Max-Planck-Institut
für empirische Ästhetik

The Ohio State University

Singing accuracy, listeners' tolerance, and pitch analysis

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Musical errors

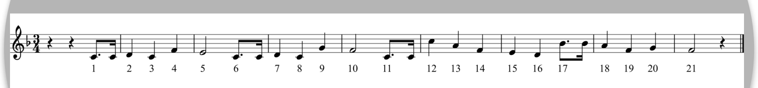
Contour error

Interval error

Tonality error

Musical errors

166 performances



http://sldr.org/sldr000774/en

Computer assisted method

(Larrouy-Maestri & Morsomme, 2013)

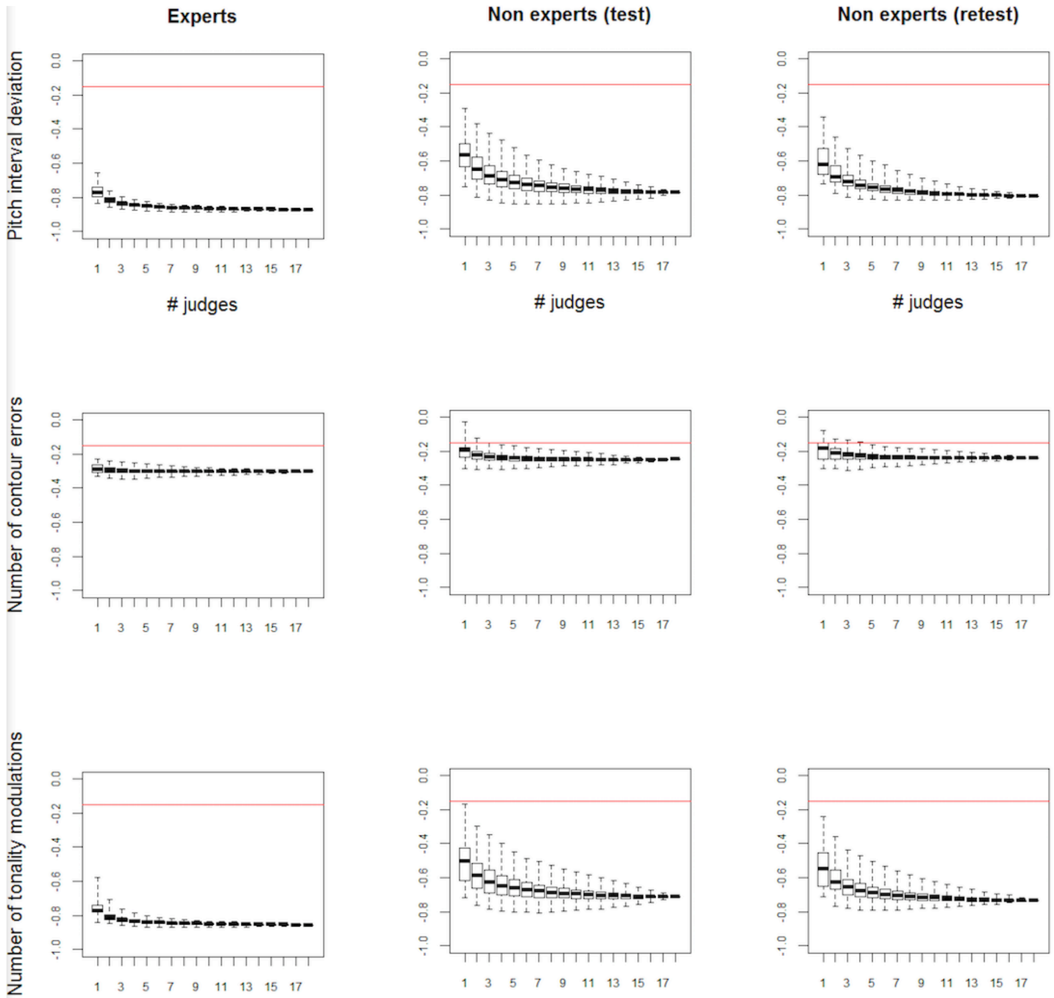
3 criteria

Judges

1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9

Out of tune In tune

Musical errors



F(3,165) = 231.51; p < .01
81%
Interval deviation Tonality modulations

F(3,165) = 104.44; p < .01
66%
Interval deviation

Larrouy-Maestri, P., Lévêque, Y., Schön, D., Giovanni, A., & Morsomme, D. (2013). The evaluation of singing voice accuracy: A comparison between subjective and objective methods. *Journal of Voice*.

Larrouy-Maestri, P., Magis, D., Grabenhorst, M., & Morsomme, D. (revision). Layman or professional musician: Who makes the better judge?

Musical errors

- Intervals are important in the definition of vocal pitch accuracy in a melodic context
- When you are an experts, you pay attention to interval deviation and number of modulations
- But … tolerance?

Tolerance

- Pitch discrimination (e.g., http://www.musicianbrain.com/pitchtest/)
- In a melodic context
  - Semitone (100 cents) Berkowska & Dalla Bella, 2009 ; Dalla Bella et al., 2007, 2009a, 2009b ; Pfordresher & al., 2007, 2009, 2010
  - Quartertone (50 cents) Hutchins & Peretz; 2012 ; Hutchins, Roquet, & Peretz, 2012 ; Pfordresher & Mantell, 2014
- Tolerance of layman listeners for non-familiar melodies
  - Much less that a quartertone !
  - Whatever the type of error, the place and size of the interval
- But … effect of **familiarity?** **Yes** (Kinney, 2009) **No** (Warrier & Zatorre, 2002)
- Effect of **expertise?** **Yes** (most of the literature) **No** (Larrouy-Maestri et al., under revision)

Tolerance: Participants

	Musicians	Non Musicians
n	30	30
Gender	5 women	5 women
Age	*M* = 41 (*SD* = 11.85)	*M* = 41 (*SD* = 12)
Instrument	20 chords 11 wind 4 percussions 5 singers	no history of choral singing no formal musical training (max 2 years and no practice during the past 5 years)
Years of training	*M* = 30.7 (*SD* = 12.32)	
Starting	*M* = 8.8 (*SD* = 4.63)	
Audiometry		hearing threshold below 20 dB HL
Production task		ability to perform Happy Birthday with respect to appropriate melodic contour
MBEA (Peretz et al., 2003)		no deficit in music perception

