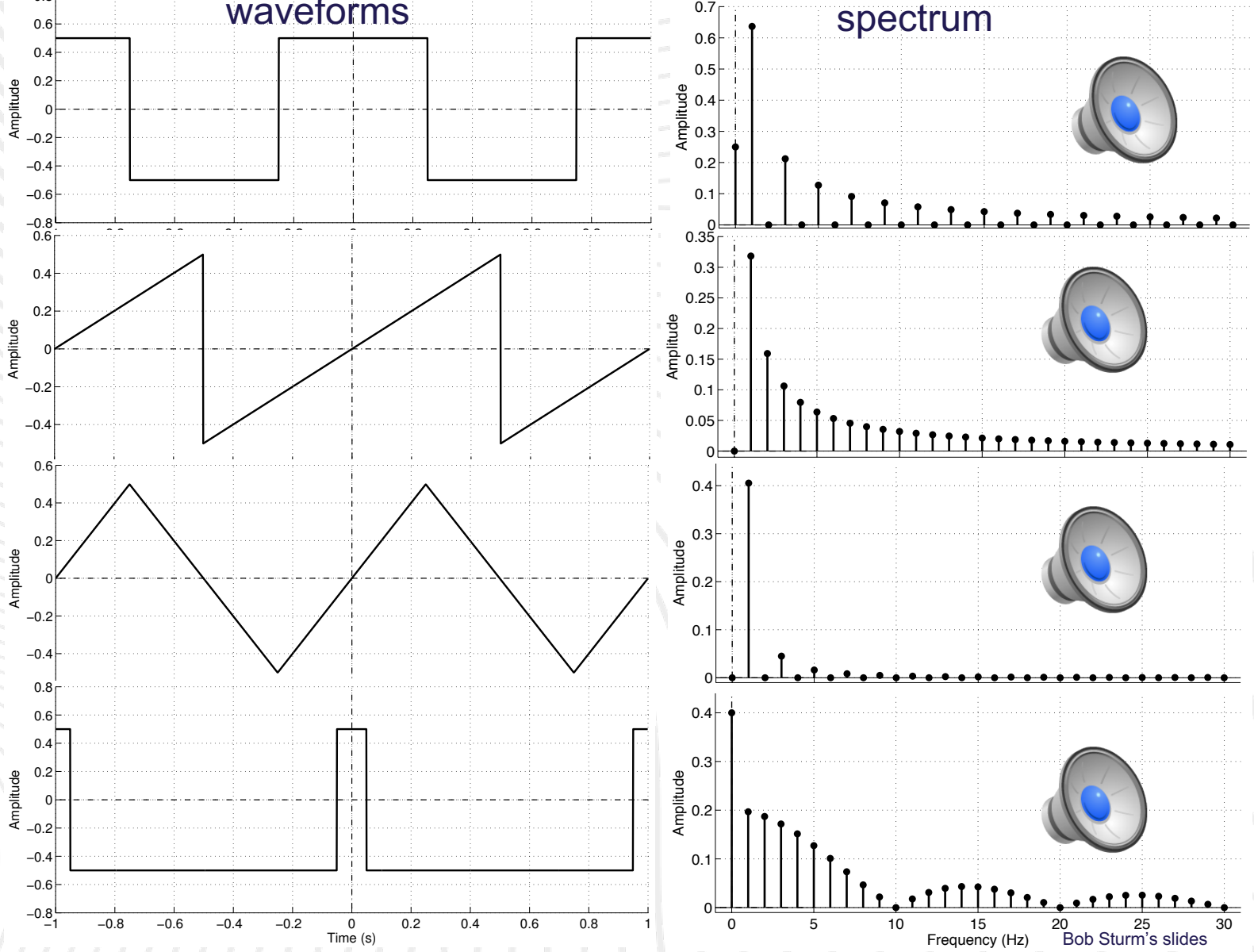

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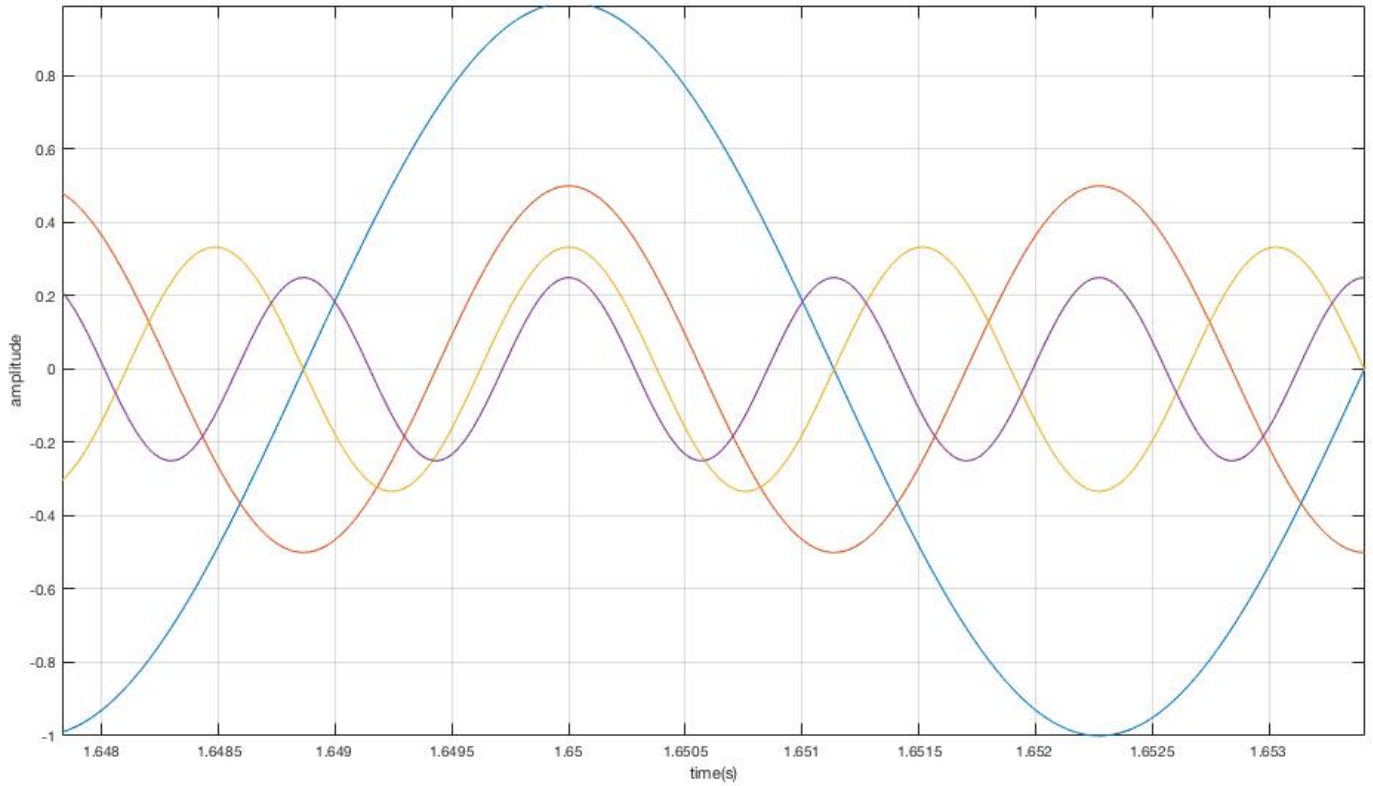
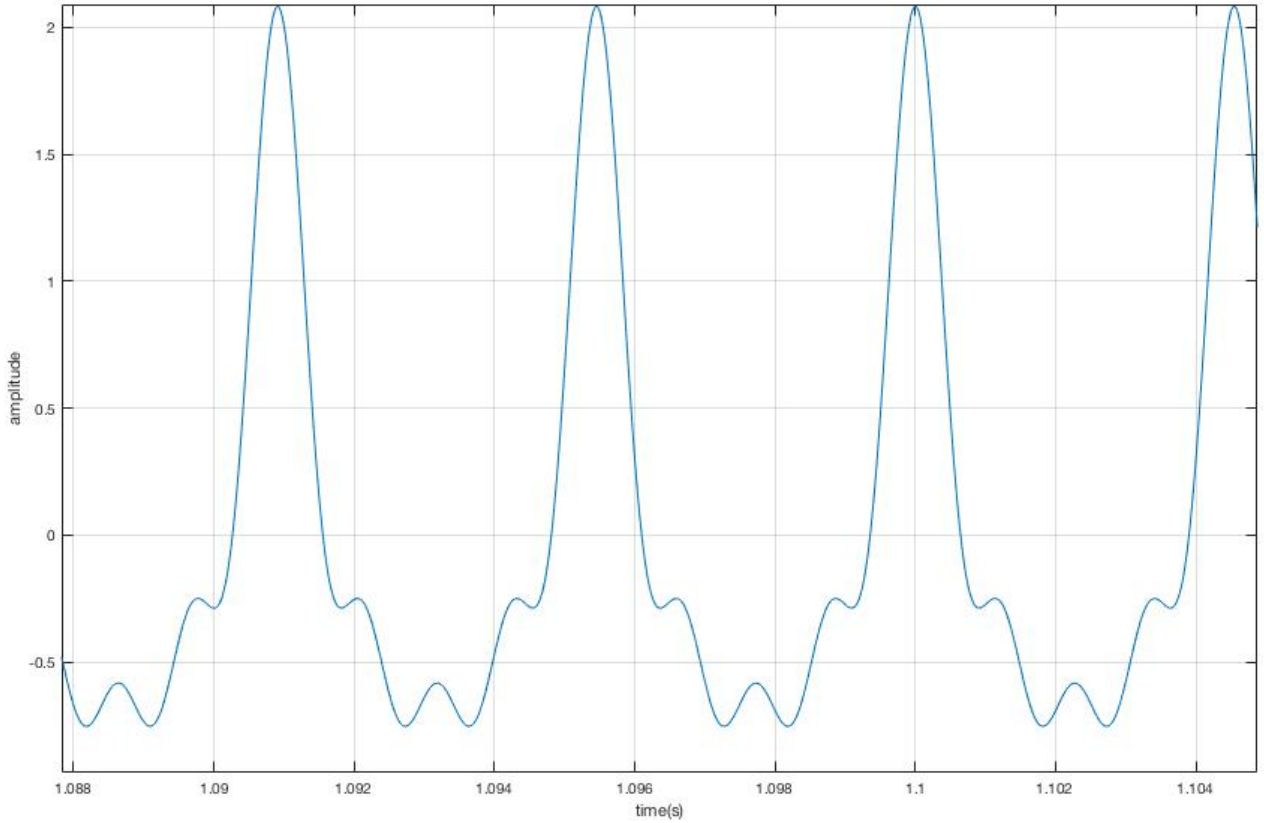
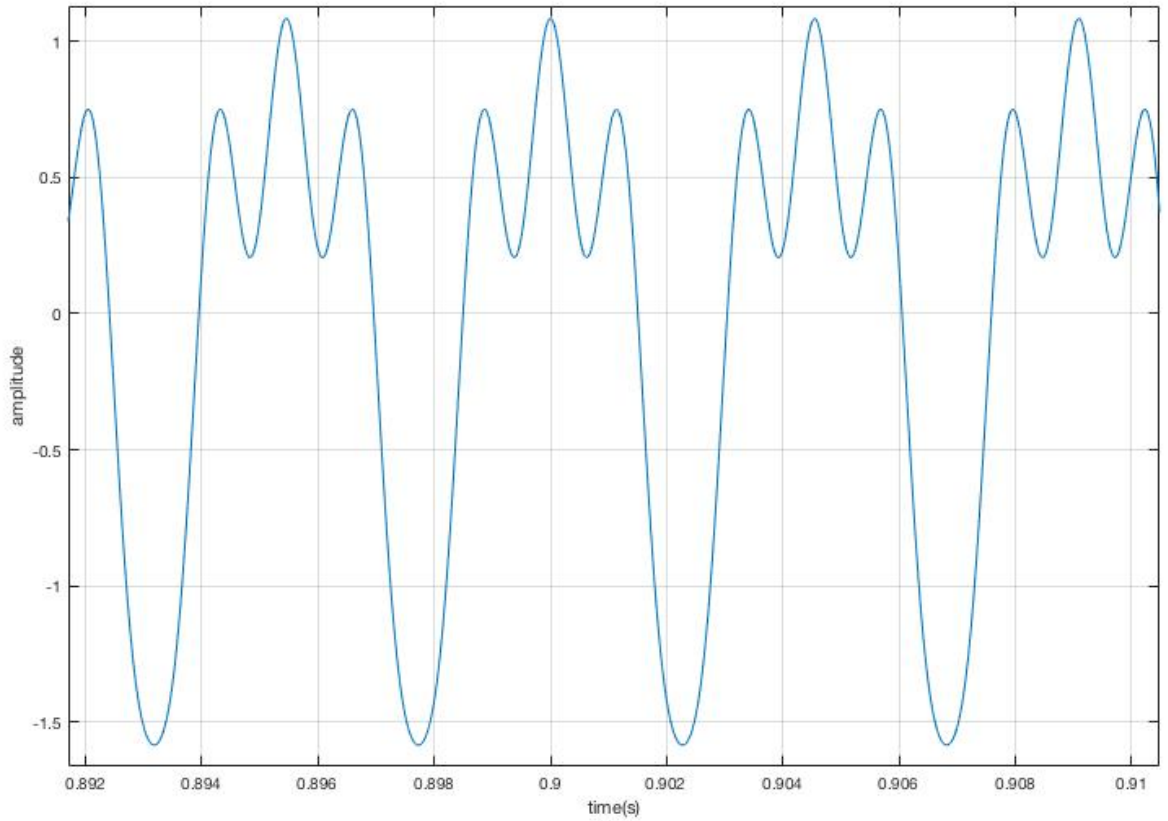
Sinusoids with frequencies multiples of the fundamental (blue)



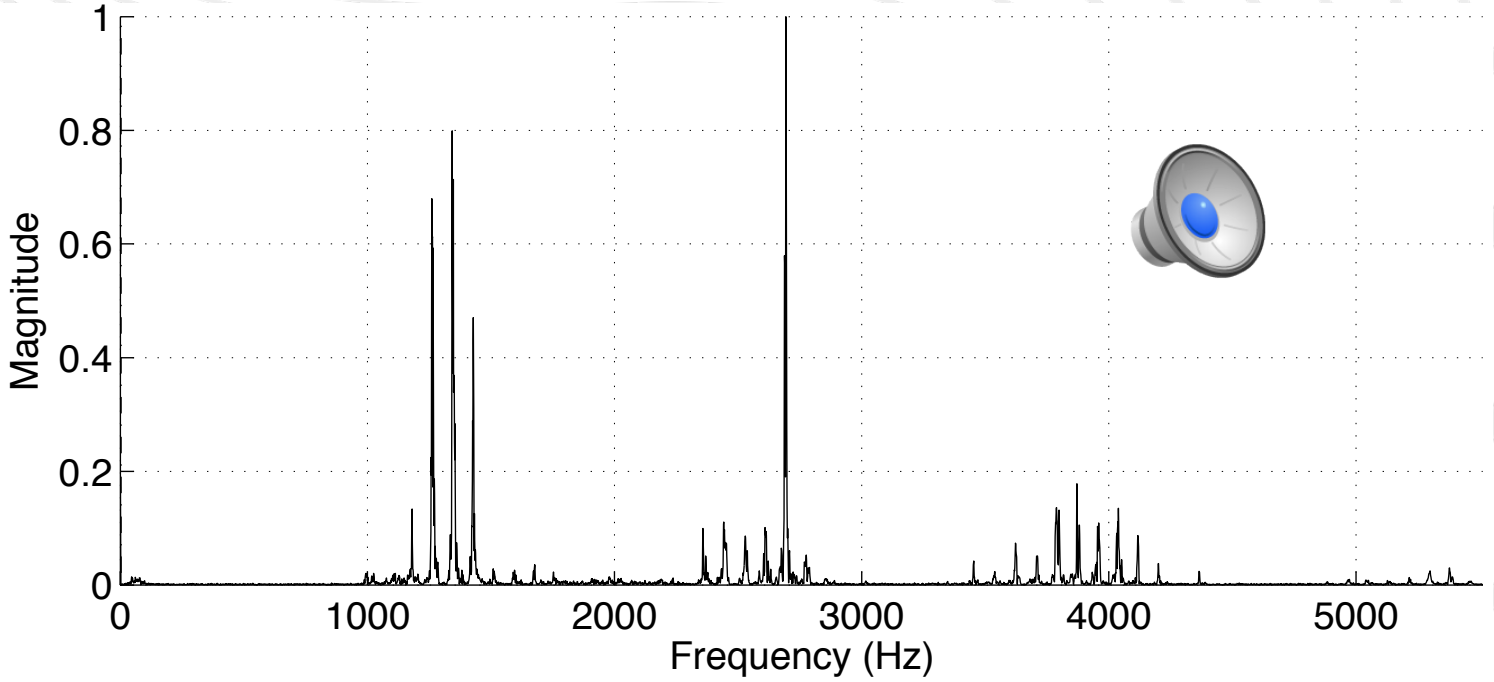
The period of the combined waveform is the same as that of the fundamental (lowest) frequency (200 Hz=> T= 5 ms)



Again the same frequencies combined – but one partial (octave, orange) with different phase. Note that the period has not changed (same as the fundamental). Pitch remains the same!



