

TECHNIQUES FOR
EXTRACTING PERFORMANCE
DATA FROM AUDIO
RECORDINGS

JOHANNA DEVANEY
SCHULICH SCHOOL OF MUSIC
McGILL UNIVERSITY

INTRODUCTION

BACKGROUND ON PERFORMANCE STUDIES

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SOME RECENT STUDIES

CONCLUSION

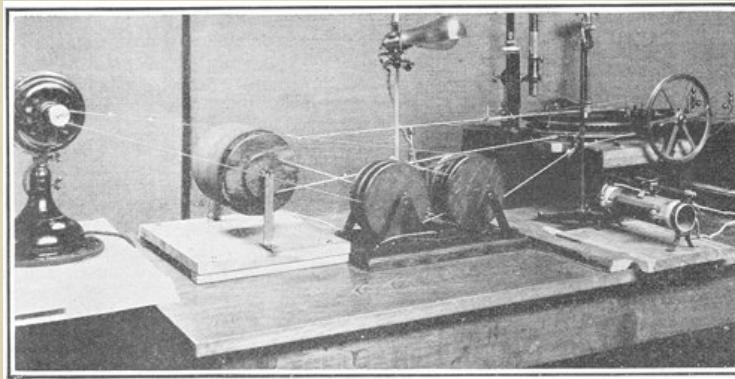
INTRODUCTION

- Why collect performance data?
- Annotation of musical recordings is the primary step in extracting performance data
- What are the challenges in collecting different types performance data?
- What are the benefits and disadvantages of manual vs. automatic extraction?

BRIEF BACKGROUND ON PERFORMANCE STUDIES

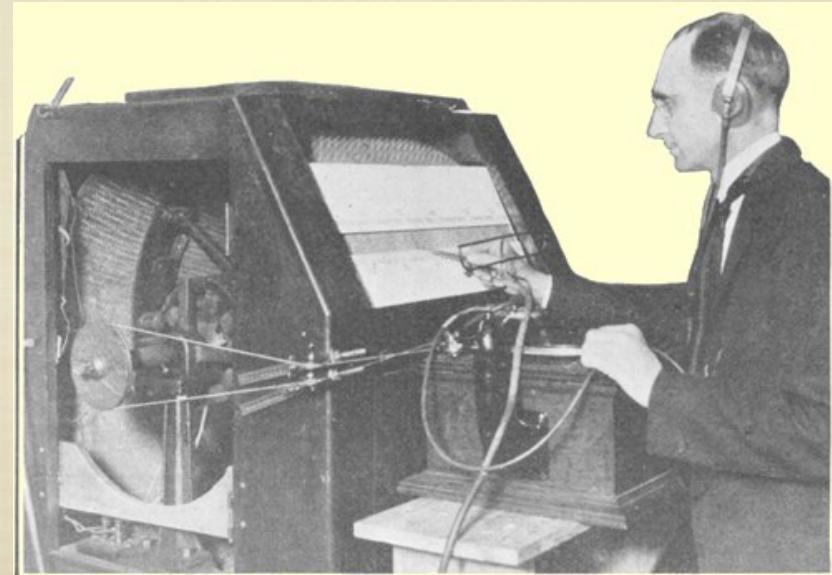
CARL SEASHORE'S WORK AT IOWA

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



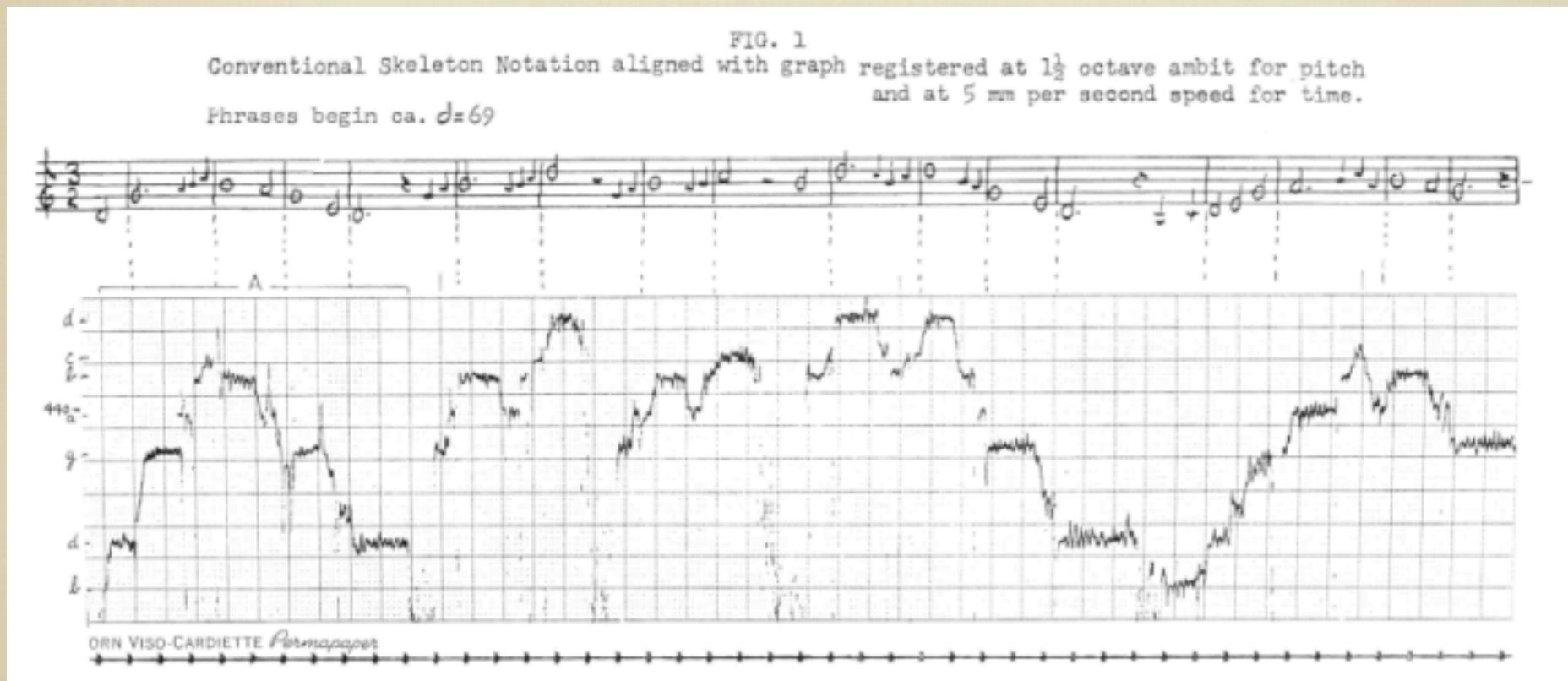
Wave recorder for use with disk phonograph; the lever, acting like a pantograph, traces the waves on a revolving smoked drum