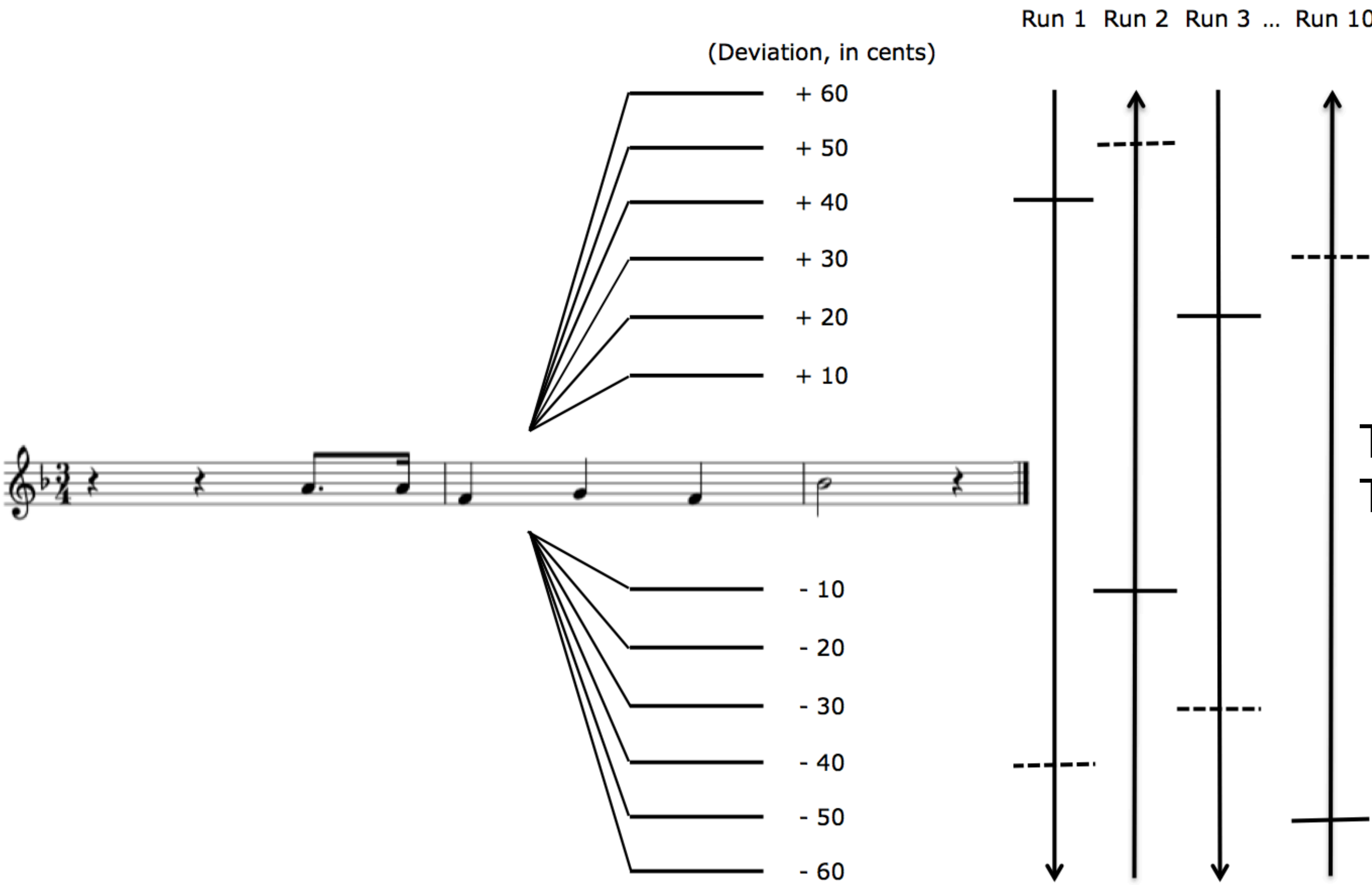
Tolerance: Material

- Familiar and Non-Familiar melodies

- Online questionnaire
  - 399 participants from 13 to 70 years old (*M* = 29.81)
  - Familiarity ratings
    - $t(398) = 20.92$, $p < .001$
    - No effect of expertise on the ratings ($p > .05$)

Tolerance: Procedure

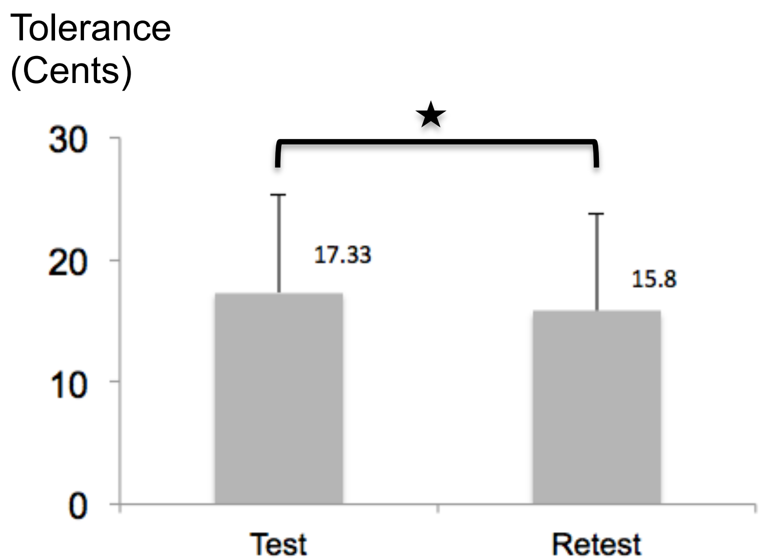
Methods of limits
(Van Besouw, Brereton, & Howard, 2008)



Two times
Test-retest paradigm

Tolerance: Test-retest

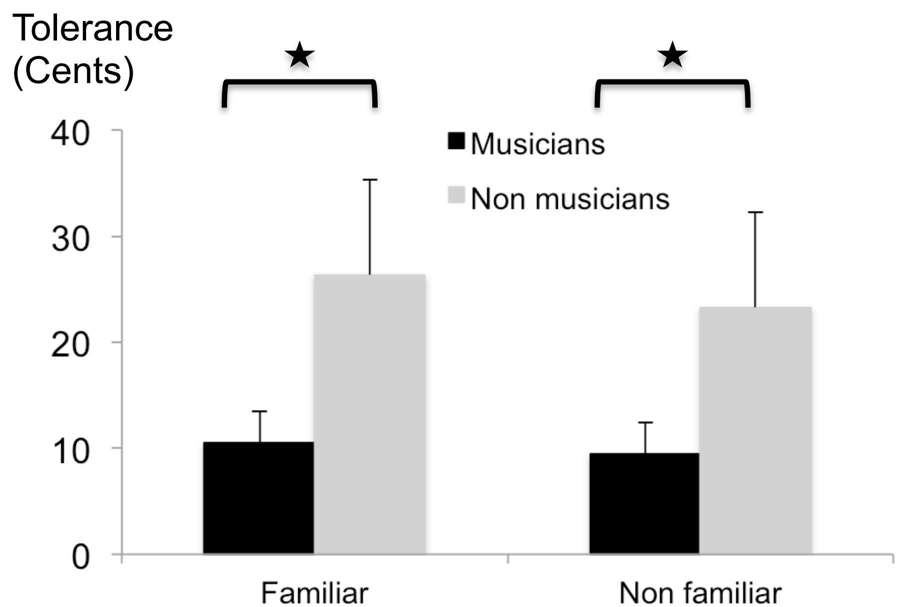
- Highly significant correlation ($r(60) = .91$, $p < .001$)



- *No effect of the direction of the deviation (i.e., enlargement vs. compression) t(59) = .-96, p = .34*
- *No effect of expertise (p = .08) or familiarity (p = .71) or interaction (p = .65) on the evolution test-retest*

- Training effect ($t(59) = 2.92$, $p = .005$)

Tolerance: Effect of expertise and familiarity



- Effect of expertise (F(1, 116) = 139.11, $p < .001$, $\eta^2 = .54$)
- No effect of familiarity (F(1, 116) = 2.74, $p = .10$)
- No interaction (F(1, 116) = .60, $p = .44$)