Bellbird in the frequency domain



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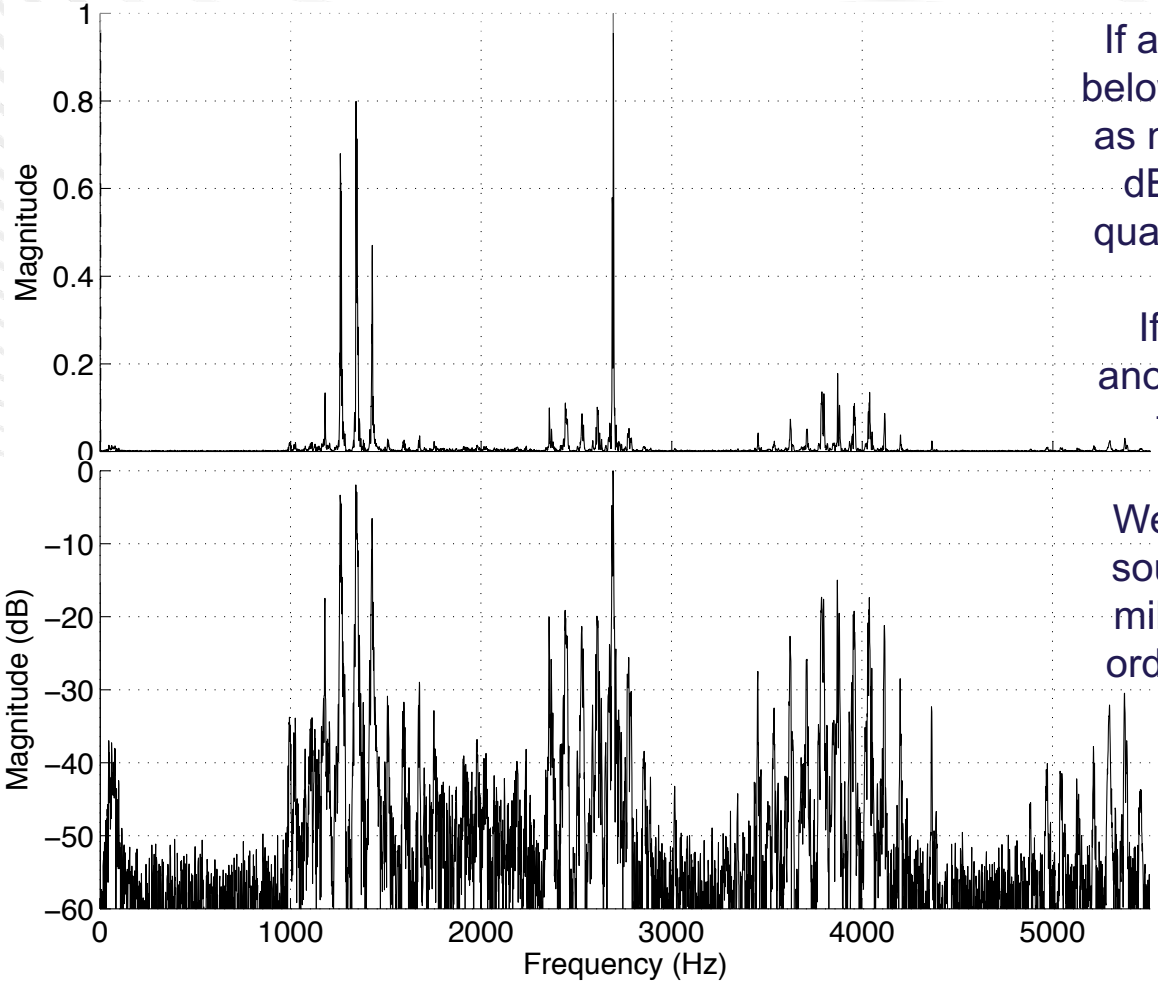
Magnitude dB



If a component is 3 dB below another, it has half as much power. If it is 6 dB below, it has one quarter as much power.

If it is 60 dB above another, it has a million times the power!

We humans can hear sounds that have one millionth the power of ordinary conversation.

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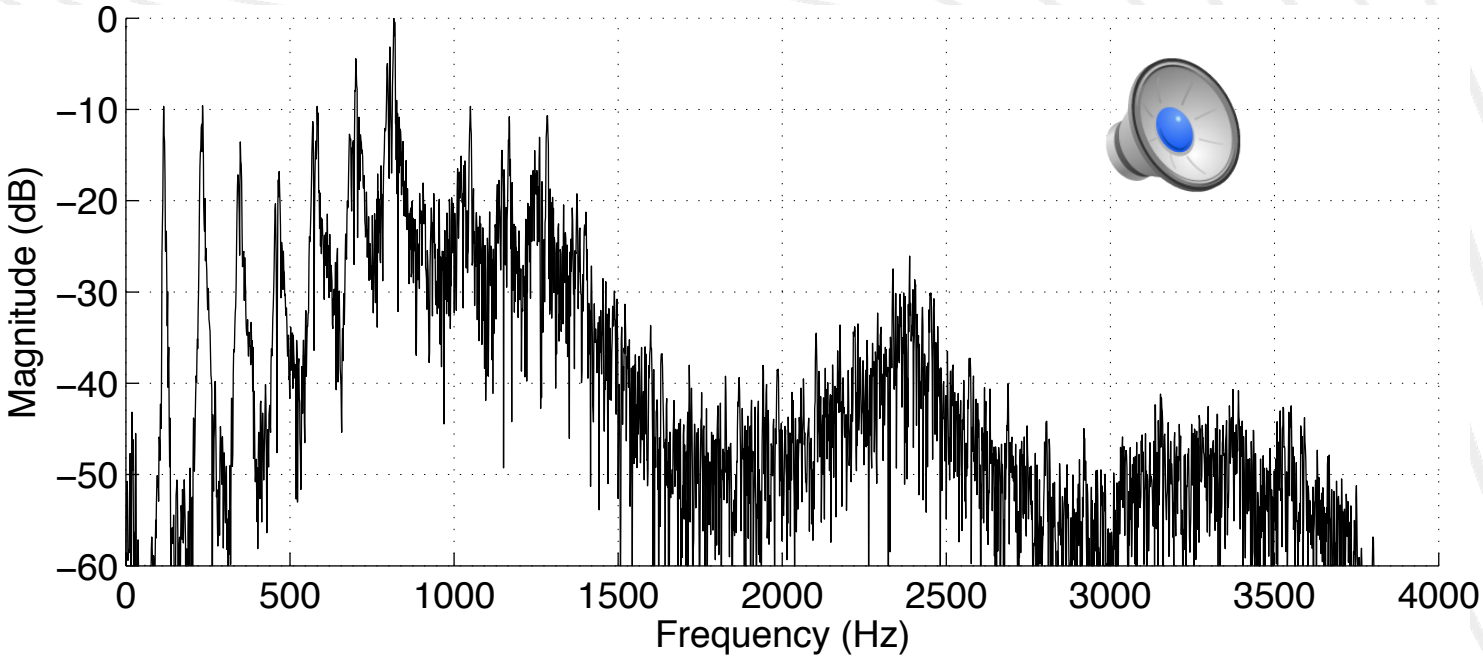
Speech signals in the freq. domain



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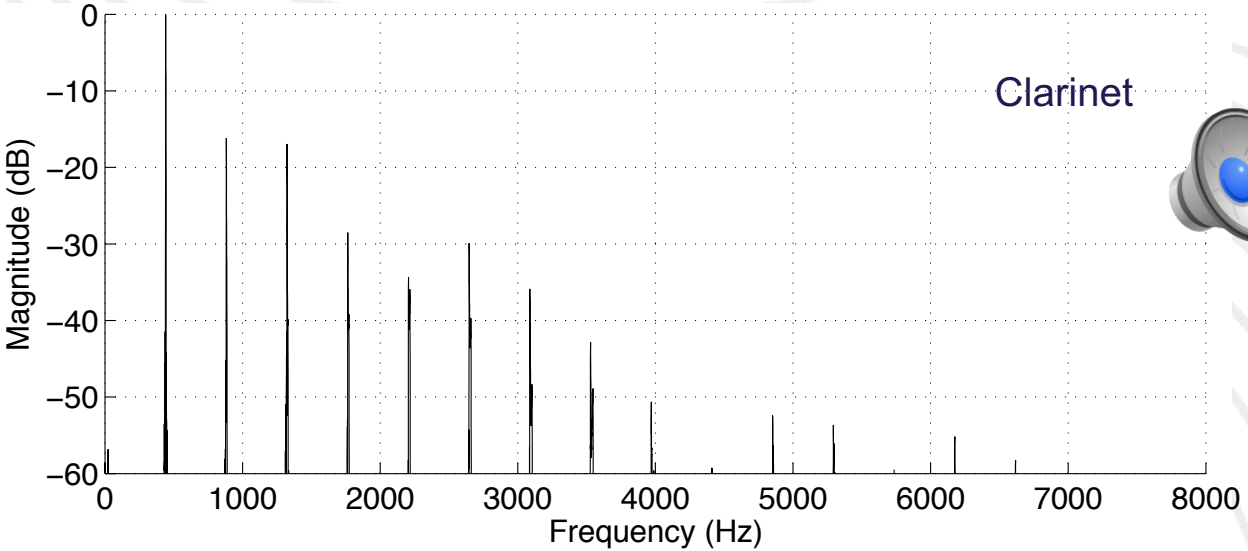

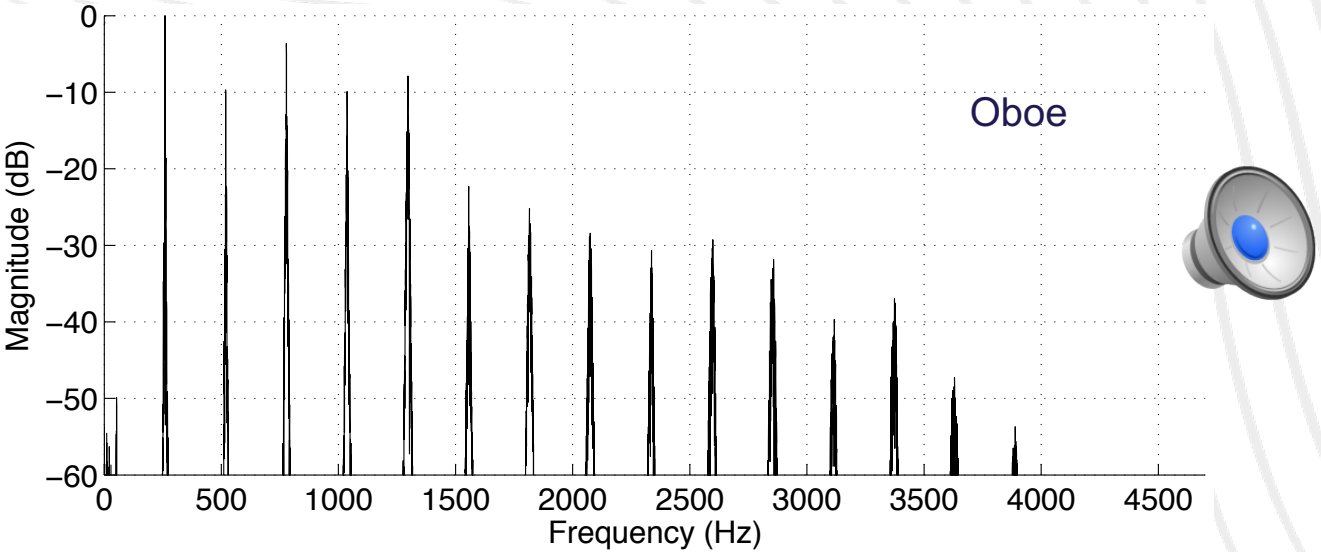

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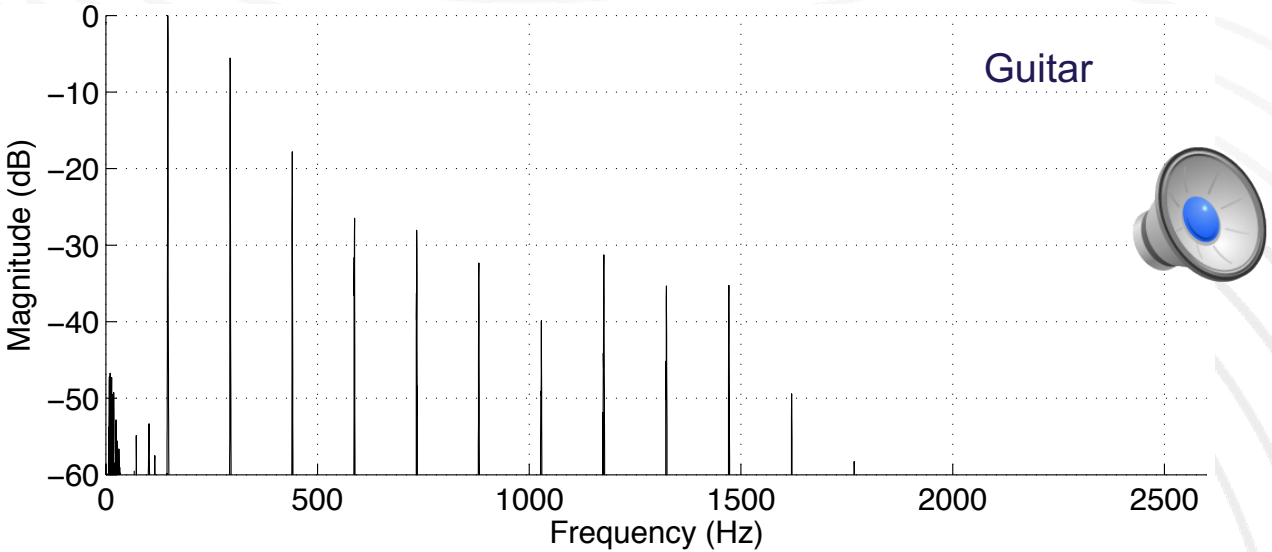