SOURCE: WWW.UH.EDU/ENGINES/EPI1736.HTM



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

CHARLES SEEGER AND THE MELOGRAPH



SOURCE: SEEGER 1957

RESURGENCE OF INTEREST

- Interest in empirical performance analysis diminished, in part due to its labouriousness
- The resurgence in interest in the late 1970s/early 1980s coincided with
 - A movement by musicologists away from equating scores with music
 - An increased interest by cognitive psychologists in music

RESEARCH IN THE 1980'S AND 90'S

- Ingemar Bengtsson and Alf Gabrielsson (1980, 1983) undertook a number of systematic experiments on musical rhythm in performance
- Neil Todd (1985, 1989) studied both rubato and dynamics in piano performance
- Eric Clarke (1989) related rhythmic tendencies to both the structural hierarchy of the piece and note-level expressive gestures
- Bruno Repp (1992, 1997) also examined timing in piano performance and related it to phrase hierarchy
- Surveys are available in Palmer (1997) and Gabrielsson (1999, 2003)

POPULARITY OF THE PIANO

- Factors
 - the large amount of solo repertoire
 - the instrument's percussive nature
 - the ease with which one can acquire accurate, minimally intrusive performance measurements from a pianist via MIDI technology
 - the feasibility of using specially equipped pianos to measure performance data more precisely than with MIDI

Doug Eck's Bosendorfer SE Piano at BRAMS



POPULARITY OF THE PIANO

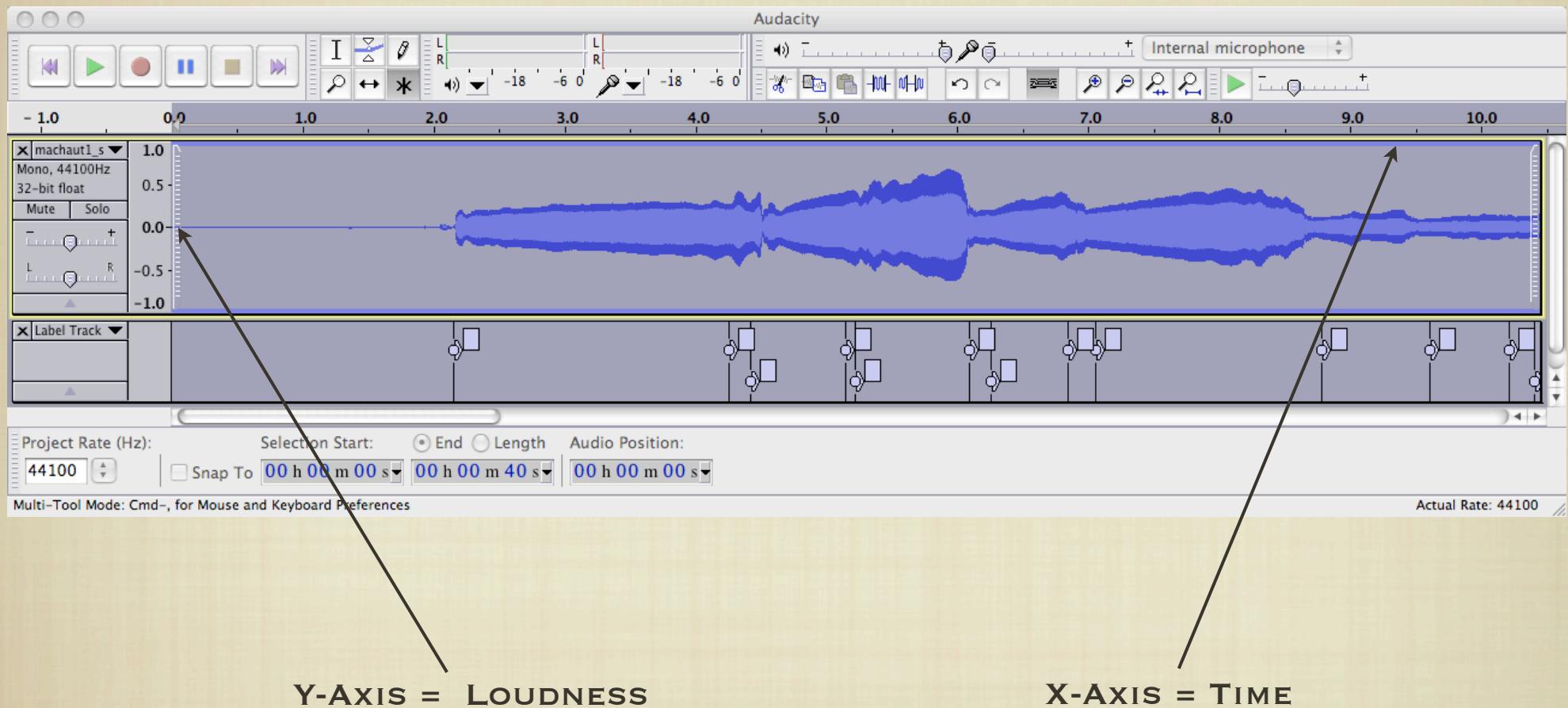
- Some issues with MIDI-based studies
 - require a MIDI-rigged piano
 - typically done in a lab environment
 - precision is limited for other instruments (when possible)
- The ability to automatically analyze recordings would greatly increase the amount of data available for empirical performance analysis