Tolerance: Effect of expertise and familiarity

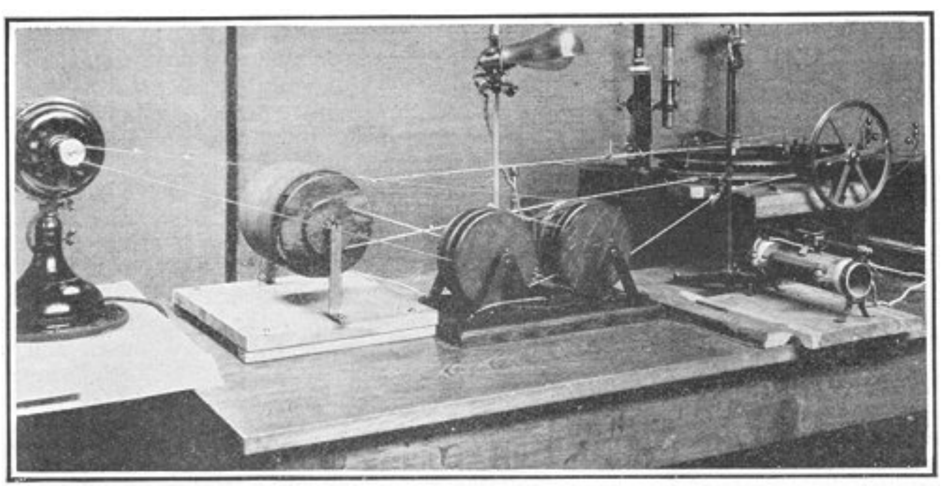
- Low tolerance of all listeners when listening to melodies slightly out of tune (less than a quarter tone)
- Highly significant expertise effect, even for a familiar song well known by the participants (i.e., Happy Birthday)
- Training effect (mainly for the musicians)
- But … perceptual limit of musicians?

Pitch analysis

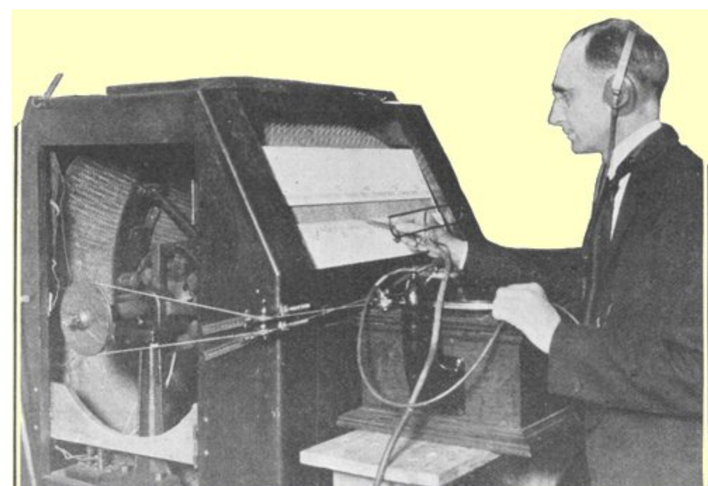
Historical Methods

University of Iowa

- Carl Seashore (1938) and colleagues studied timing, dynamics, intonation, and vibrato in pianists, violinists, and singers
  - Equipment: piano rolls, films of the movement of piano hammers during performance, phono-photographic apparati



Wave recorder for use with disk phonograph; the lever, acting like a pantograph, traces the waves on a revolving smoked drum

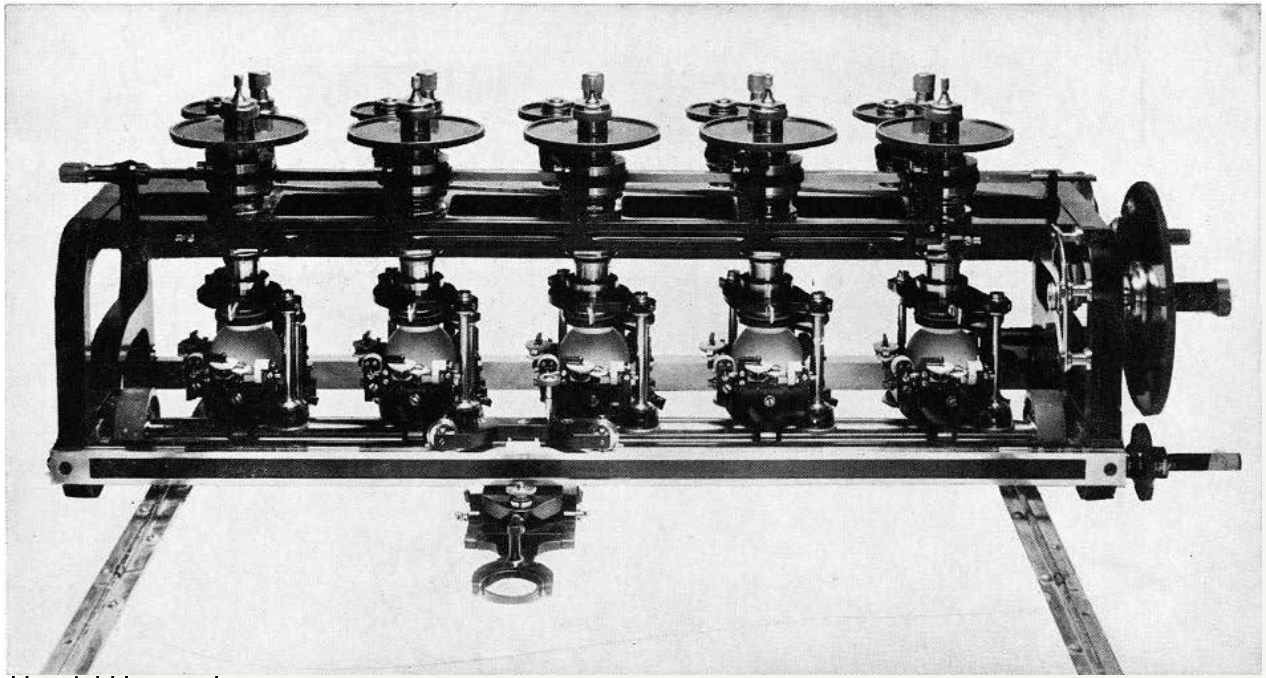


The tonoscope for analyzing the pitch of the tones on a disk phonograph record

Cary (1922)

Historical Methods

Phonophotography technique



Henrici Harmonic Analyzer

Seashore (1937)

- Frequency graphed in 10 cent units
- Intensity graphed in decibels
- Timing information as a function of linear space

Manual Annotation by Tapping

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Tap Snap

mazurka.org.uk/cgi-bin/tapsnap

Mazurka Project

AHRC Research
Centre for the History and Analysis of Recorded Music

This webpage will auto correct reverse conducting taps so that they align with the nearest onset in the audio. The input tapping data can contain taps for all of the events, or just a selection of the events, such as the beats.

Input data is a text file with the event times in seconds on the first column of each line as output from Sonic Visualiser annotation layers. The tapping data is usually generated manually by tapping to a audio recording in Sonic Visualiser. The onset data is usually generated automatically from a plug-in for Sonic Visualiser, such as Spectral Reflux.

Input Tapping Data

First, specify the location of the beat tapping data to be processed in one of the fields below.