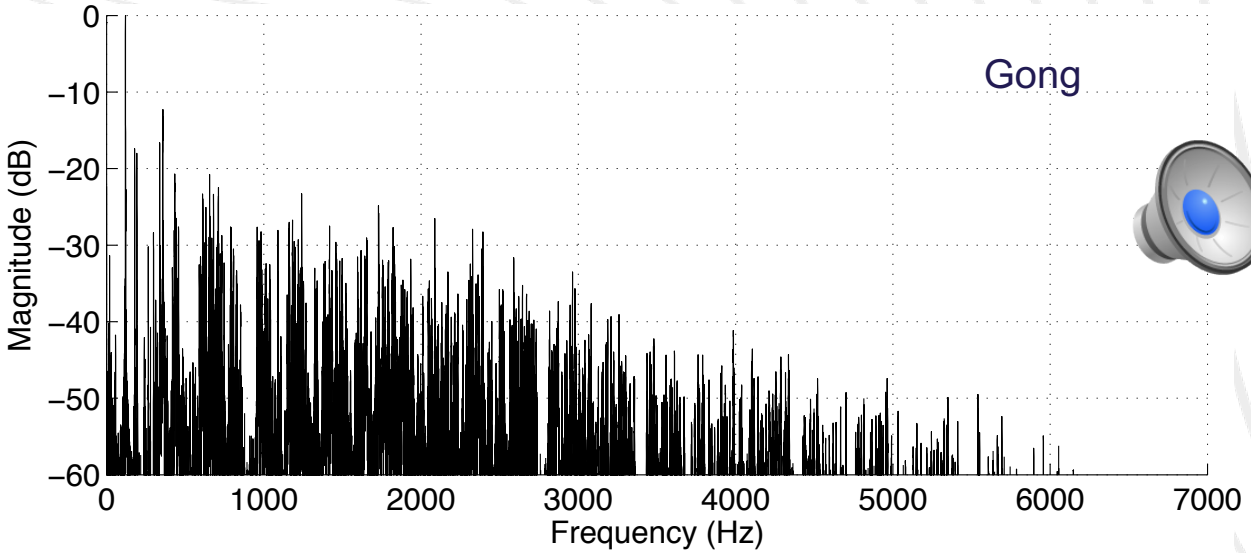

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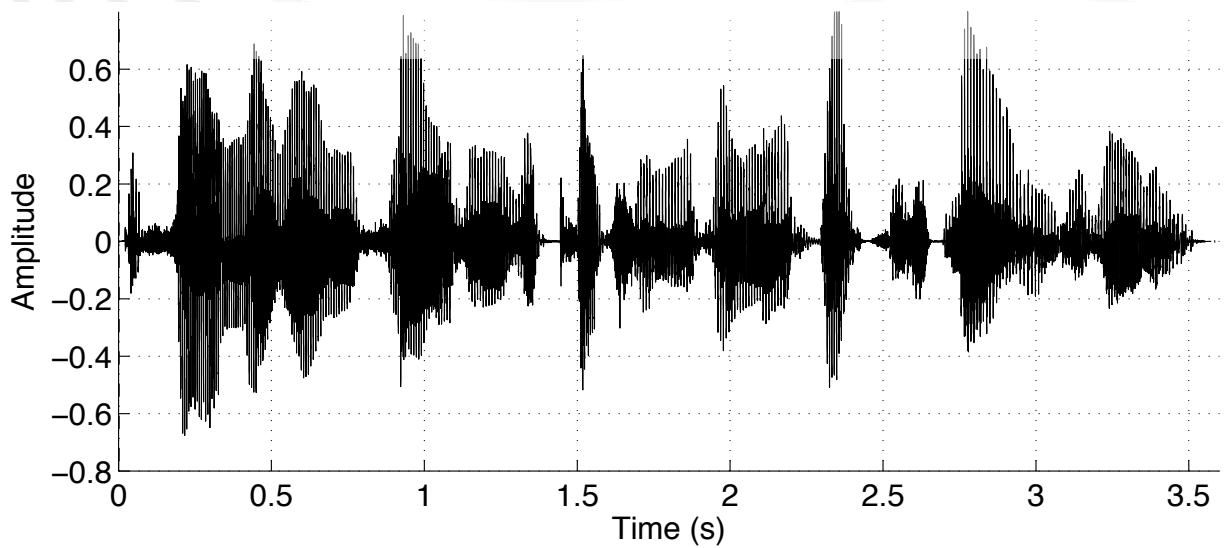
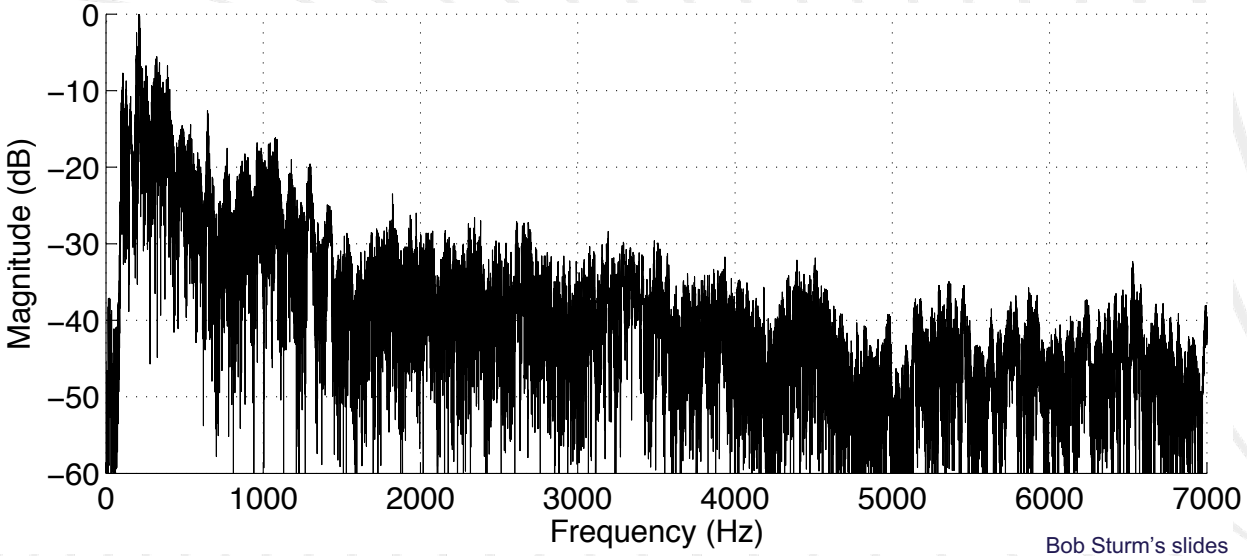
Spectrum of entire sentence





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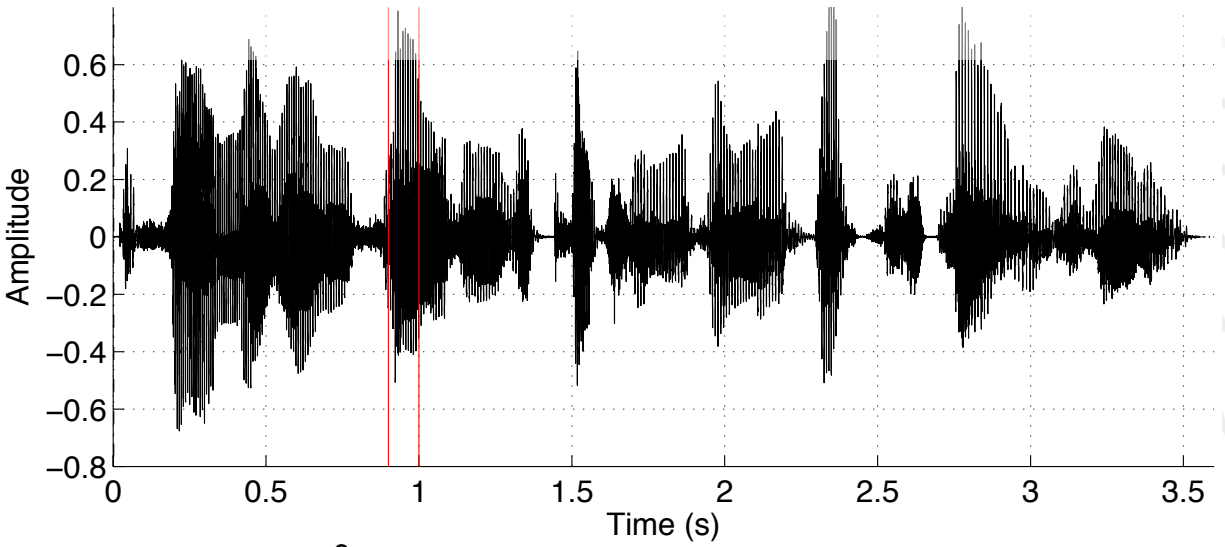
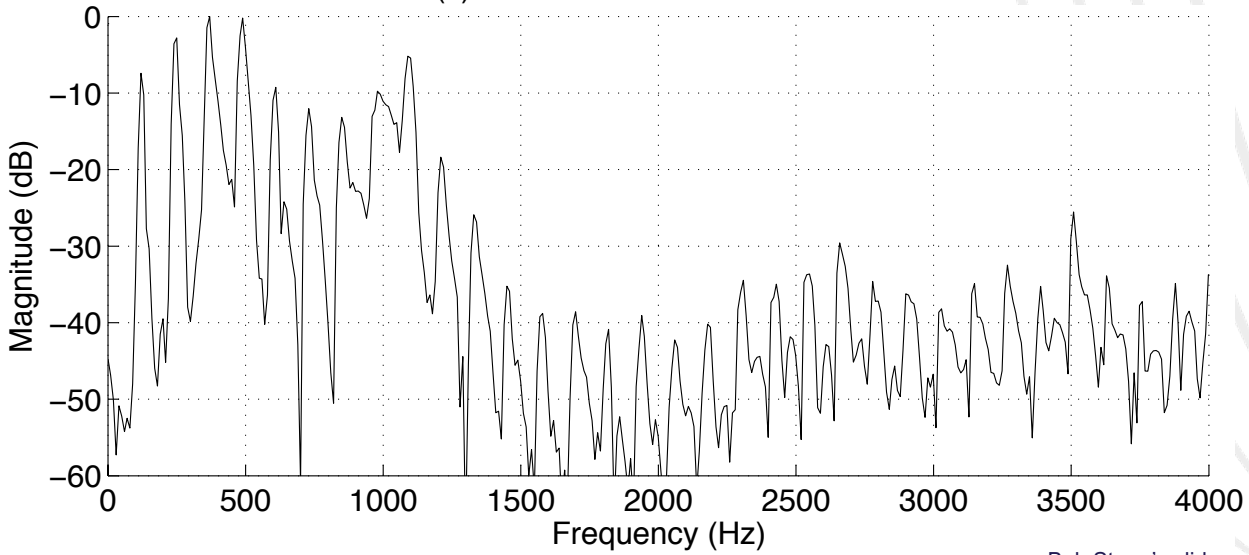
Spectrum of piece of sentence





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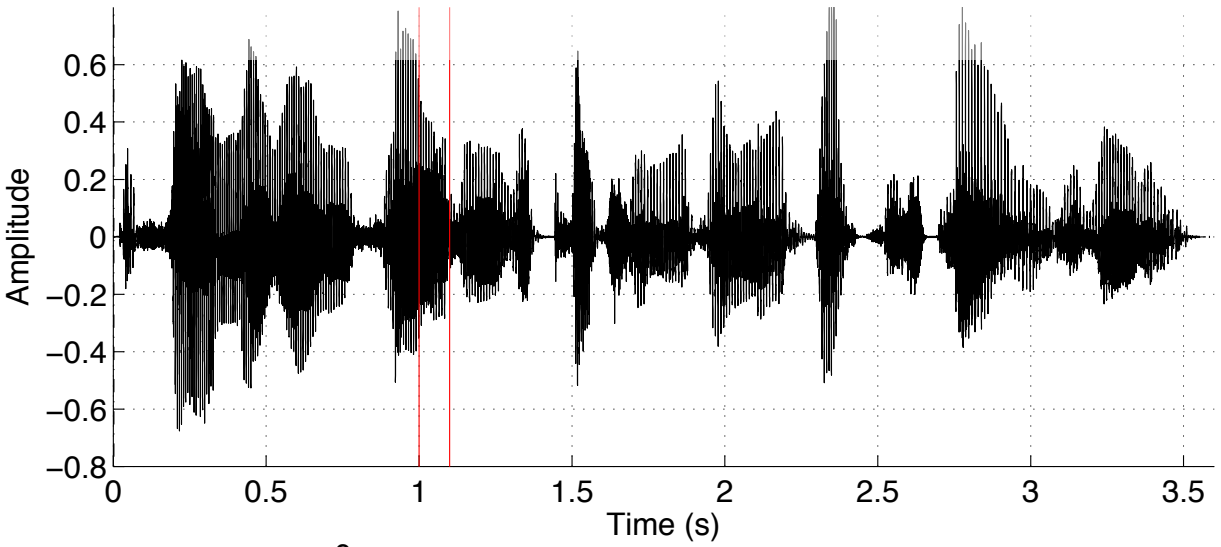
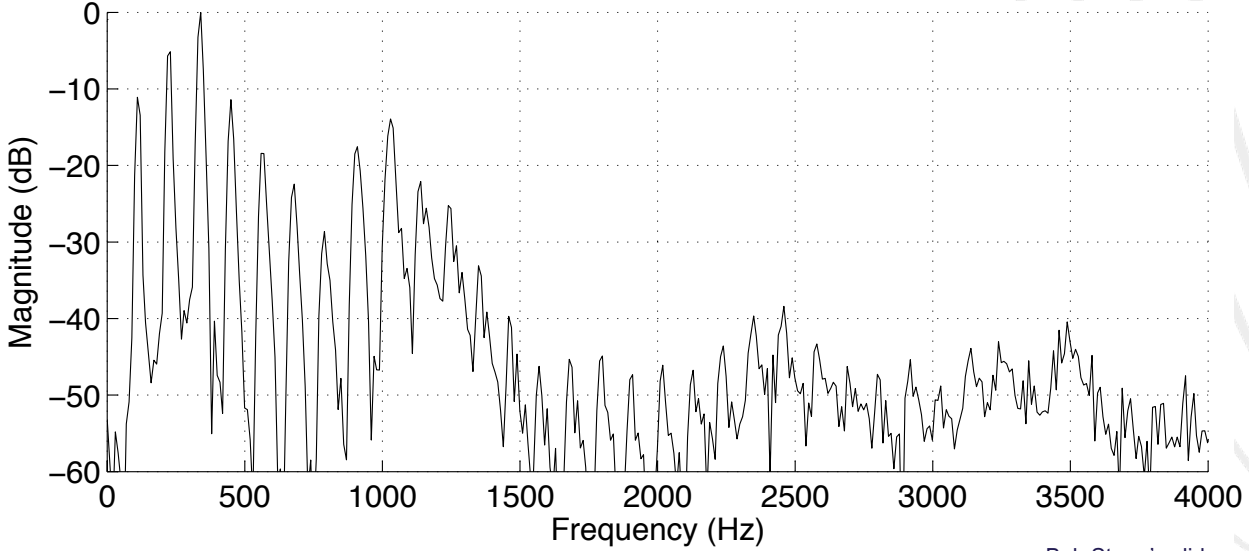
Spectrum of piece of sentence





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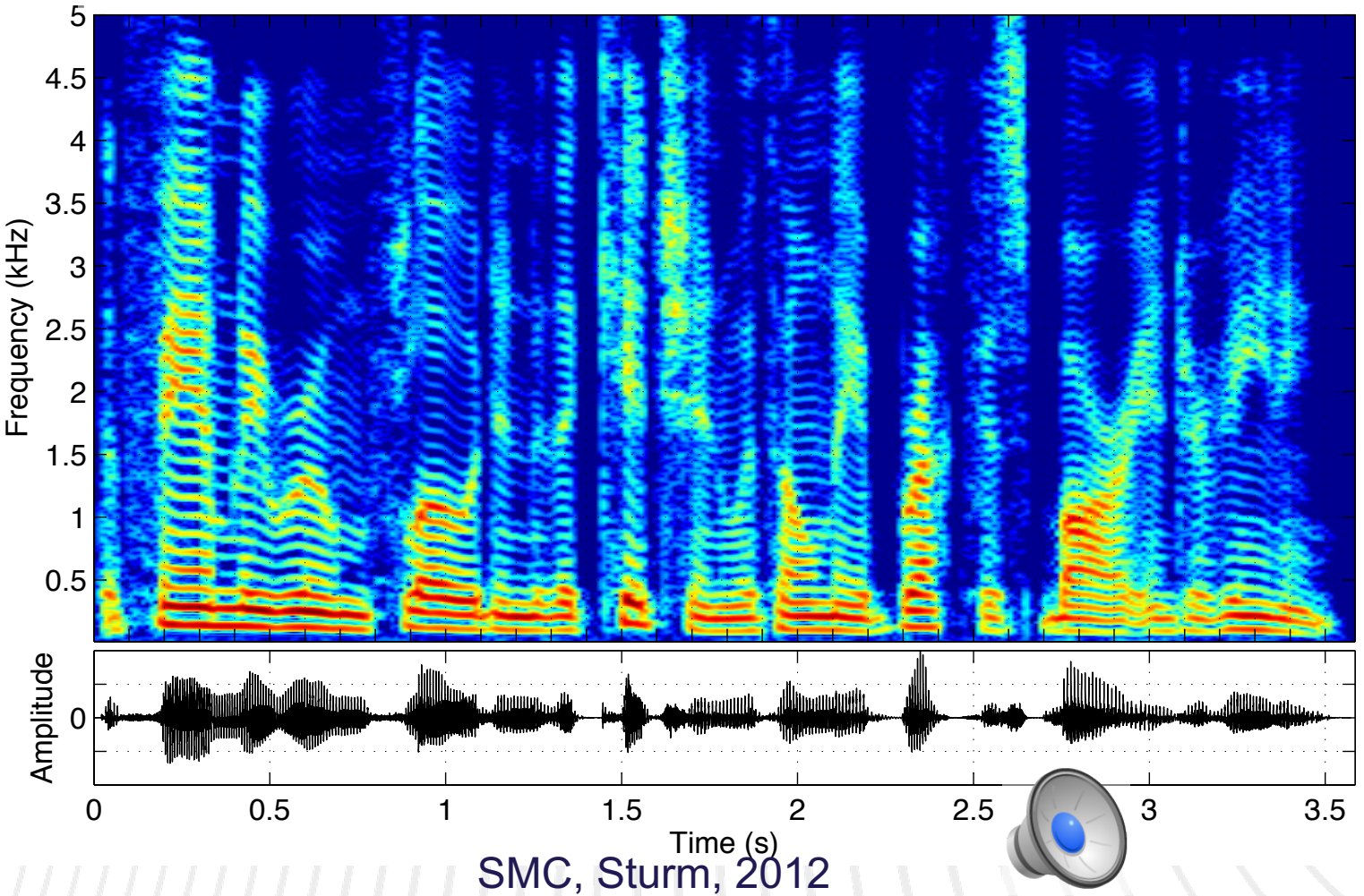
Getting time into the plot