TOOLS FOR ANALYSING RECORDINGS

MANUAL APPROACH

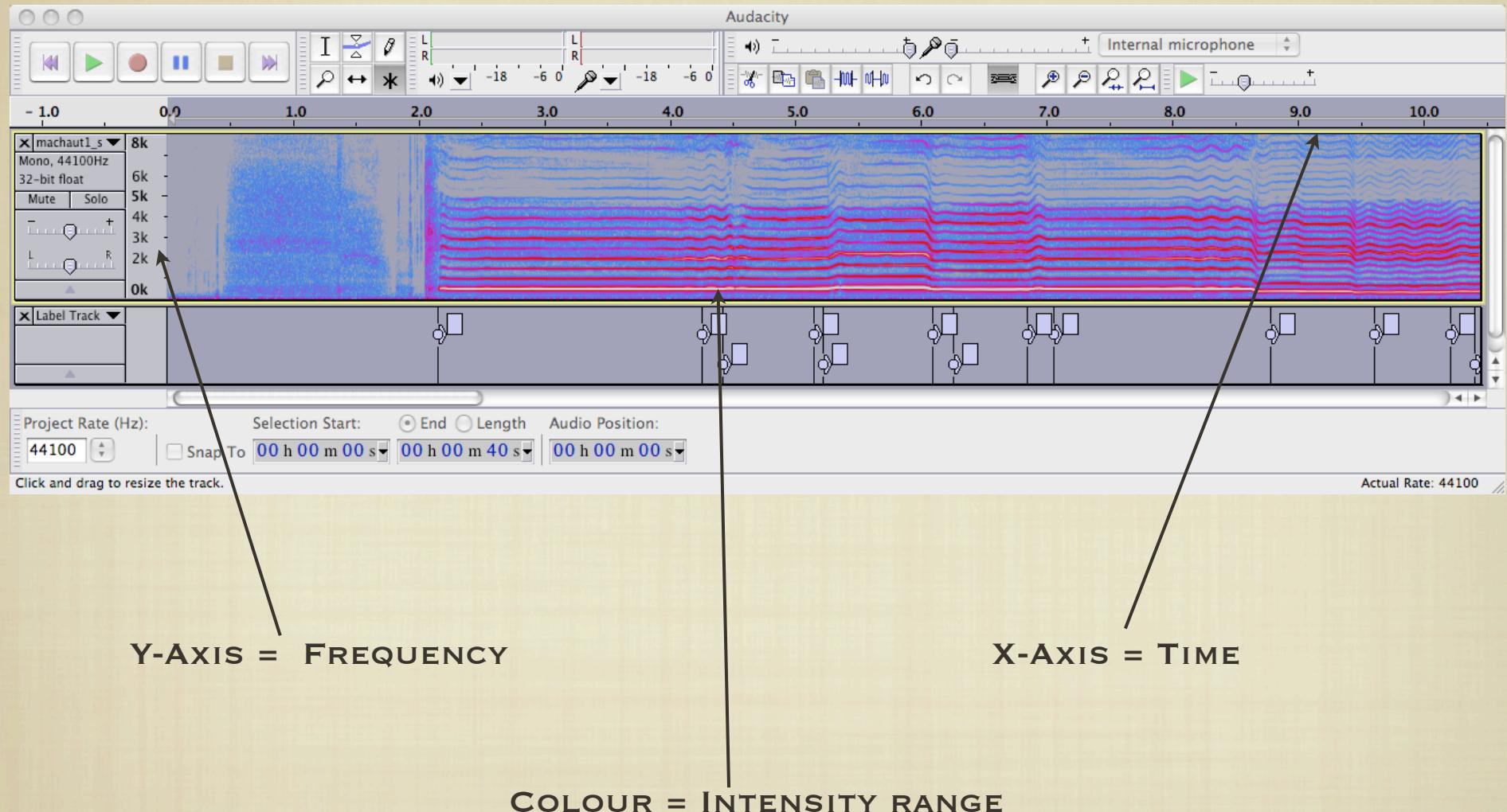
- Timed events can be determined by
 - Listening to the recording with a stopwatch
 - Tapping along to the recording
 - Labeling a visual representation of the recording

TIME DOMAIN REPRESENTATION (IN AUDACITY)