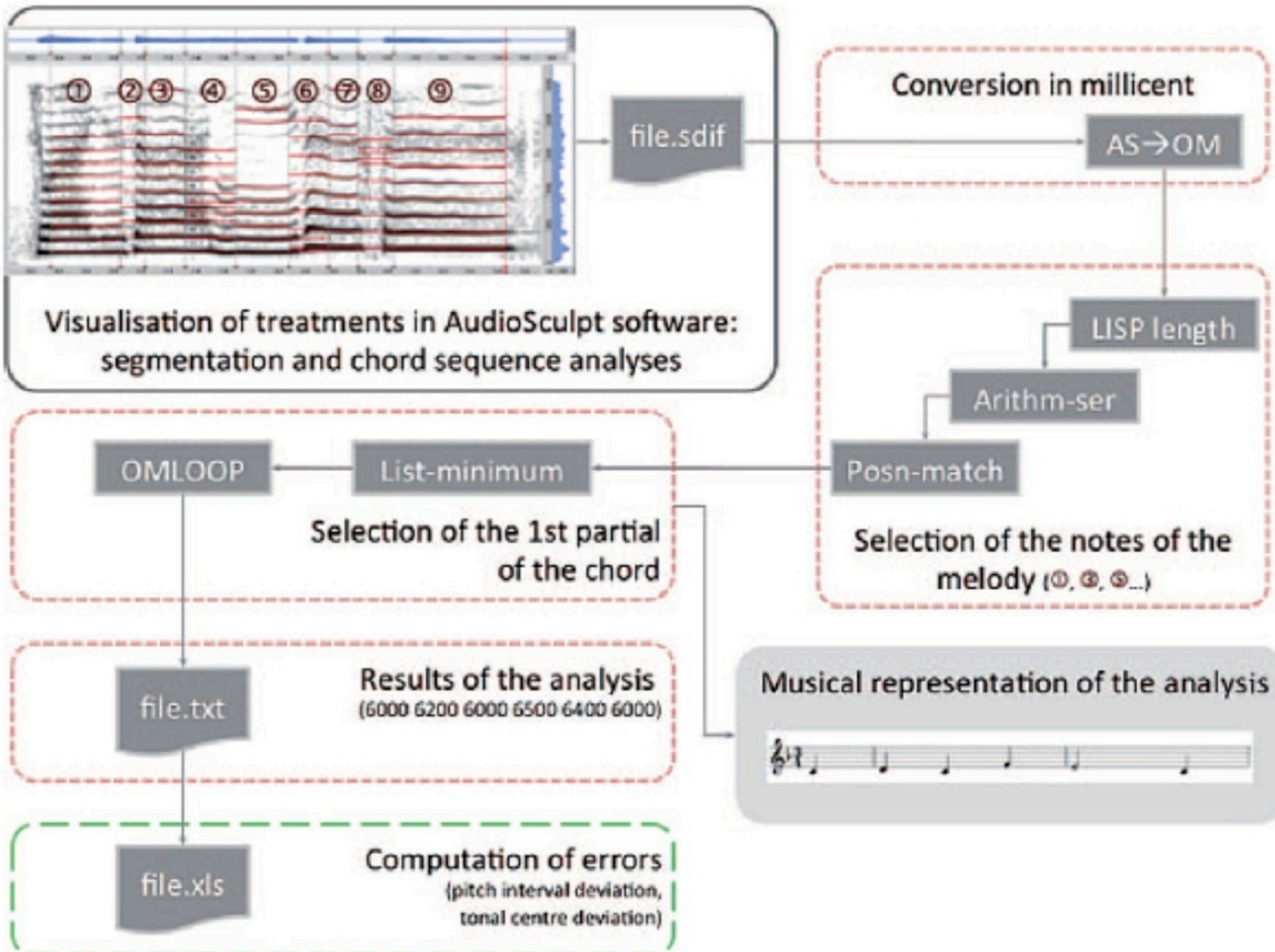
Upload a file from your computer: Choose File No file chosen

Or, **paste** the contents of the data file here:

Or, specify a data file **URL**:

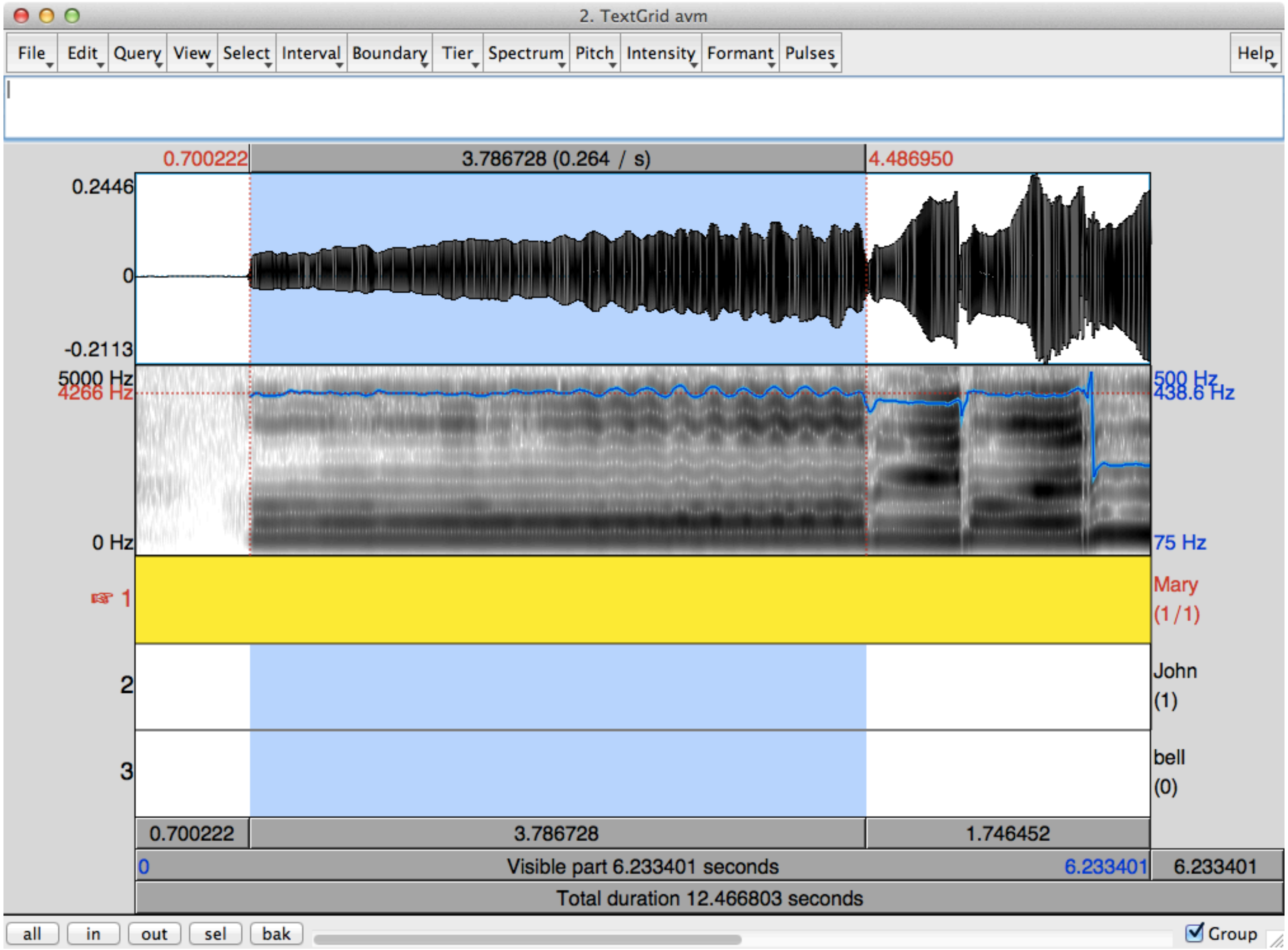
Manual Annotation with Software

Audio Sculpt + Open Music



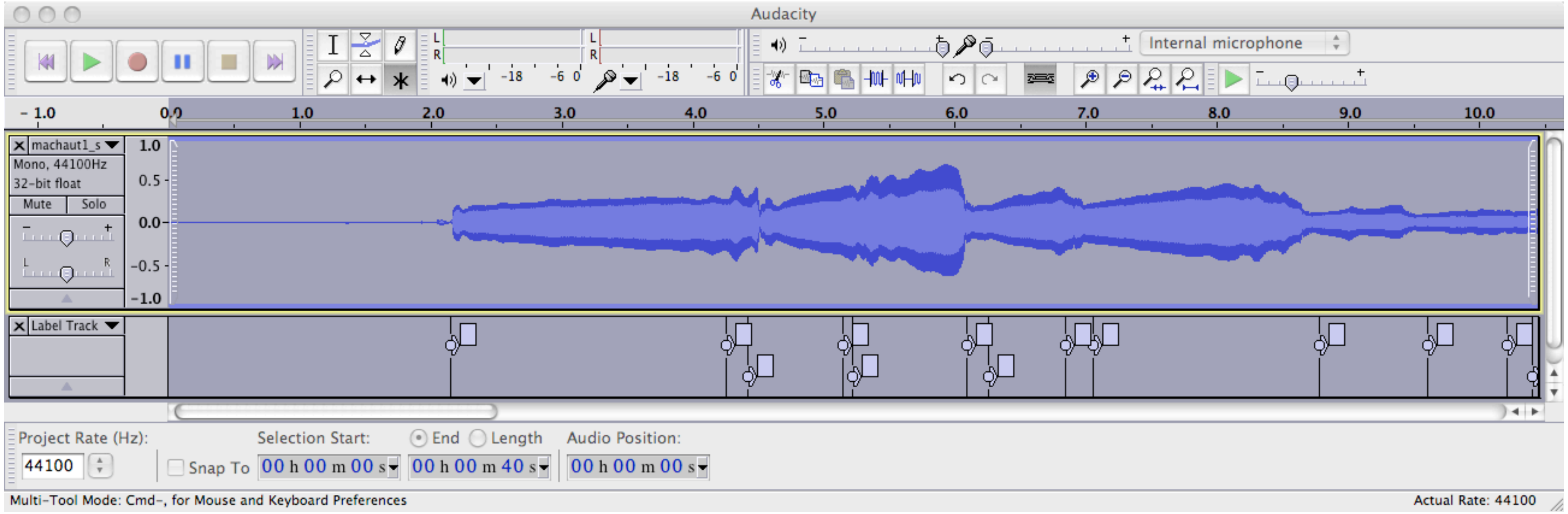
Manual Annotation with Software

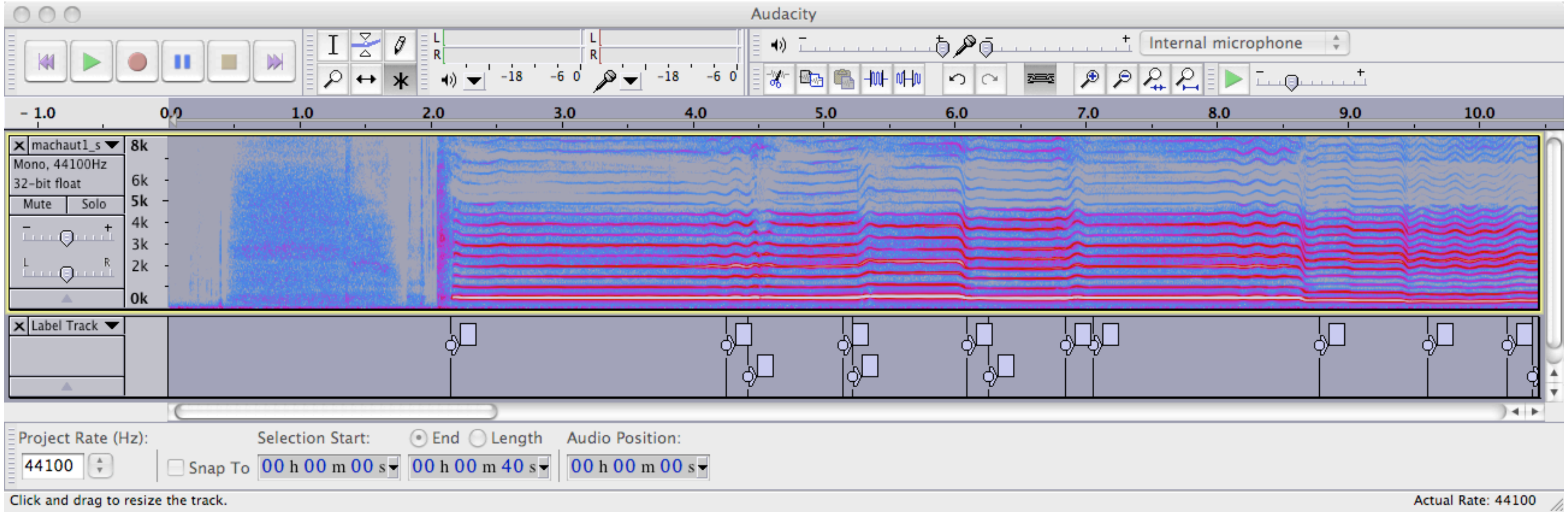
PRAAT



Manual Annotation with Software

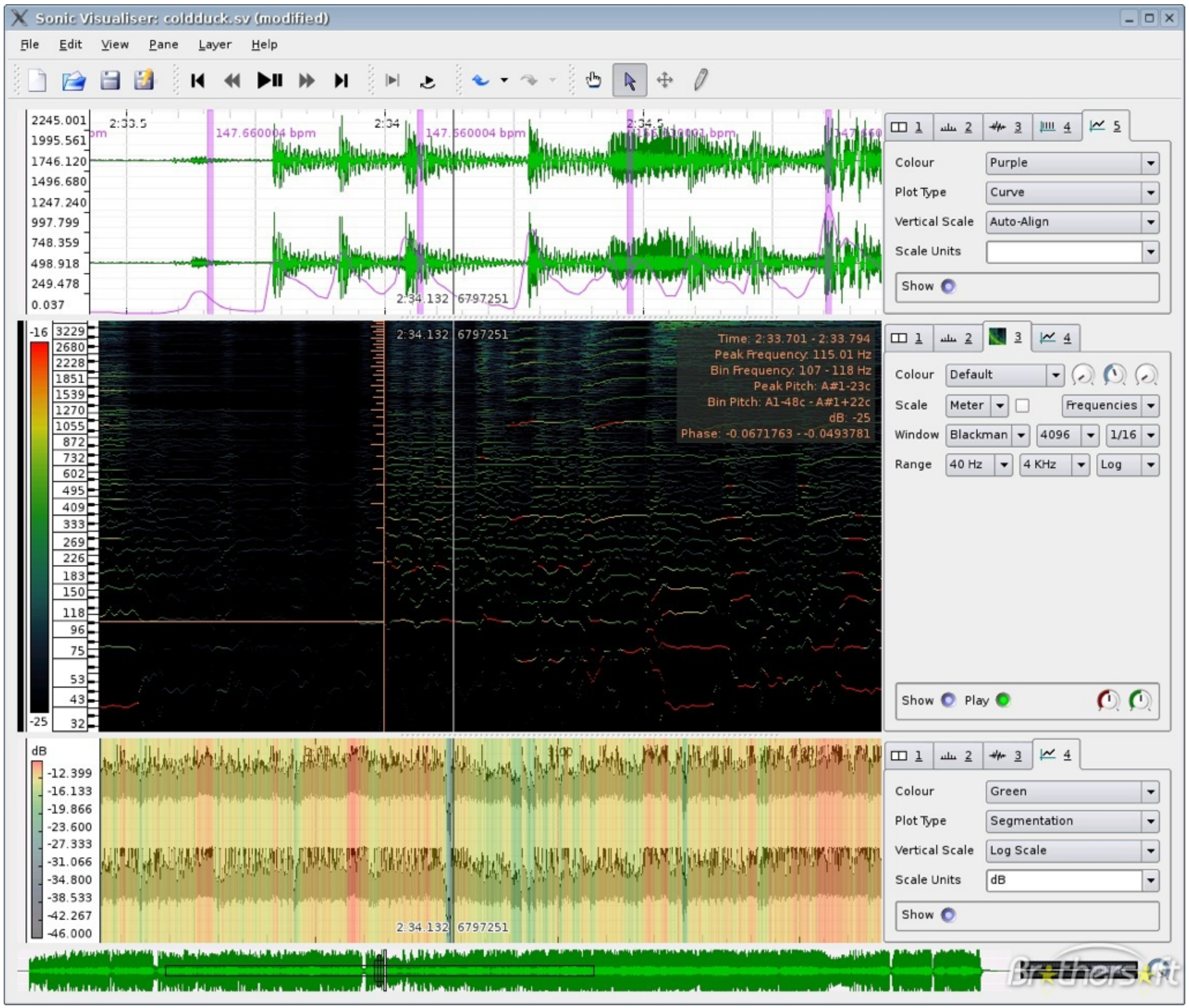
Audacity





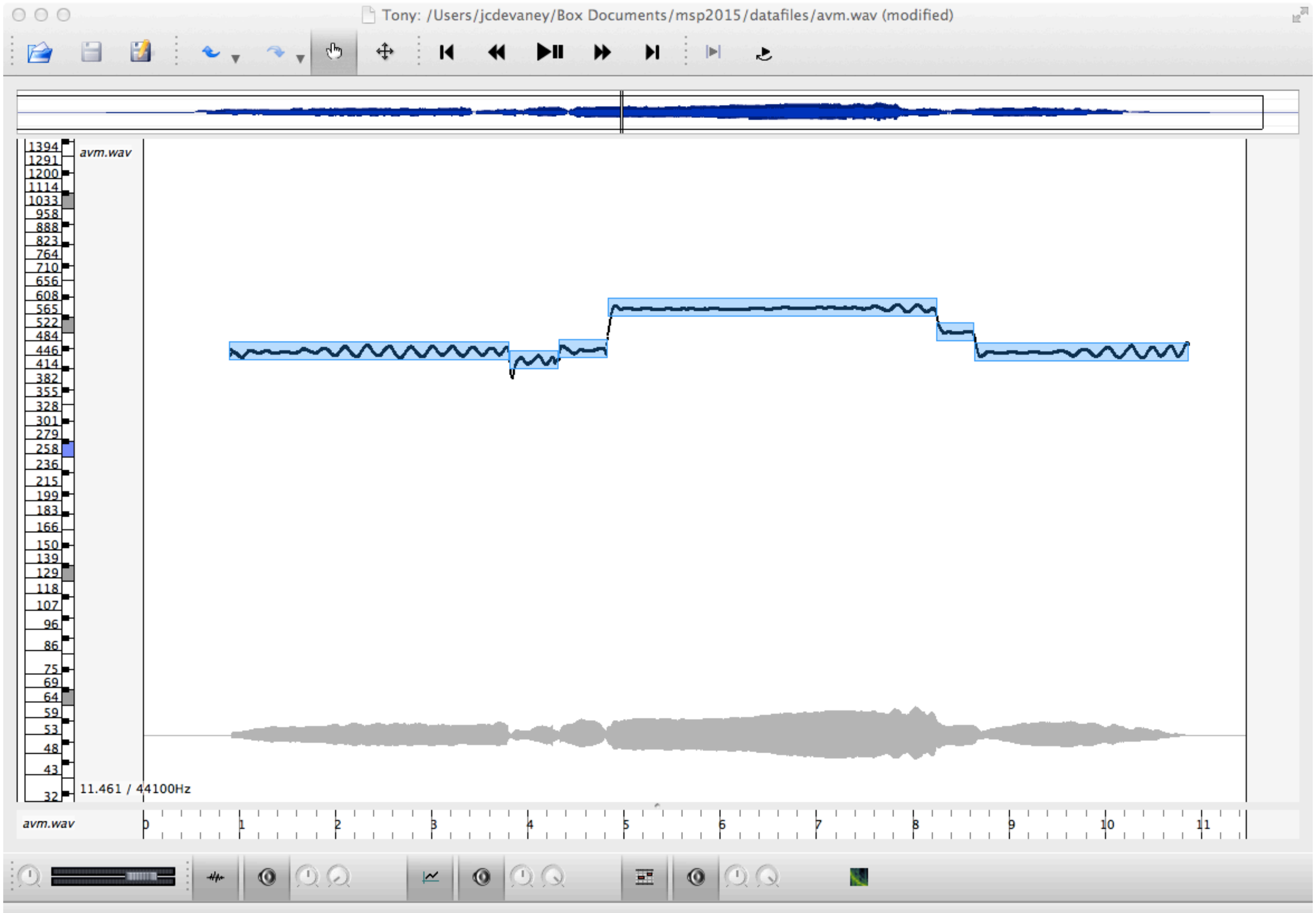