Short-term Fourier Transform



SMC, Sturm, 2012

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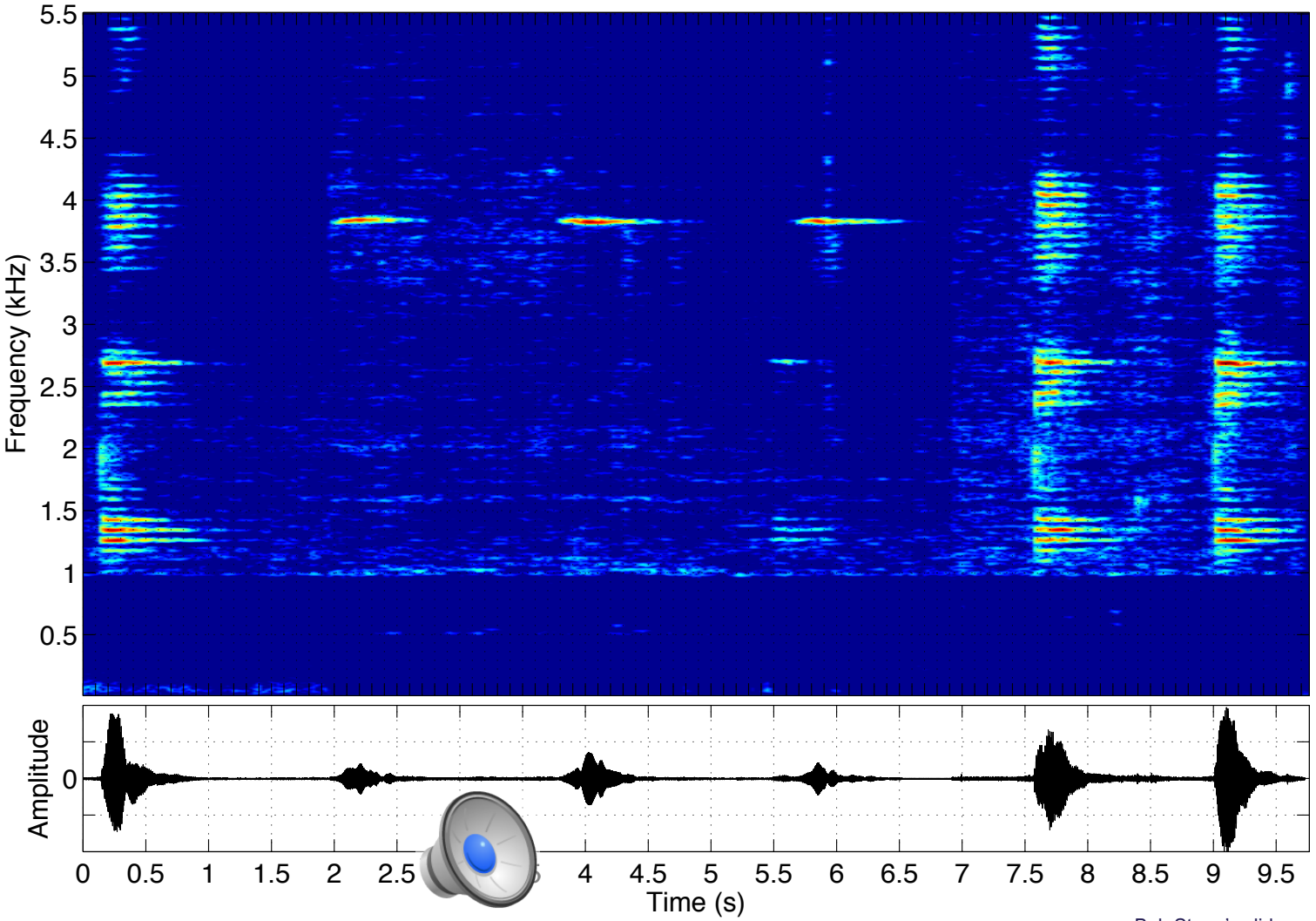
Short-term Fourier Transform



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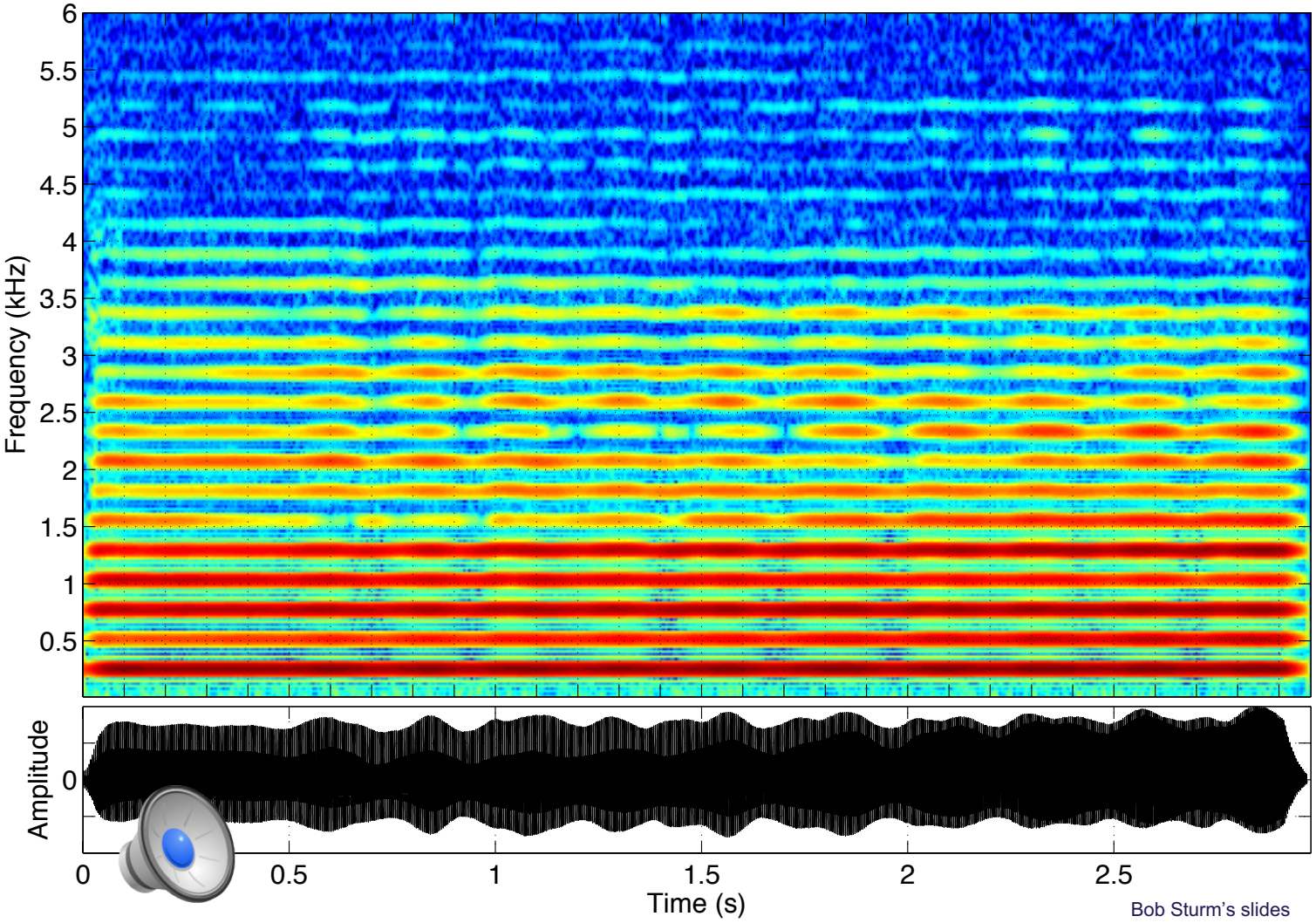
Short-term Fourier Transform



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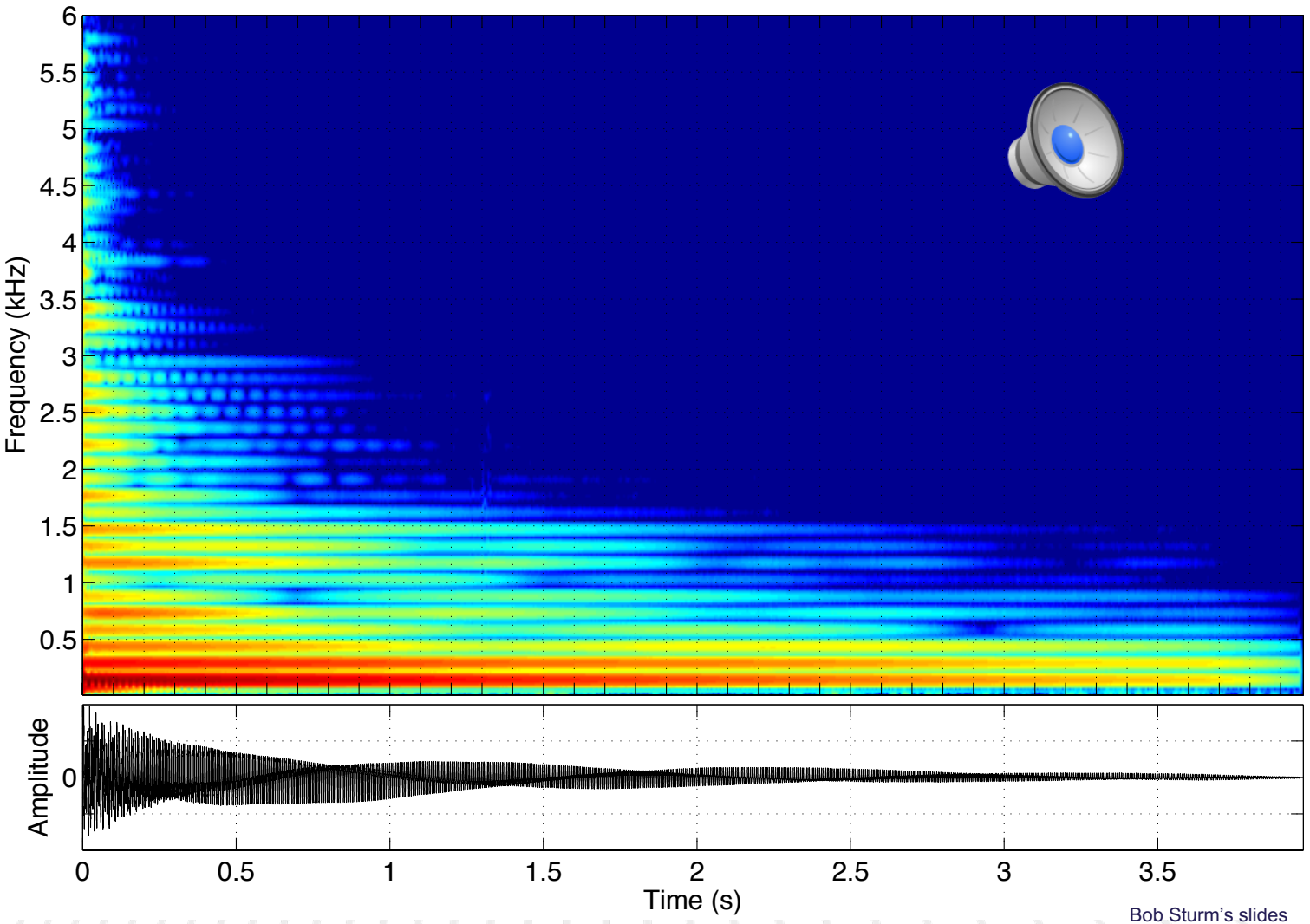
Short-term Fourier Transform



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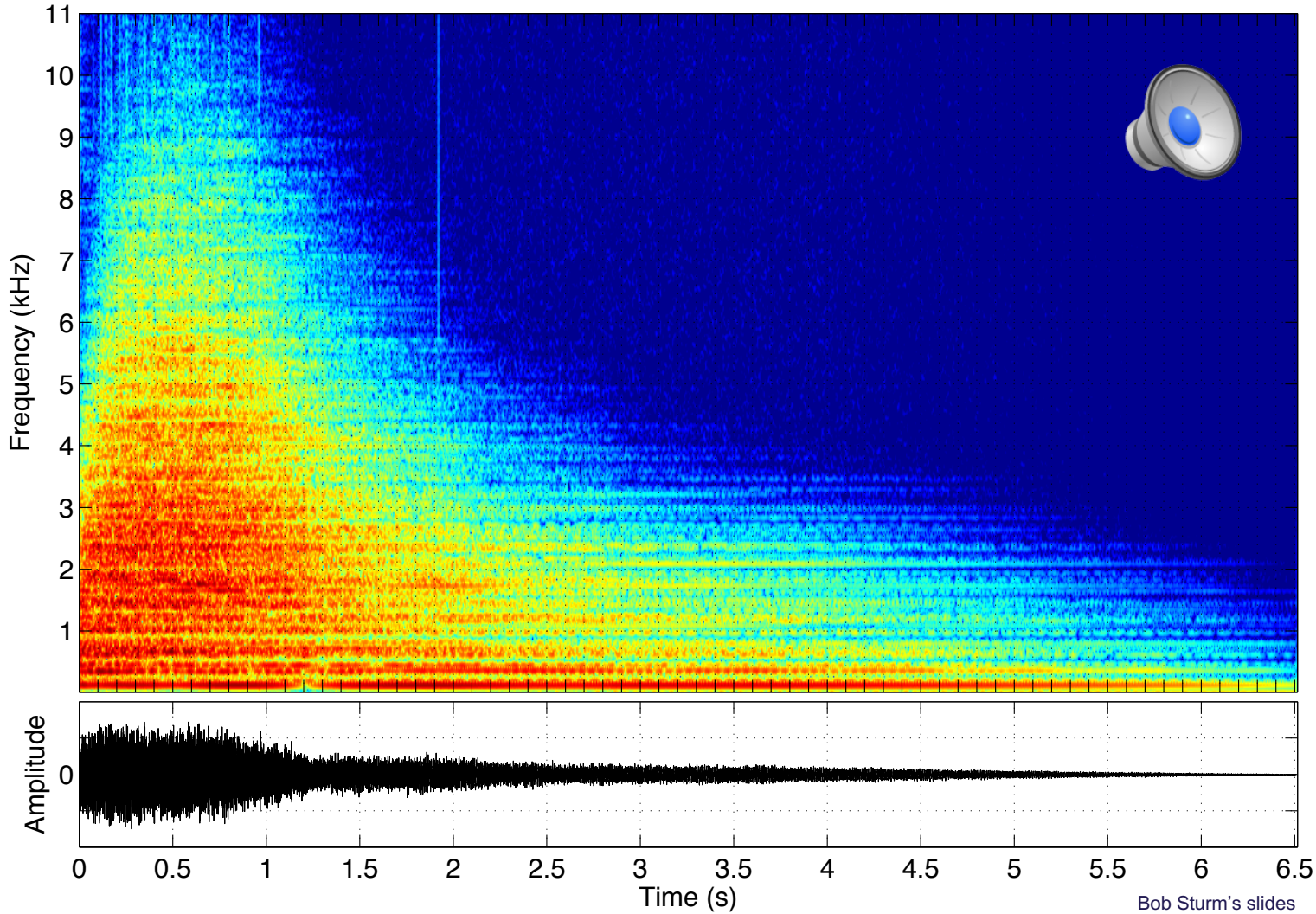
Short-term Fourier Transform