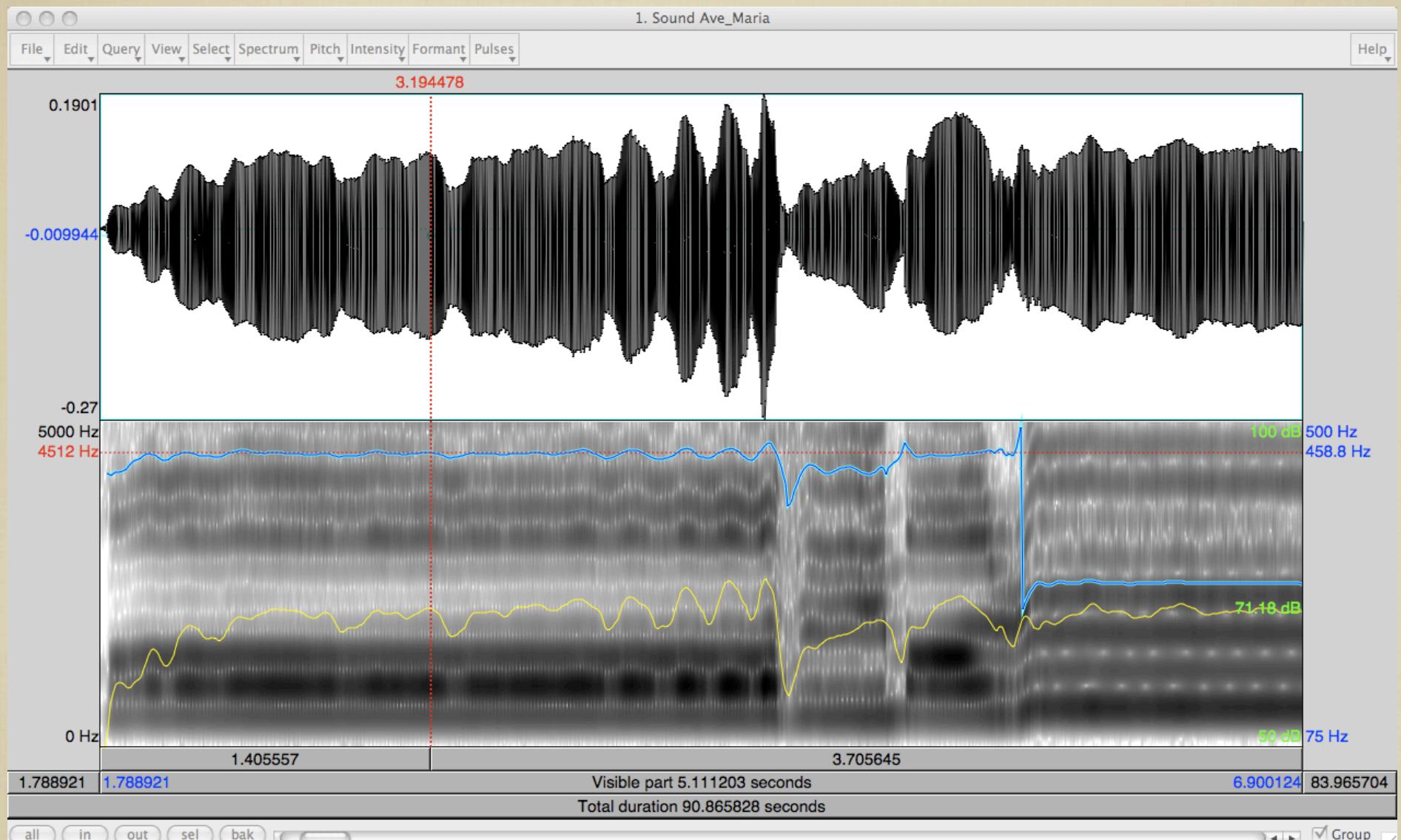


AUDACITY.SOURCEFORGE.NET

FREQUENCY DOMAIN REPRESENTATION (IN AUDACITY)