Automatic Annotation

Sonic Visualiser



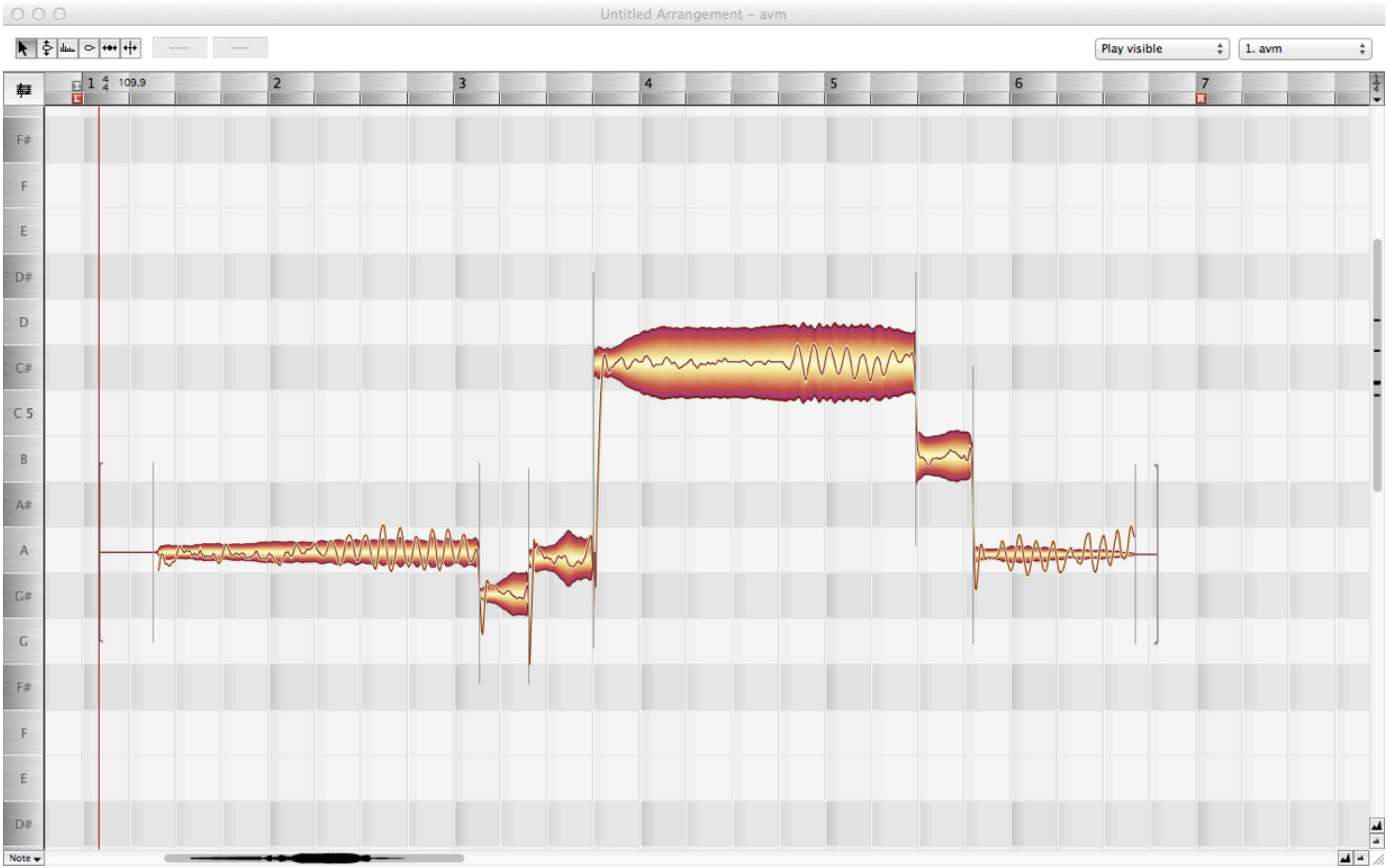
Automatic Annotation

TONY



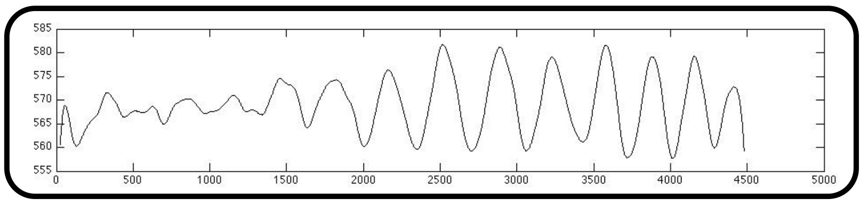
Automatic Annotation

Melodyne

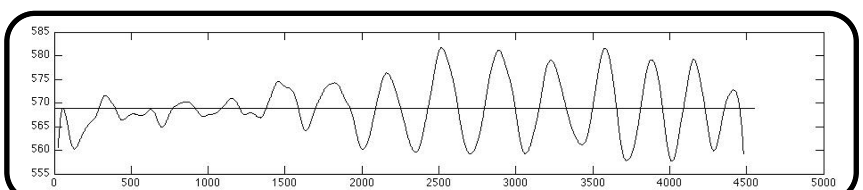


Identify Note Onsets and Offsets

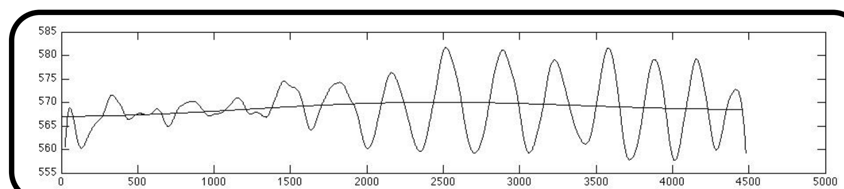
Fundamental Frequency (F_0) Estimation