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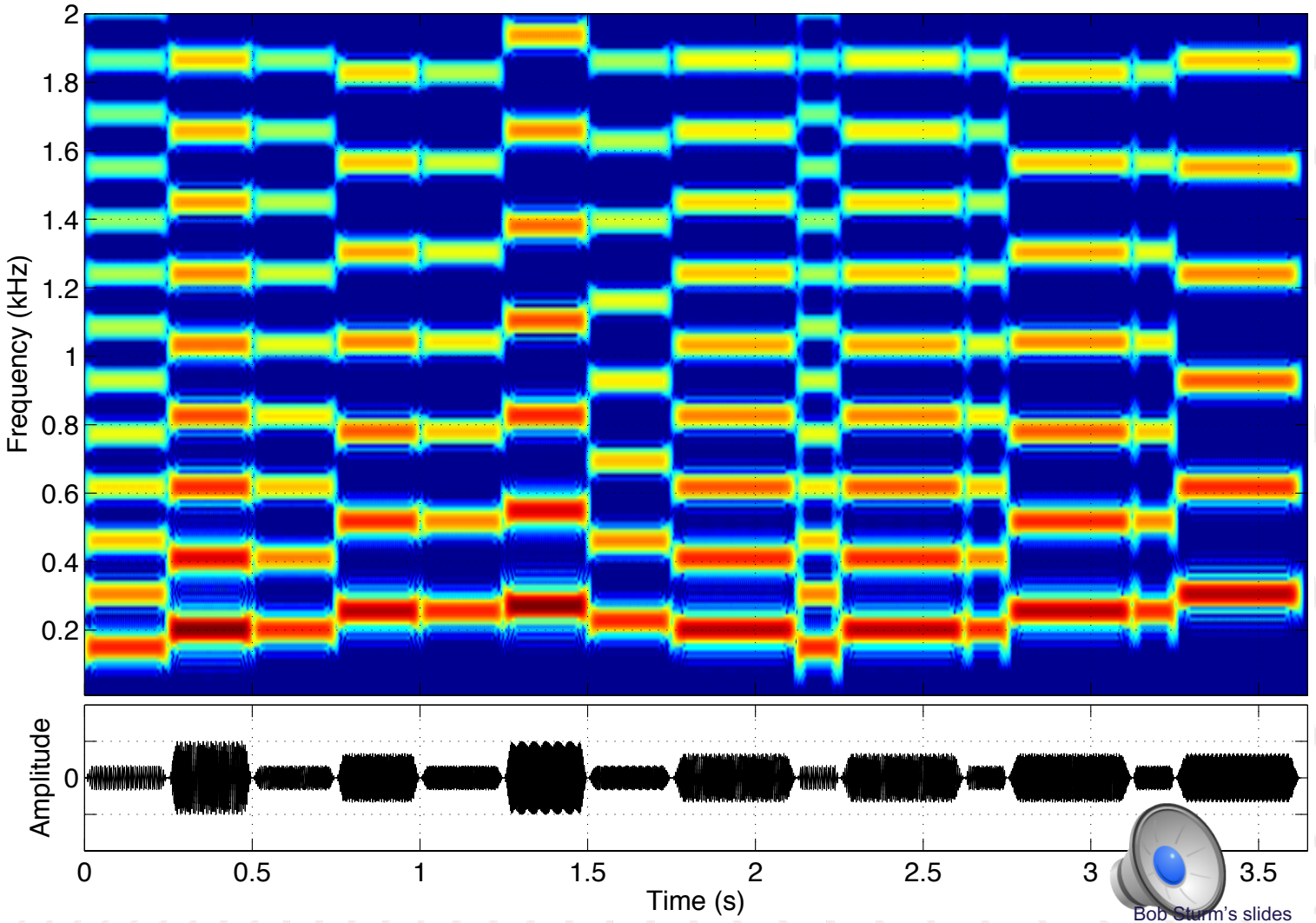
Short-term Fourier Fødselsdag



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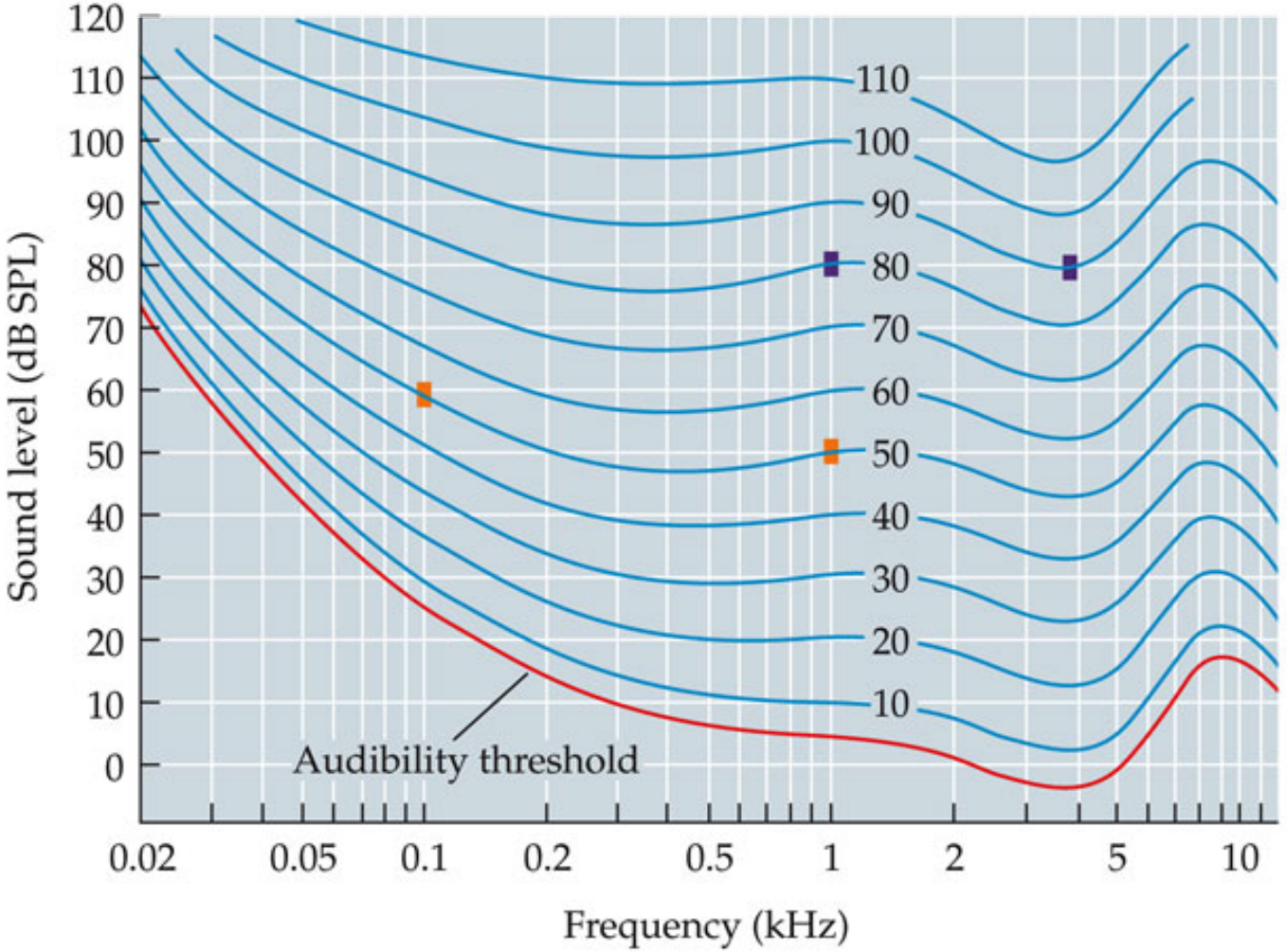
Loudness

- The physically measurable sound pressure level (SPL) does not exactly correspond to how loud we perceive a sound to be.
- Varies with frequency.
- The perceived *loudness* of a sound can be measured by adjusting the sound level of a tone to perceived equal loudness to a reference tone (typically 1kHz).

Equal loudness curves



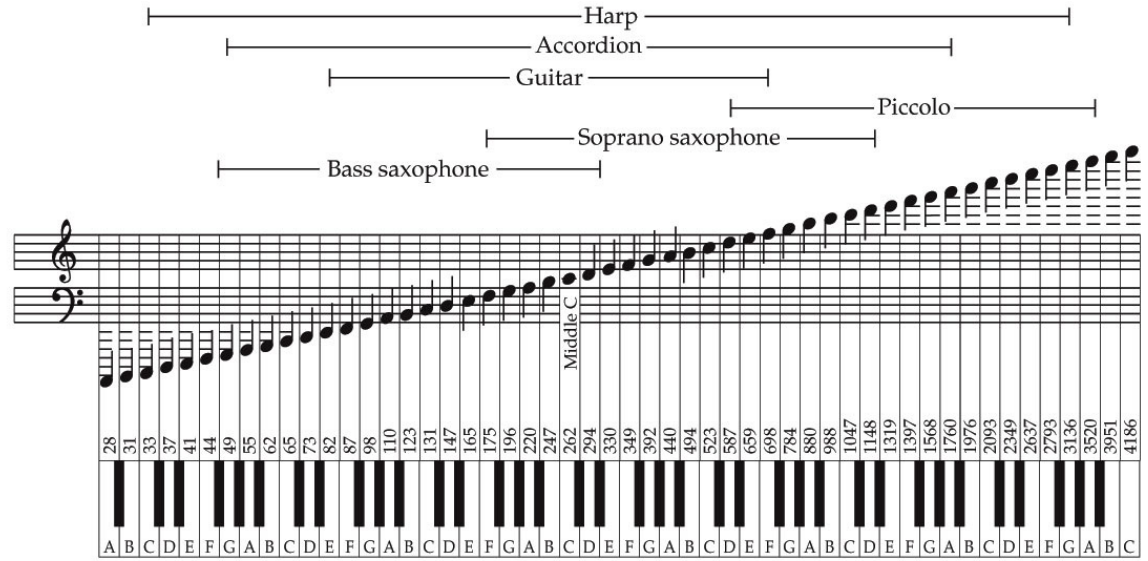
Hearing thresholds

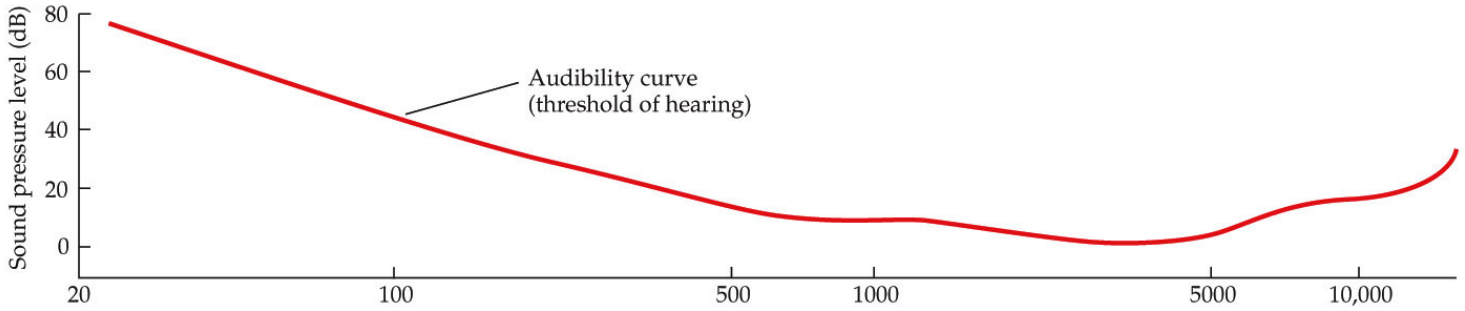
- What could this mean in practice when you listen to music at low sound level on your home stereo?
  - Consider the bass frequencies
- In which frequency range are we most sensitive?
  - Why?

Pitch perception

- Pitch: The subjective attribute for frequency
  - Like loudness not exactly equivalent
- Research using pure tones suggest that we are good at detecting small frequency differences
  - In the order of a fraction of a percent in frequency

Musical sounds extend across a frequency range from about 25 to 4200 Hz

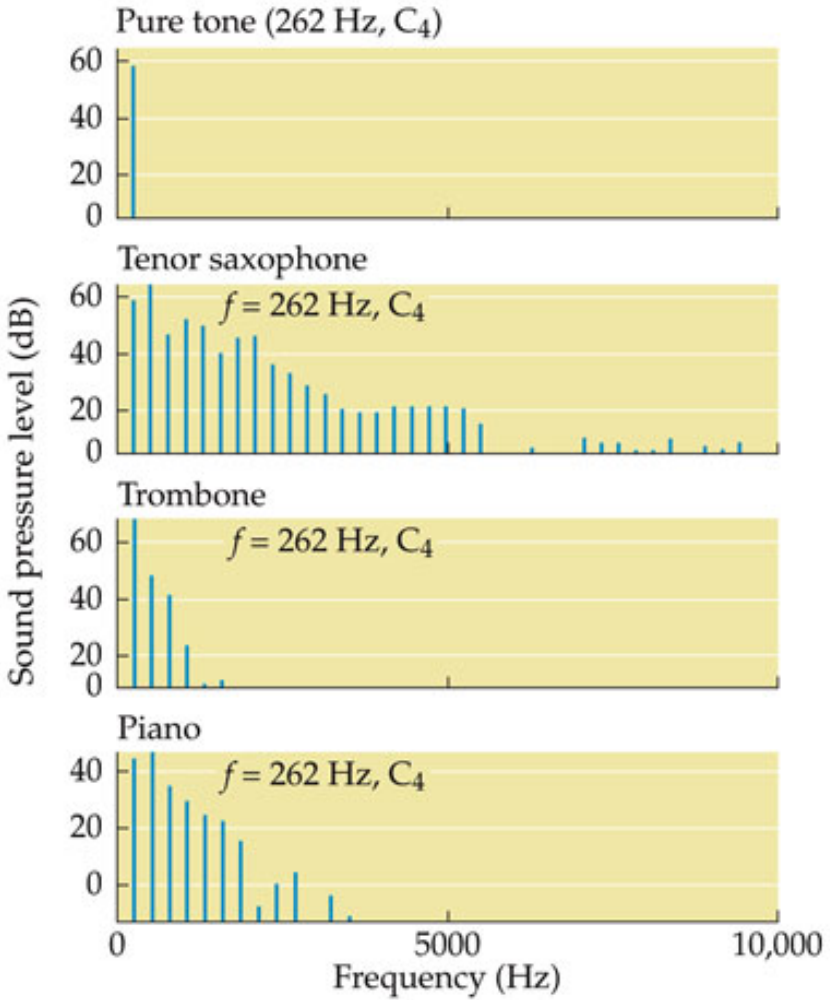




Timbre

These sounds all give the same sensation of pitch, but have different TIMBRE.