PRAAT



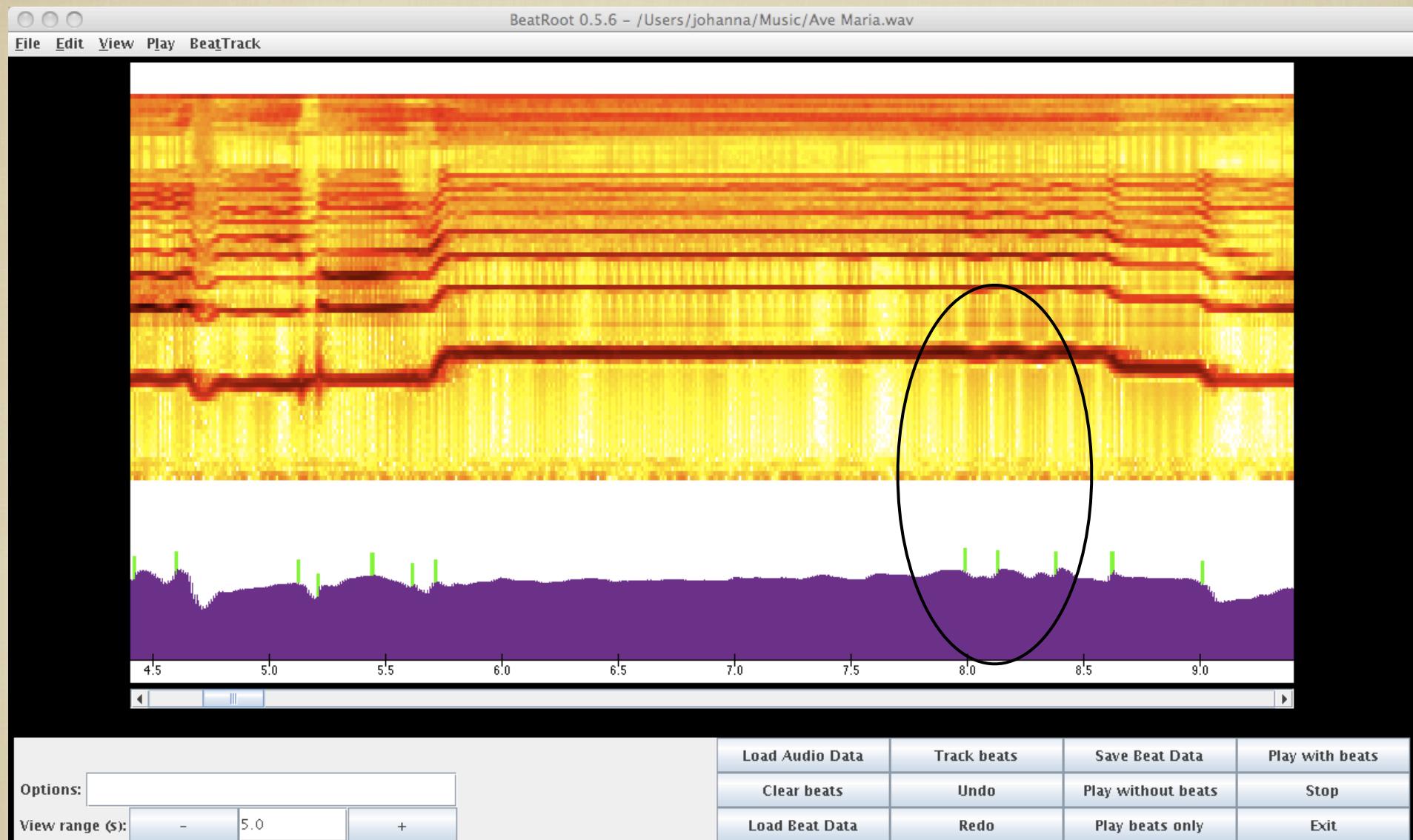
WWW.FON.HUM.UVA.NL/PRAAT

[HTTP://WWW.MUSICOLOGY.NL/WM/RESEARCH/PRAAT_MUSICOLOGISTS.HTM](http://WWW.MUSICOLOGY.NL/WM/RESEARCH/PRAAT_MUSICOLOGISTS.HTM)

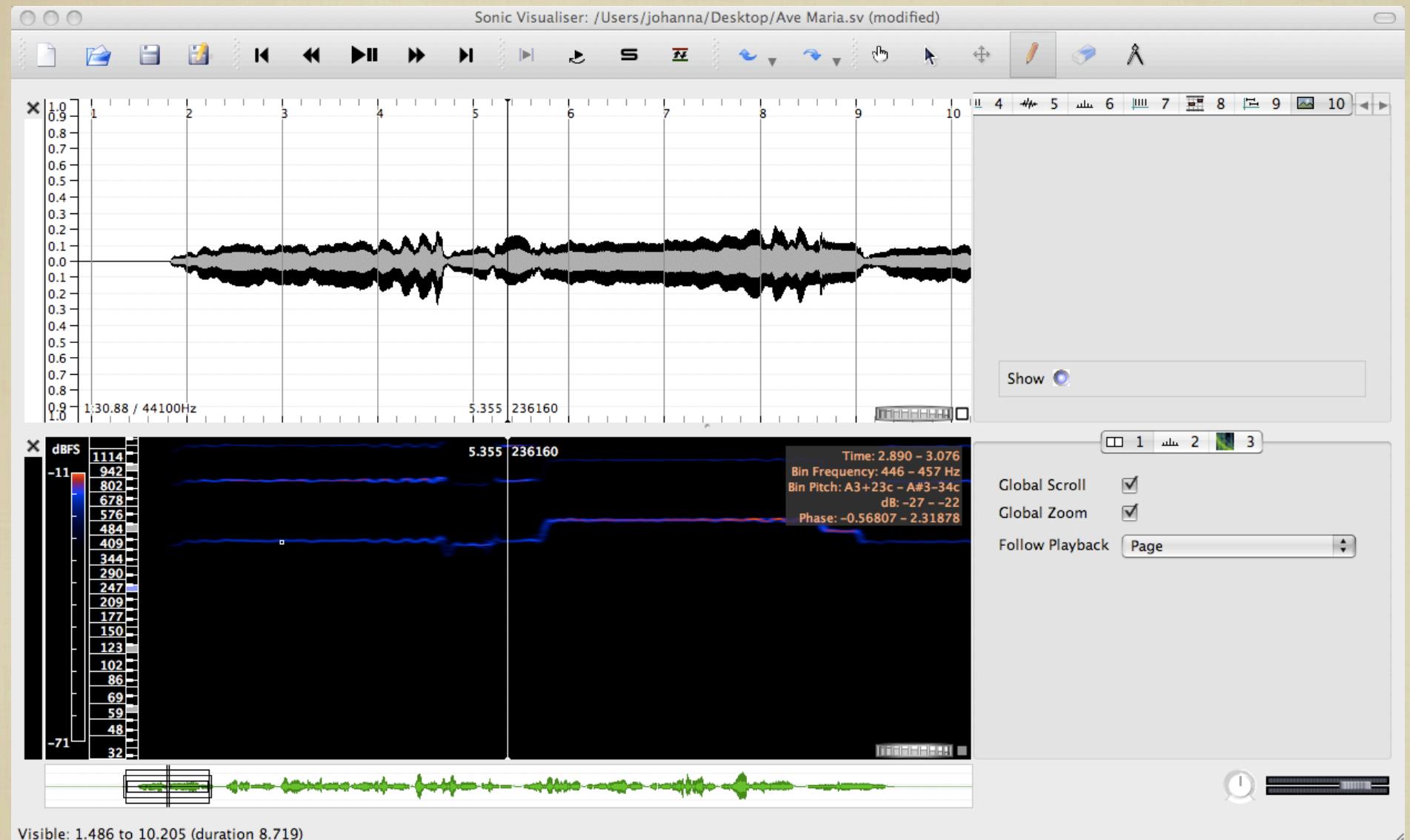
PERFORMANCE PARAMETERS

	TIMING & TEMPO	DYNAMICS	TIMBRE	TUNING	VIBRATO
NOTE ONSET	✓	✓	✓	✓	✓
NOTE OFFSET		✓	✓	✓	✓
LOUDNESS		✓			
SPECTRAL DESCRIPTION			✓		
FUNDAMENTAL FREQUENCY ESTIMATES				✓	✓