Perceived Pitch



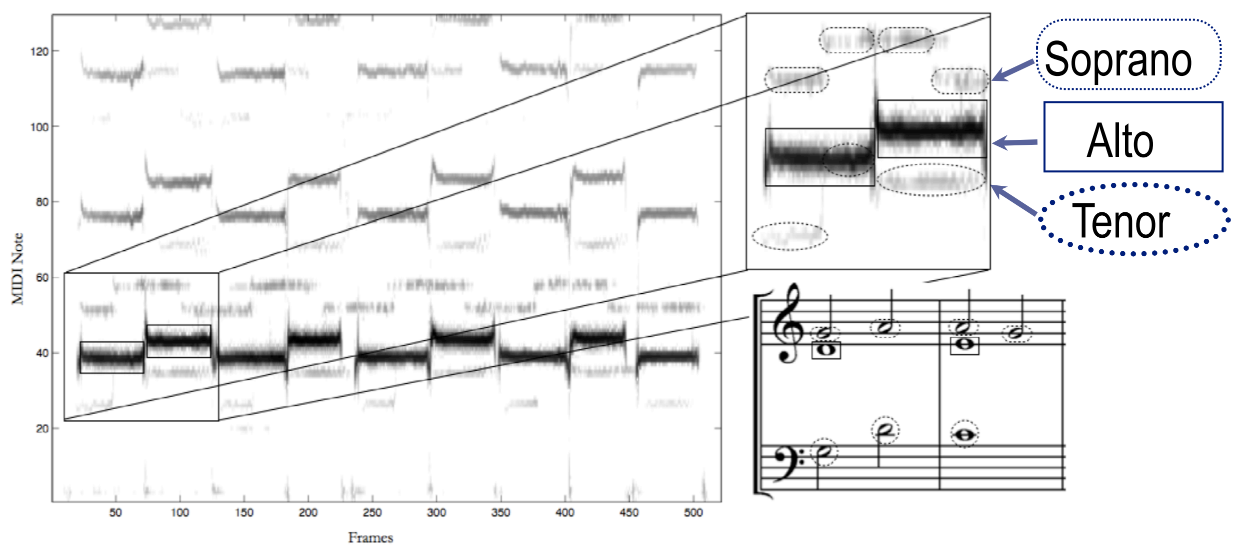
Evolution of F_0



Score-guided performance data extraction

Monophonic and quasi-polyphonic

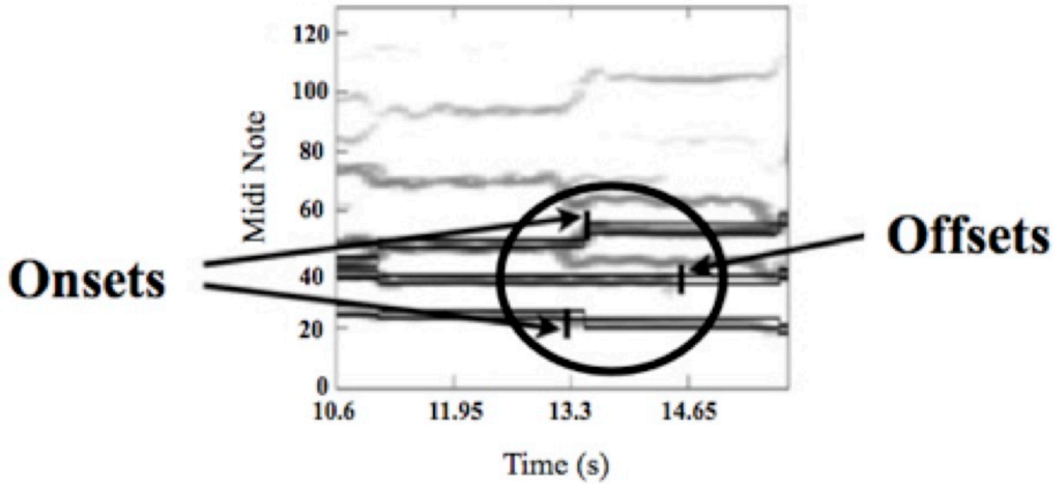
- Timing information is available via MIDI/audio alignment
- Fundamental frequency (F_0), and amplitude can be reliably extracted