Timbre is basically what makes sounds of the same pitch and loudness sound different



SENSATION & PERCEPTION 2e, Figure 9.8

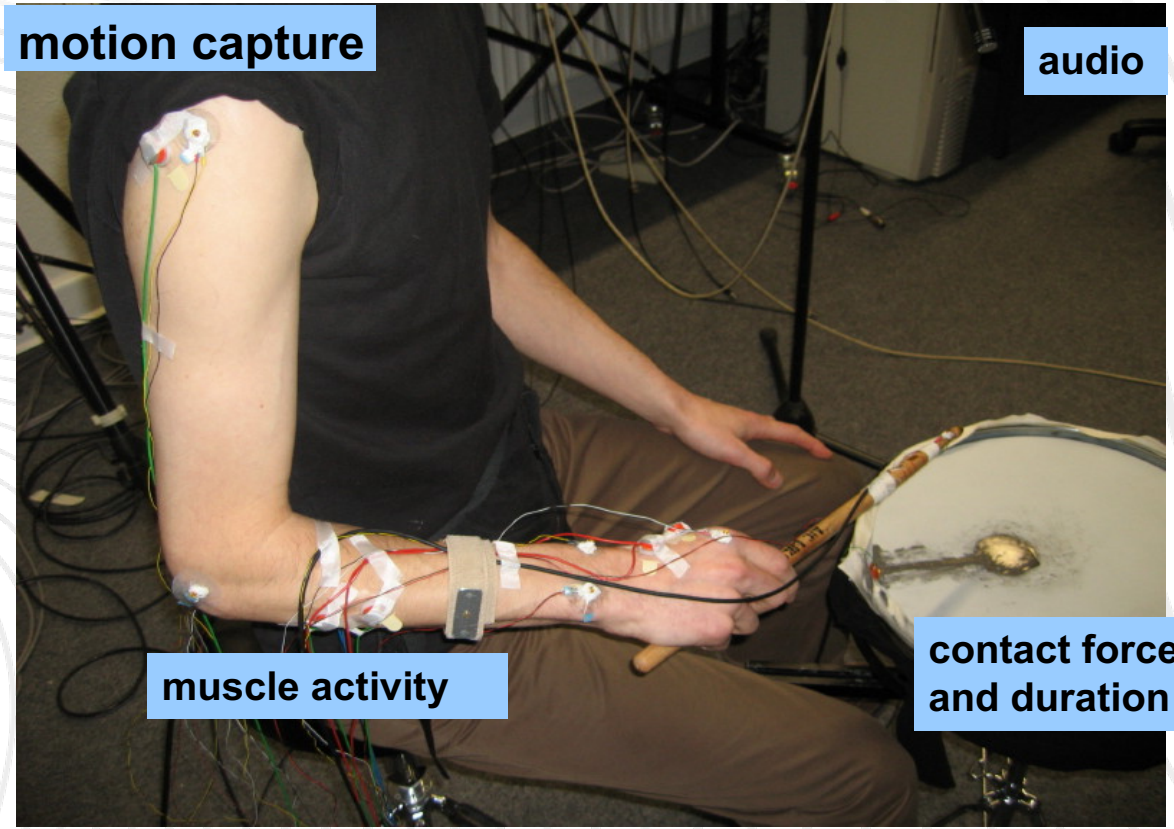
EXAMPLES FROM RESARCH

SOFIA DAHL

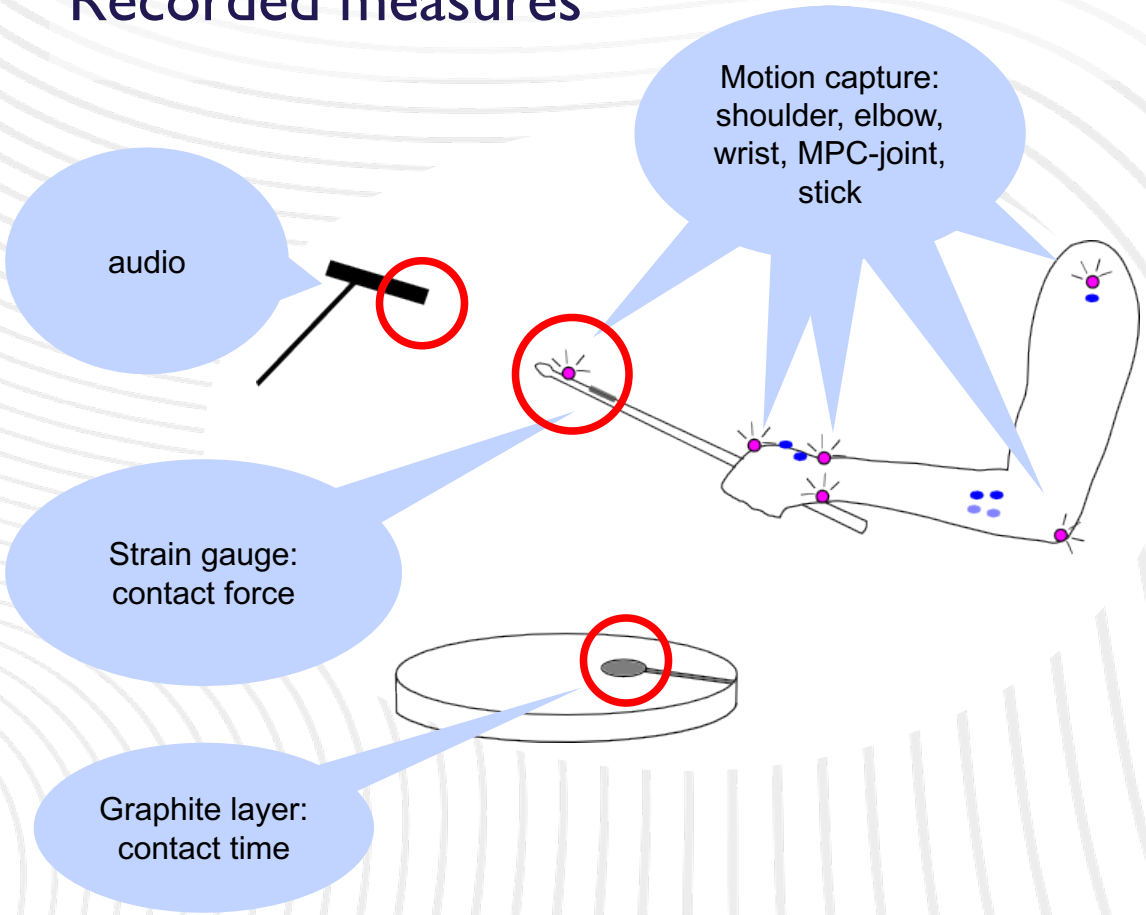
AALBORG UNIVERSITY
DENMARK

CONTROLLING SOUND IN DRUMMING

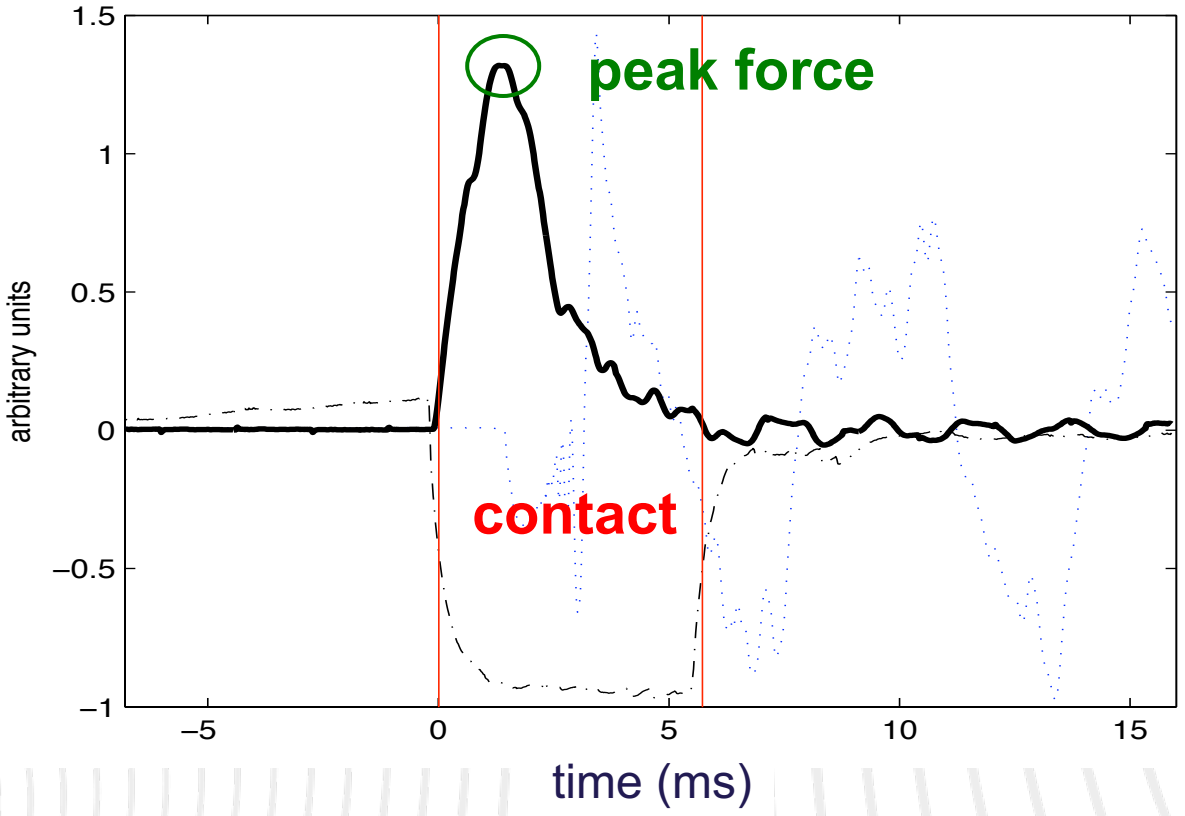
Measuring movement and sound in drumming



Recorded measures

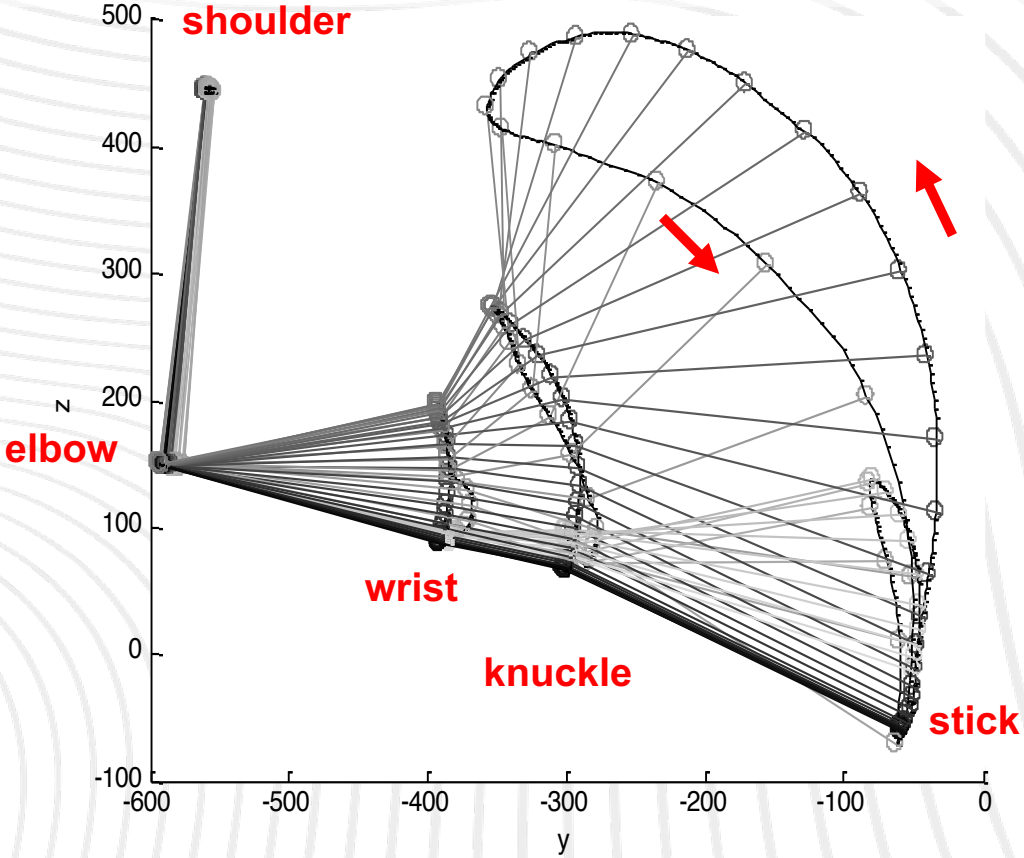


Measurement of force and contact time

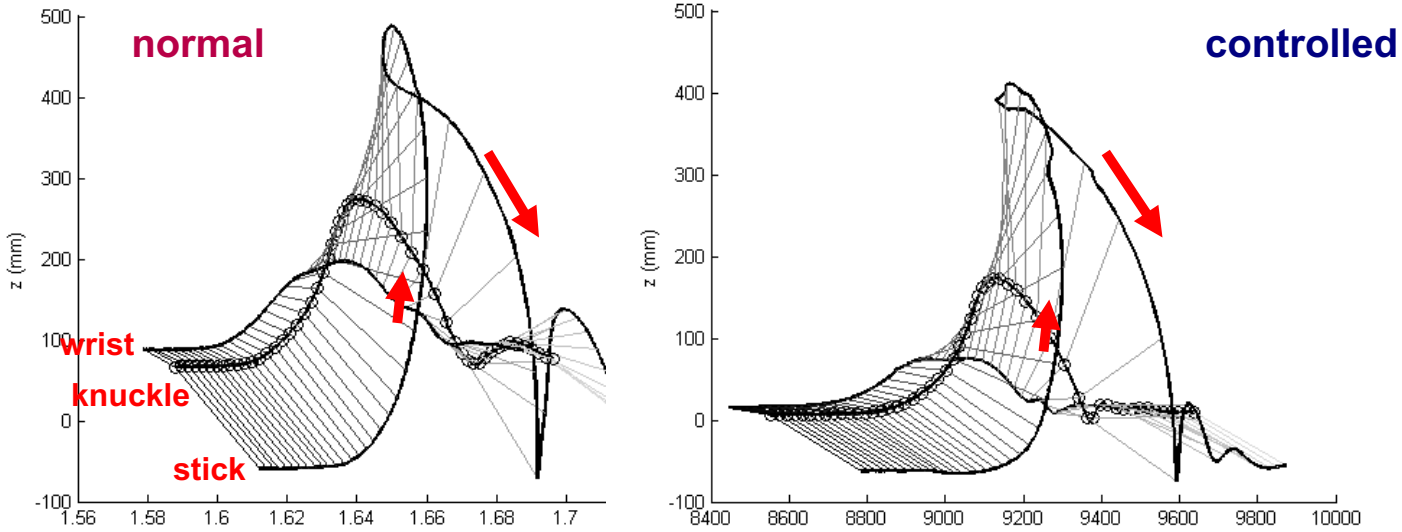


Dahl, Altenmüller (2008)