BEATROOT



SONIC VISUALISER



WWW.SONICVISUALISER.ORG

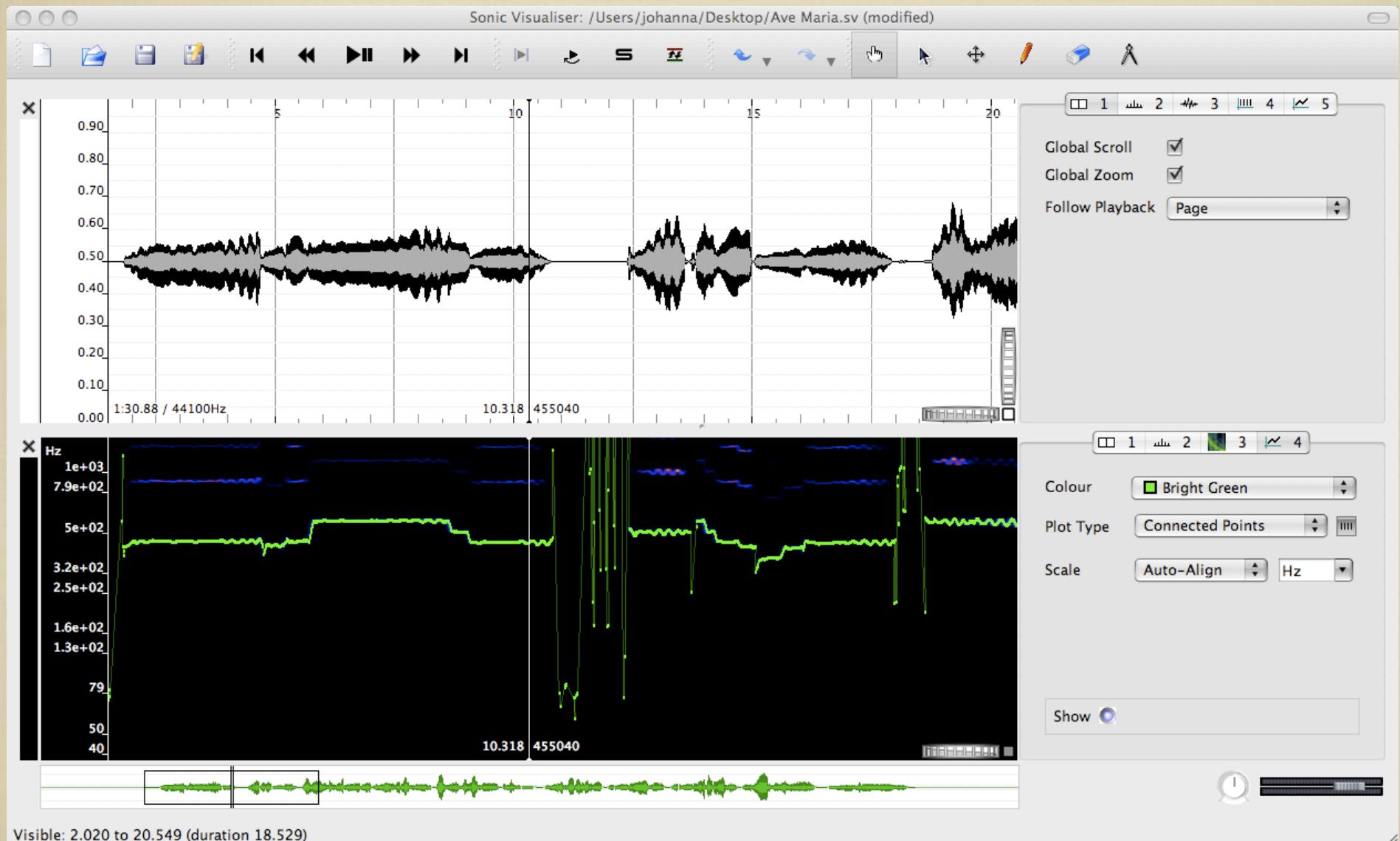
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SONIC VISUALISER PLUG-INS