Devaney, Mandel, and Ellis (2009)

Score-guided performance data extraction

Polyphonic



- Timing information (including asynchronies between lines) is available in the alignment
- F_0 and amplitude are harder to extract
- Currently exploring the using High Resolution methods with Roland Badeau for the task of score-guided extracting of frequency and loudness information in polyphonic audio

Devaney and Ellis (2009)
Devaney (2014)

Perceived Pitch

Possible calculation methods

Shonle and Horan (1980)	Geometric mean over the duration of the note
Iwamiya, Kosugi, and Kitamura (1983)	• Center frequency between peaks and troughs in vibratos and symmetrical trills • In asymmetrical trills pitch shifts according to the direction of the asymmetry
D'Alessandro and Castellengo (1994, 1995)	• F_0 at the end of the note was more significant for the pitch perception than the beginning of the note. Mean of the steady-state portion oft he note rather than the mid-point between the maximum and minimum frequencies
Gockel, Moore, and Carlyon (2001)	• Weighted mean based on the fundamental frequencies' rate of change, with higher weightings for frames that had a smaller rate of change

Evolution of F_0

Modeling note trajectories

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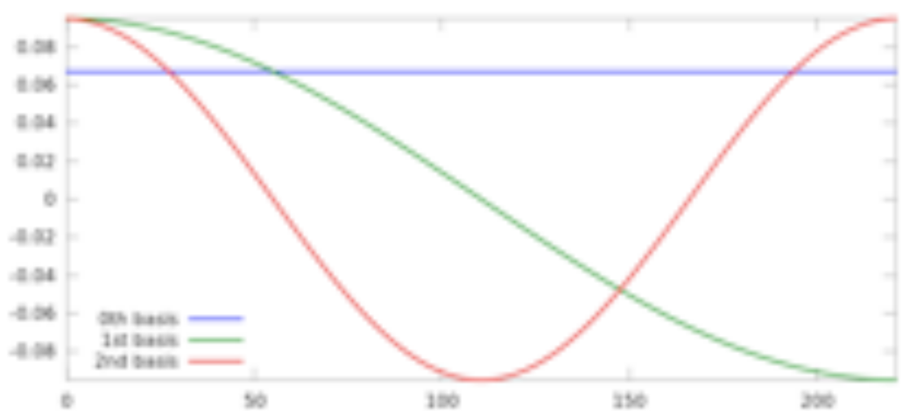
- Characterizing F_0 trajectories is under-studied
- One option is to decompose of F_0 trace with the Discrete Cosine Transform to estimate slope and curvature



Devaney, Mandel and Fujinaga (2011)
Devaney and Wessel (2013)

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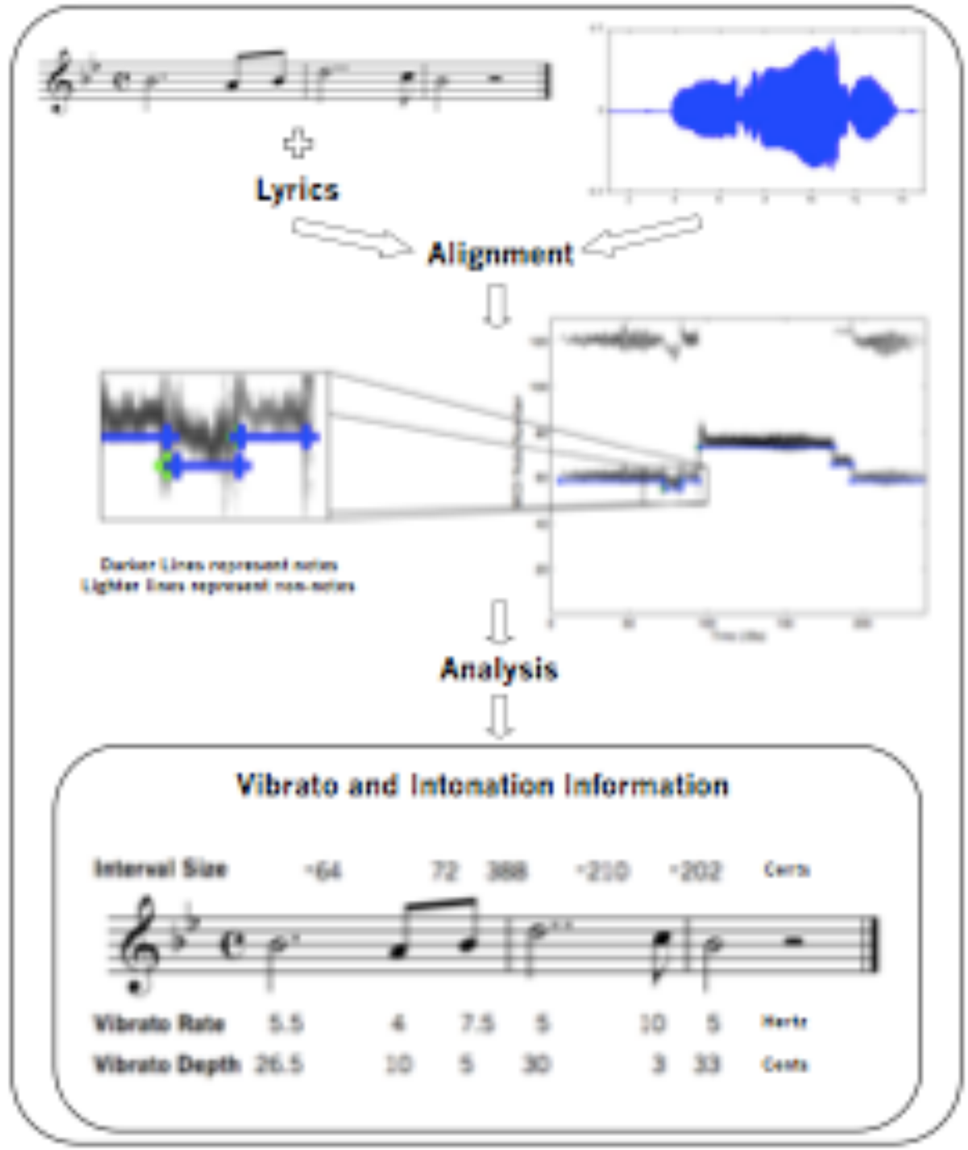
Automatic Music Performance and Comparison Toolkit

AMPACT



www.ampact.org

Thank you for your attention!

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