Motion capture data for a single *mf* stroke

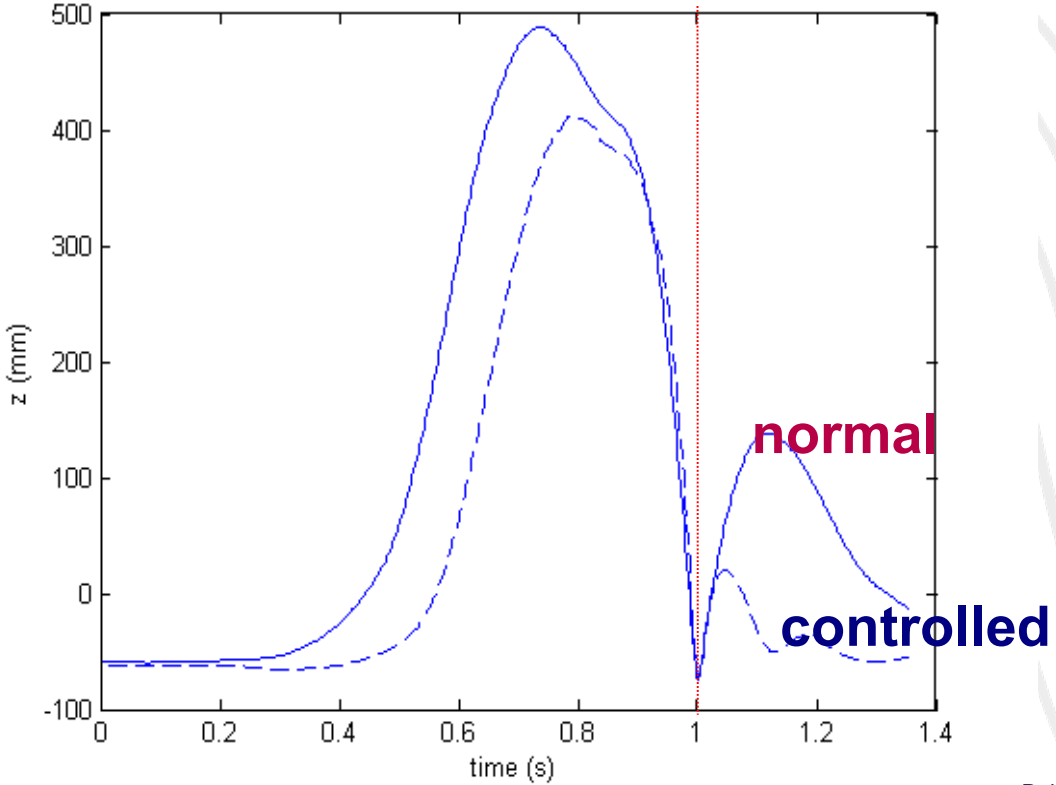


“Normal” and “Controlled” strokes



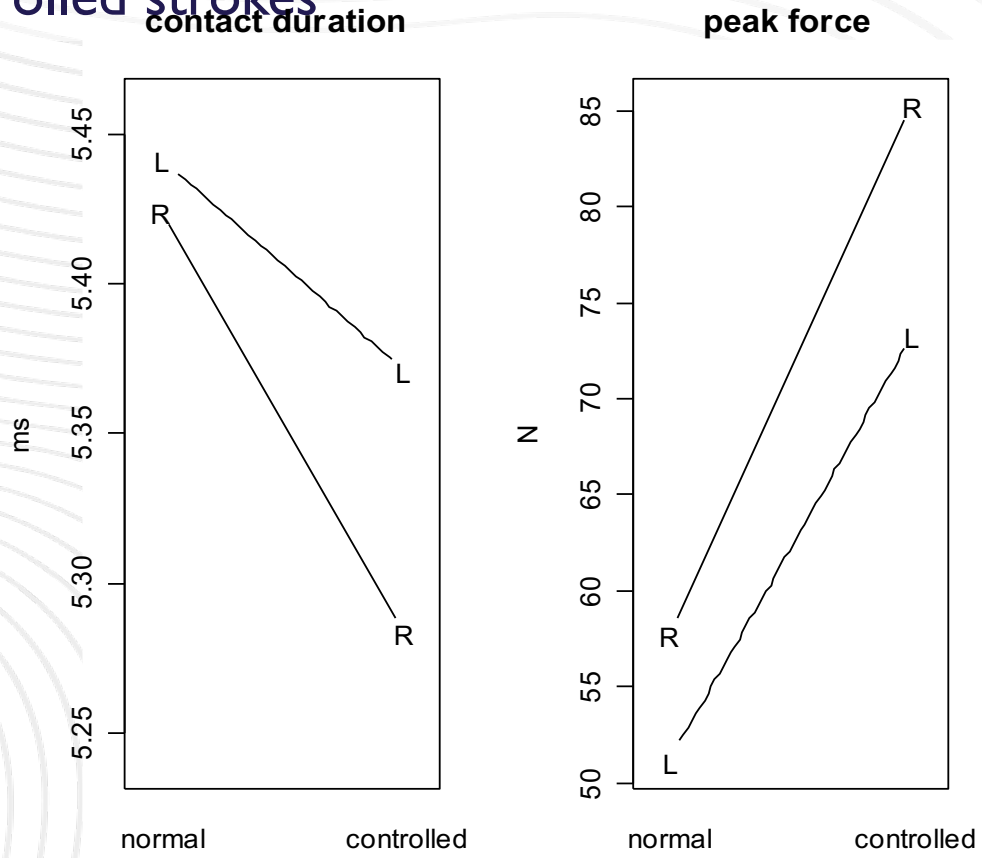
Dahl, Altenmüller (2008)

Vertical displacement of stick marker



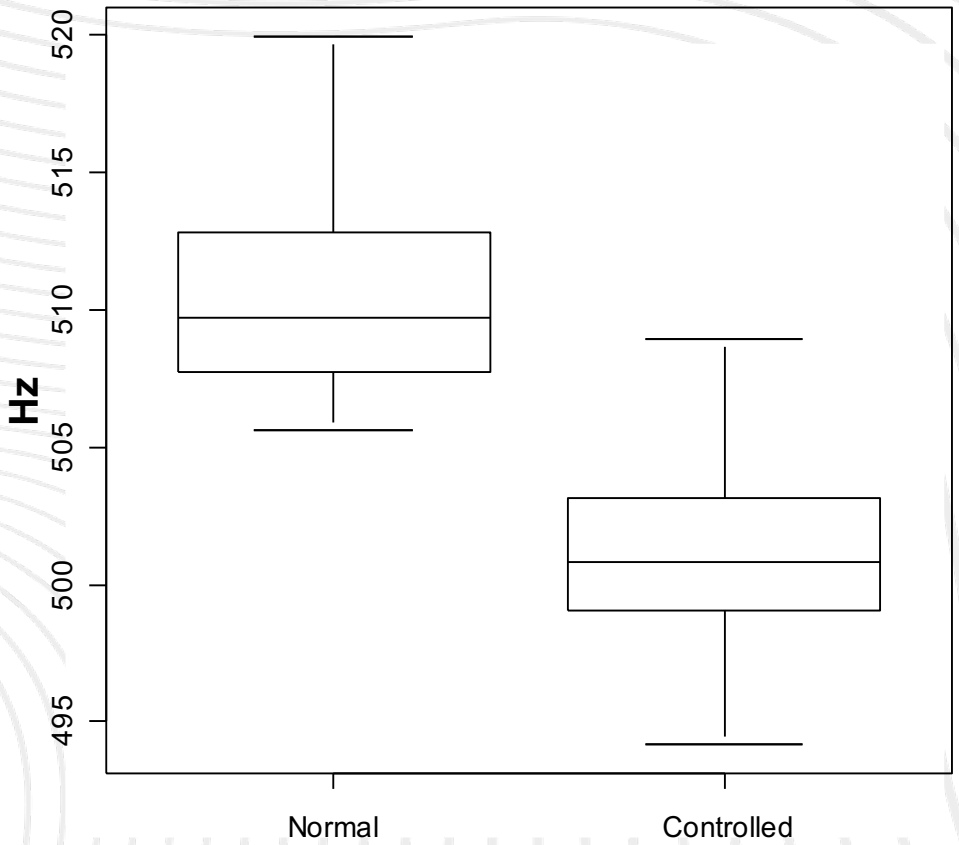
Dahl, Altenmüller (2008)

Contact force and duration for normal and controlled strokes



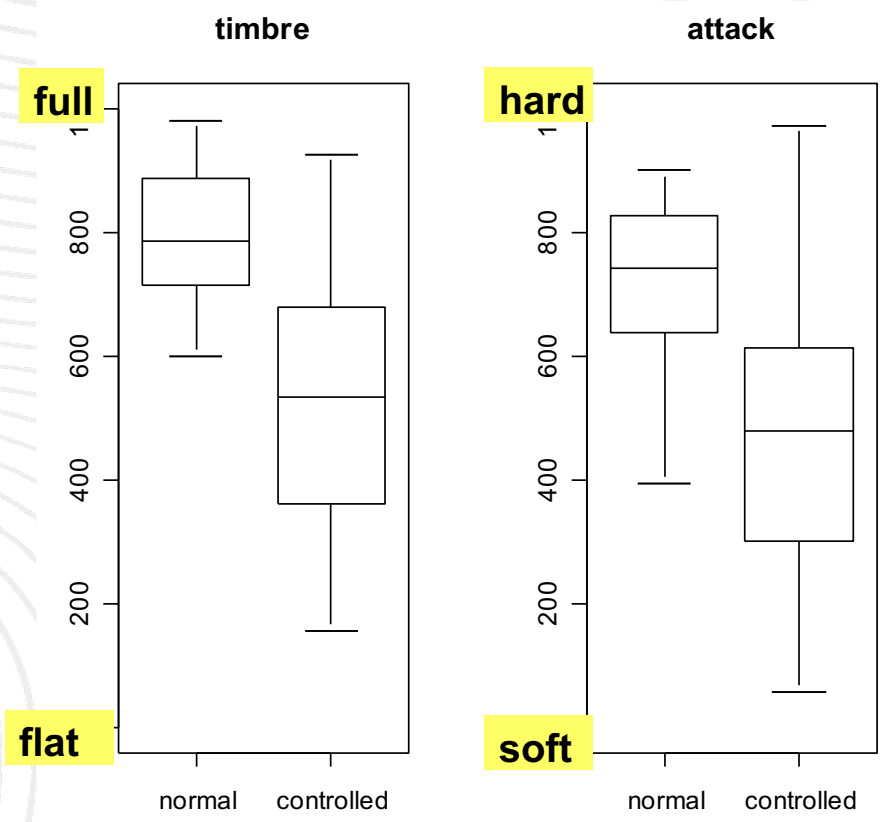
Dahl, Altenmüller (2008)

Spectral centroid (considering 16-1000 Hz)



Dahl, Altenmüller (2008)

Ratings for timbre and attack: results

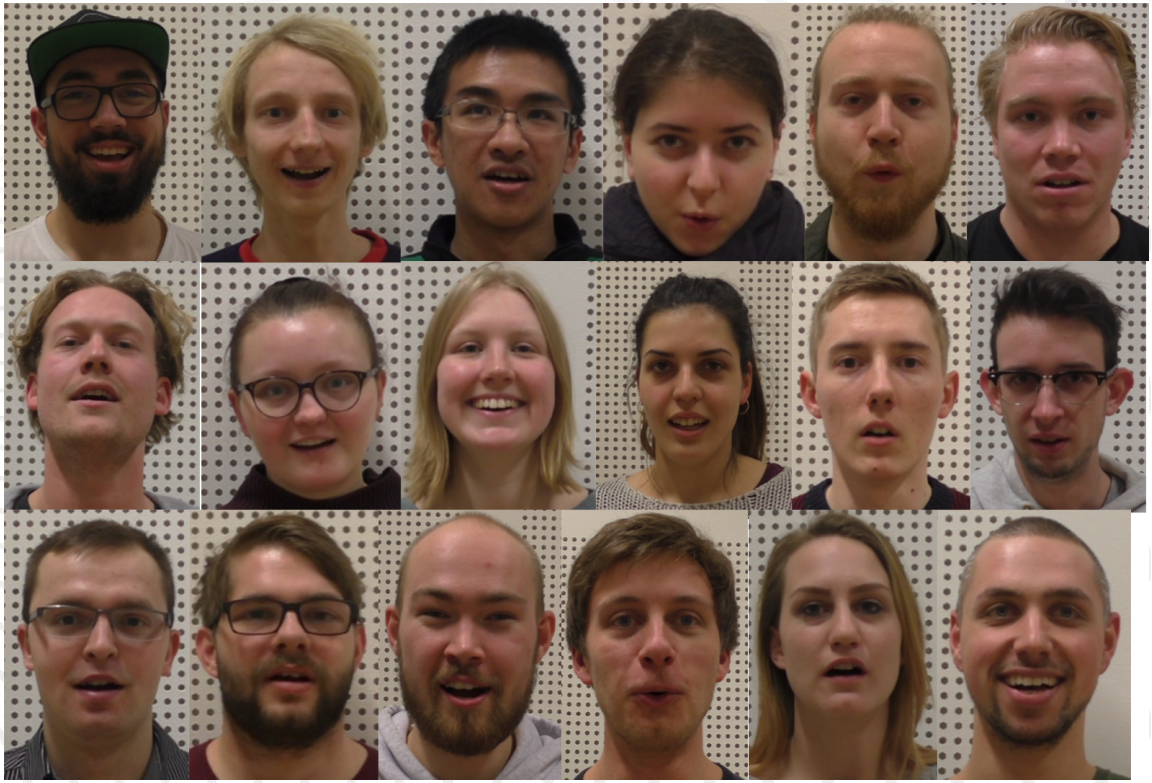


Dahl, Altenmüller (2008)

COMMUNICATION OF EMOTION

Which is the friendlier looking face?

Experiment



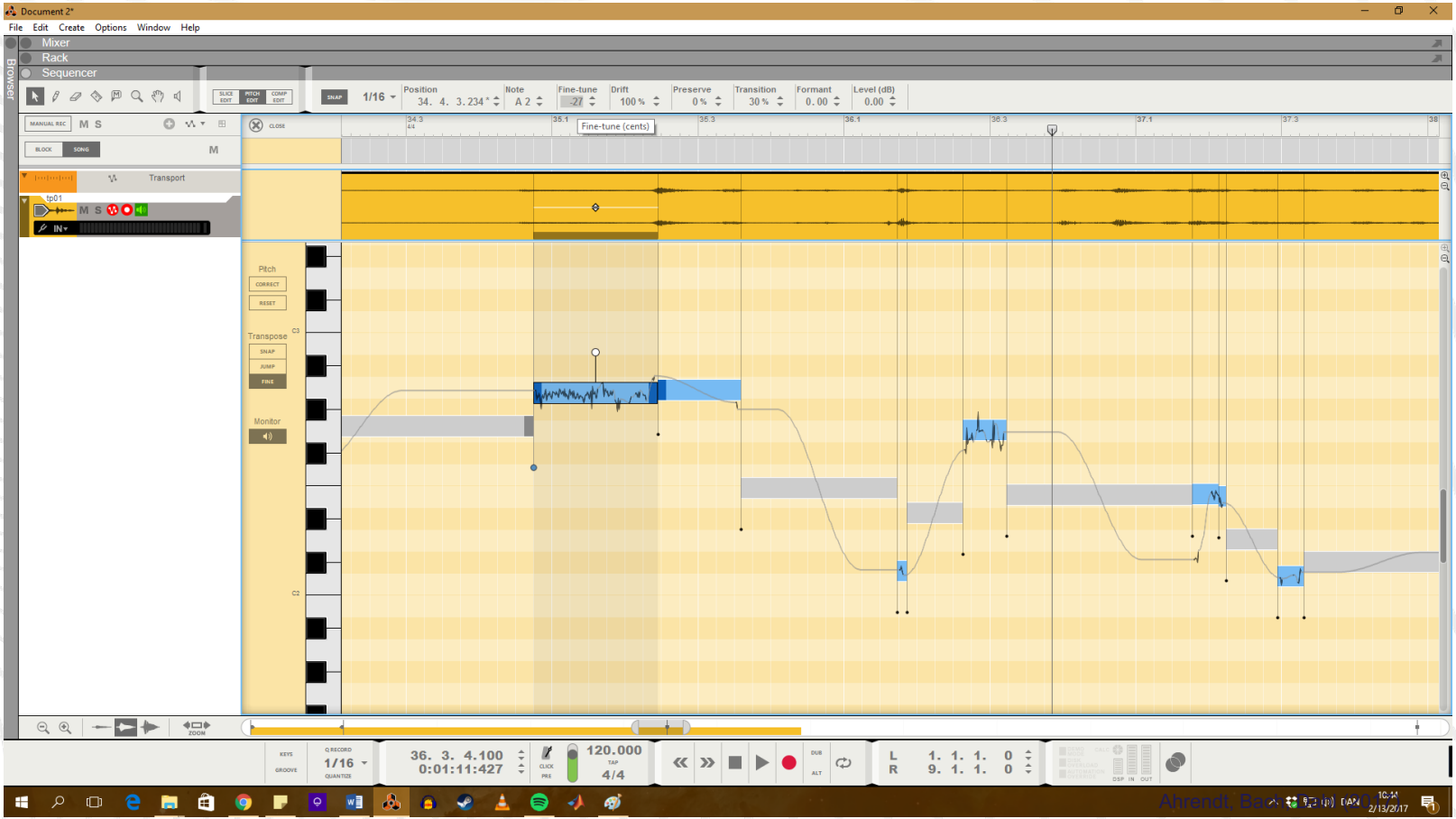
- **19 participants (5 female, 14 male)**

Participants first sang a note and vowel of their choice and were then asked to sing both higher and lower than the first note.