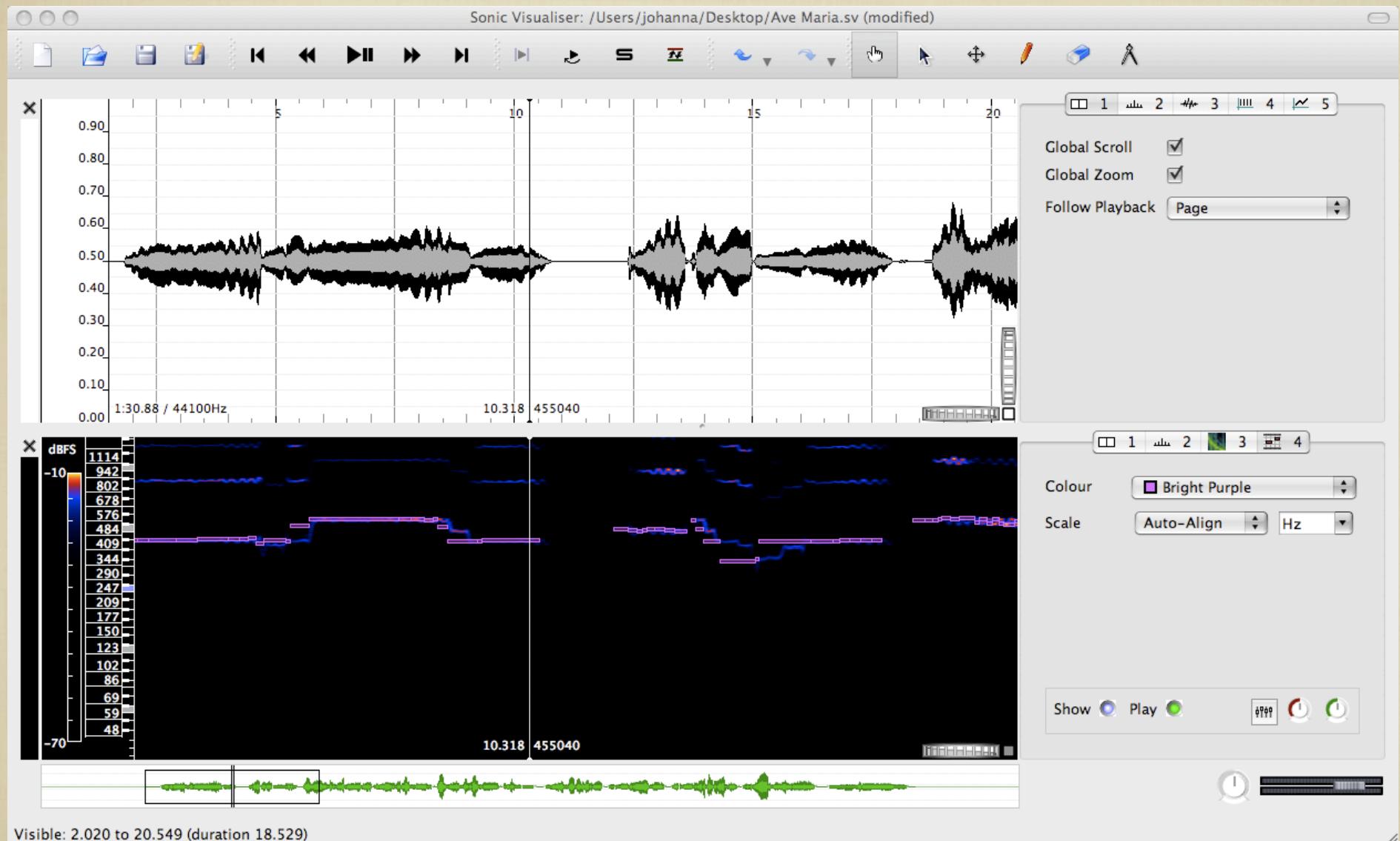
- Queen Mary plugin set - note onset detector, beat and barline tracker, and tempo estimator
- Vamp Aubio plugins - onset detection, pitch tracking, note tracking and tempo tracking
- Mazurka plugins - spectral visualisation and feature extraction plugins
- MATCH Vamp plugin - automatic alignment
- OnsetsDS plugin - note onset detector

[HTTP://WWW.VAMP-PLUGINS.ORG/DOWNLOAD.HTML](http://www.vamp-plugins.org/download.html)