The order high/low was randomized

Ahrendt, Bach, Dahl (2017)

Pitch extraction

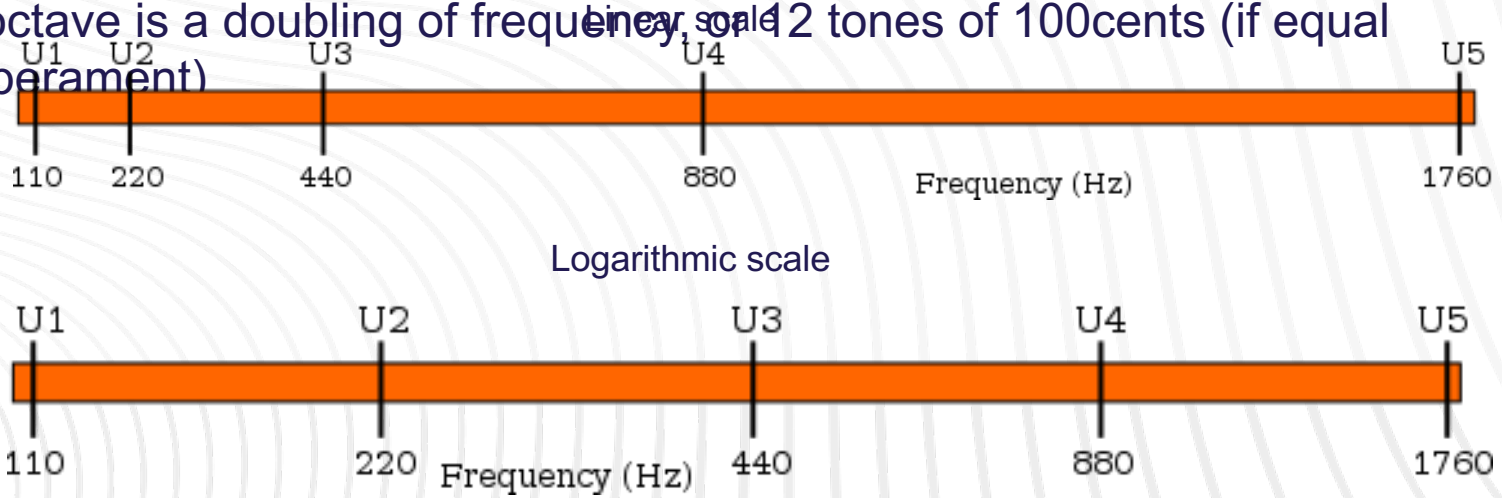


Cents

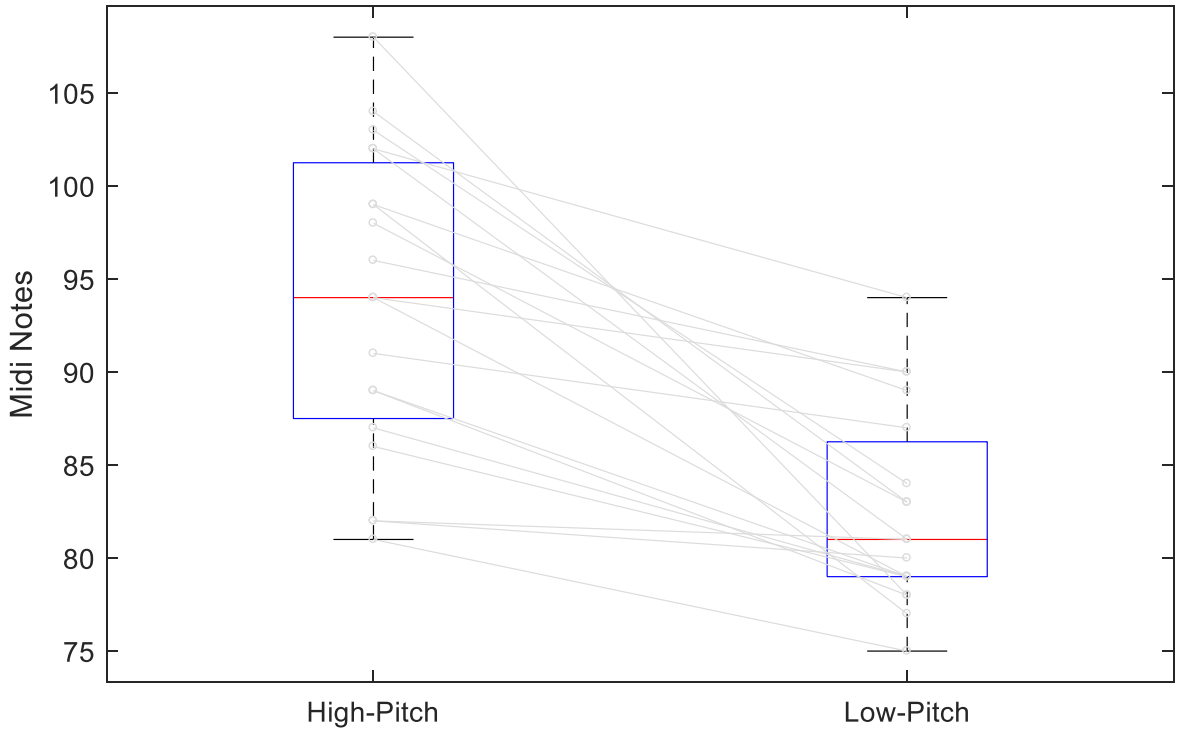
A relationship between two frequencies, a and b, that is related to our perception of pitch

$n = 1200 * \log_2 (b/a)$

An octave is a doubling of frequency, or 12 tones of 100cents (if equal temperament)



Sung notes

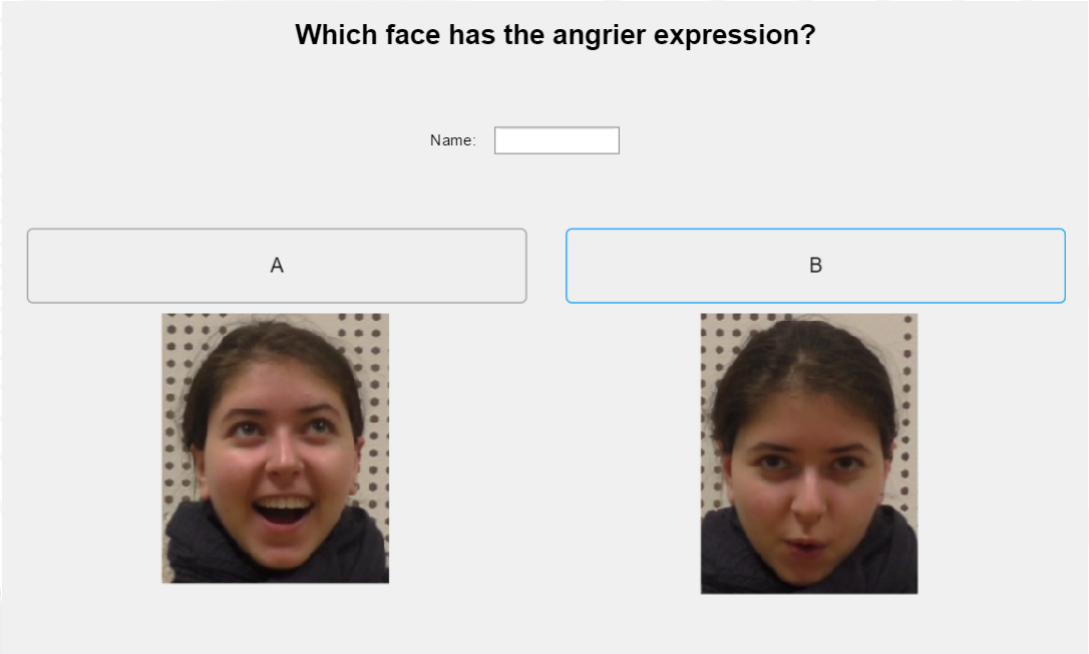


- Median high pitch: 94 MIDI notes (2490 cents, A#2)
- Median low pitch: 82 MIDI notes (1339 cents, A#1)
- Overall range: 3244 cents
- Average range: 1151 cents

Ahrendt, Bach, Dahl (2017)

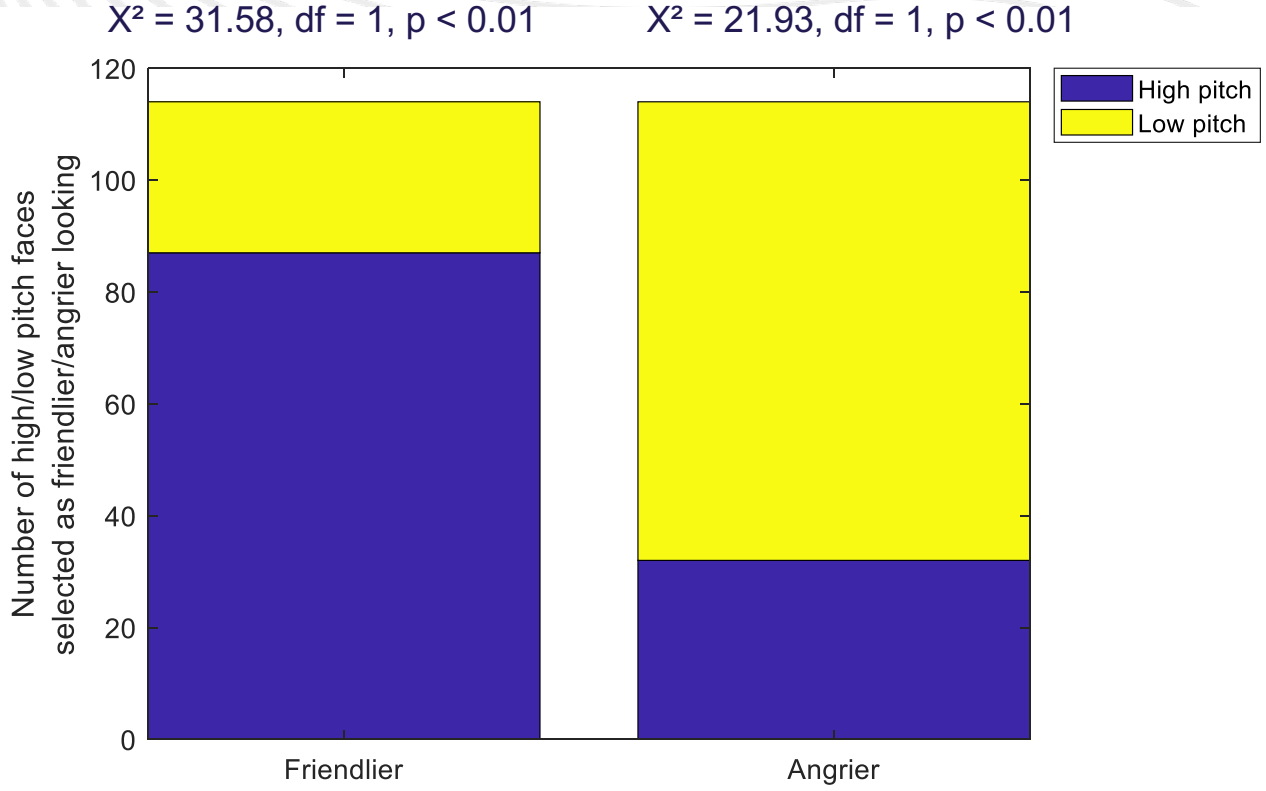
Ratings

Two groups of six assessors selected which of a picture pair they found more friendly looking resp. more angry looking



Ahrendt, Bach, Dahl (2017)

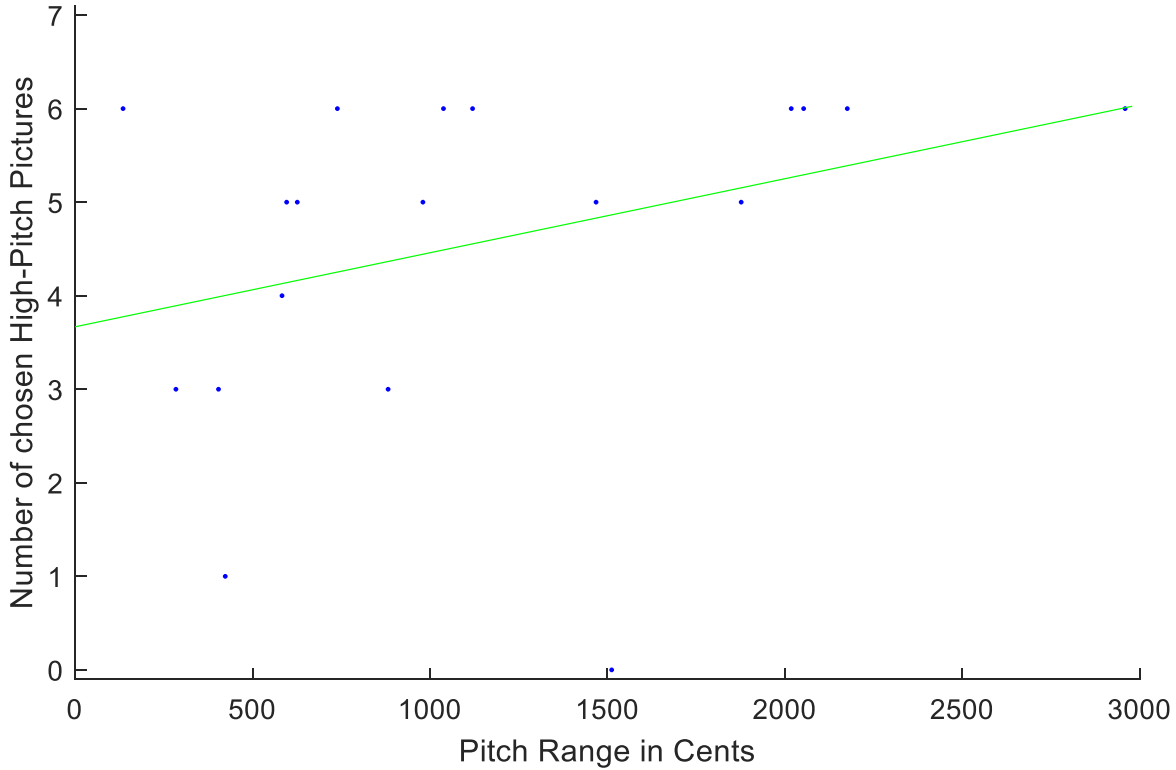
Result



- Each bar shows 114 choices (19 pairs * 6 assessors)

Ahrendt, Bach, Dahl (2017)

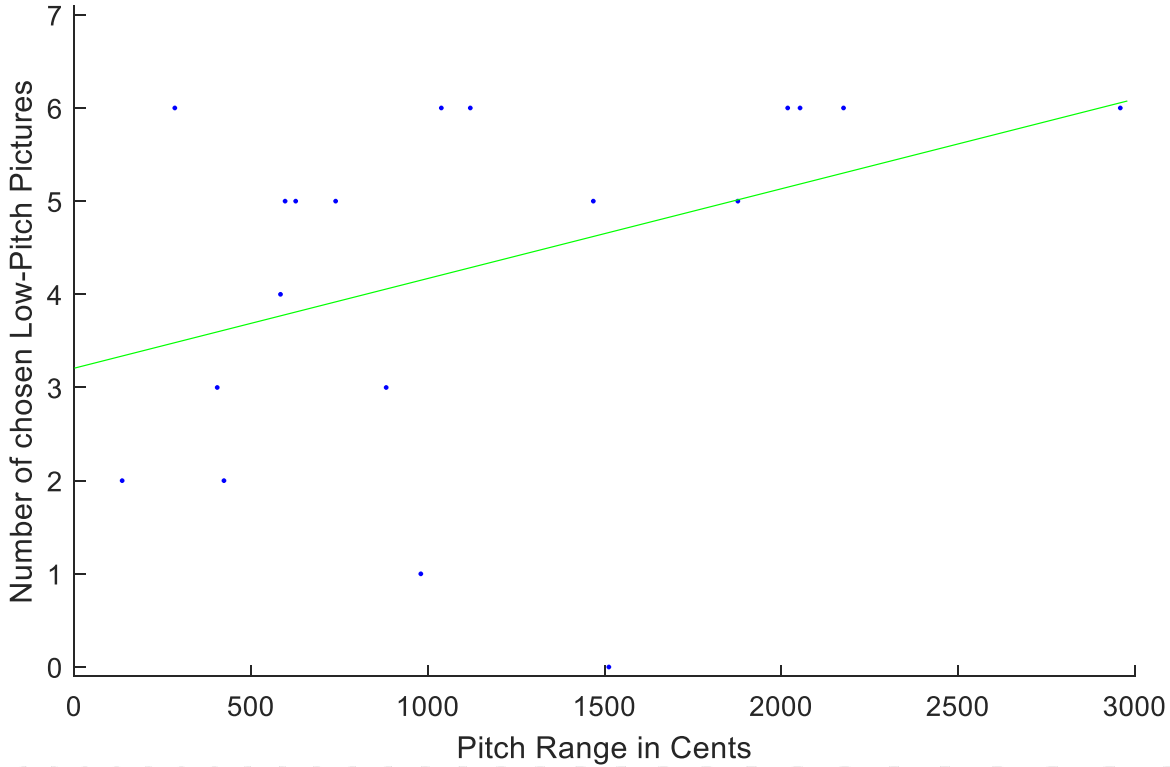
Pitch range vs. number of choices – friendlier



r = 0.34, t = 1.48, df = 17,
p-value = 0.16

Ahrendt, Bach, Dahl (2017)

Pitch range vs. number of choices – angrier



r = 0.39, t = 1.74, df = 17,
p-value = 0.10

Ahrendt, Bach, Dahl (2017)