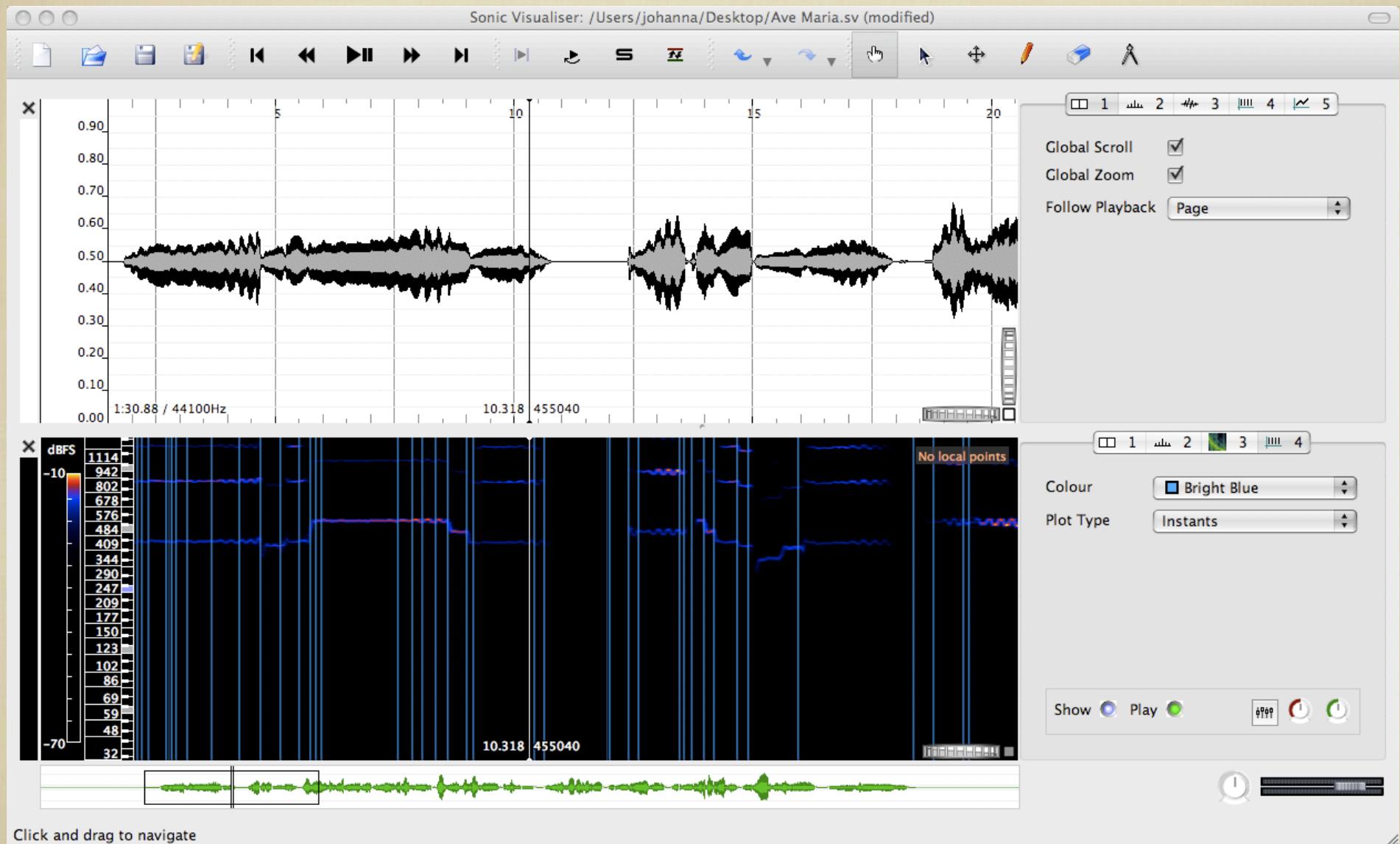
AUBIO PITCH DETECTOR



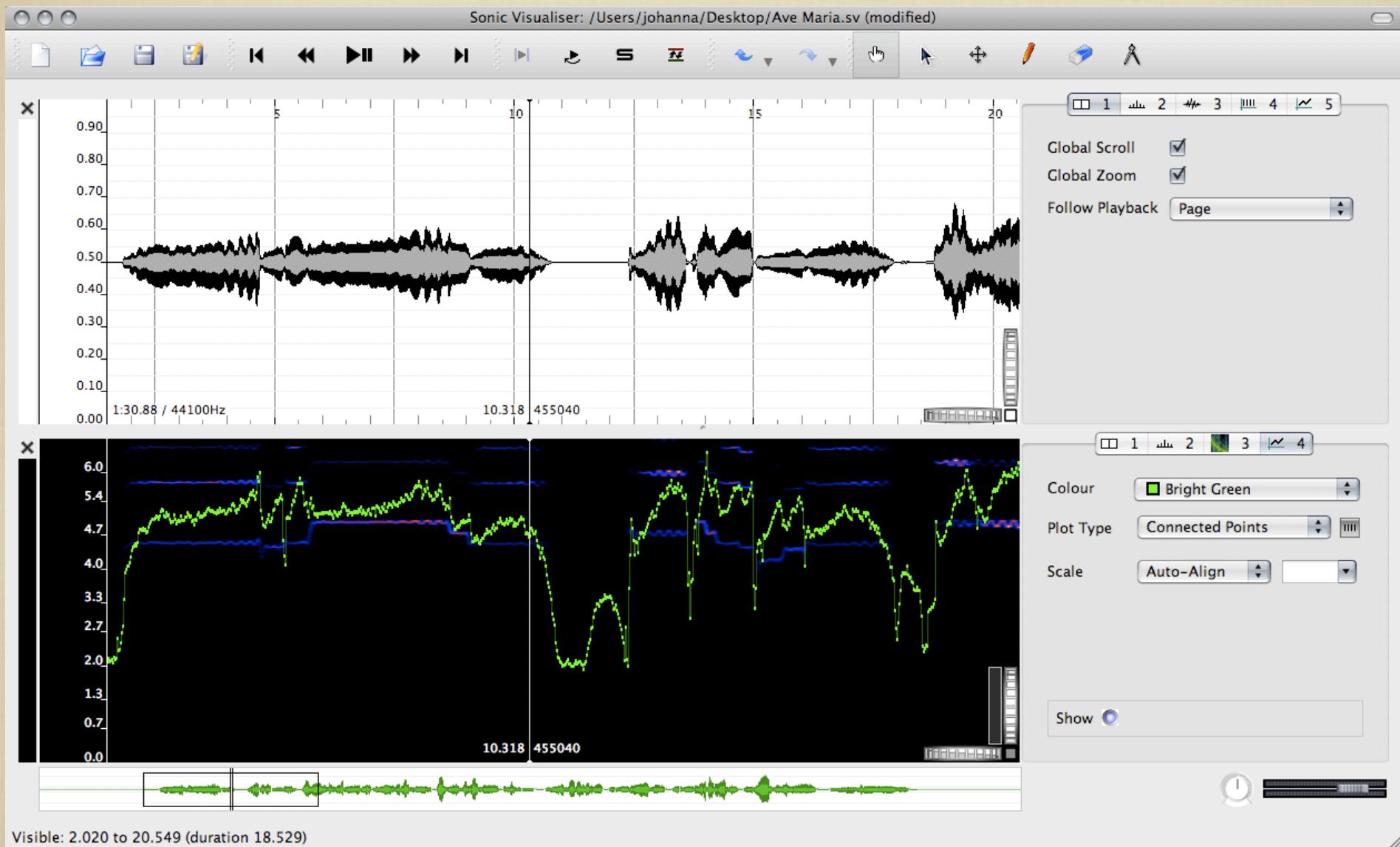
AUBIO NOTE TRACKER



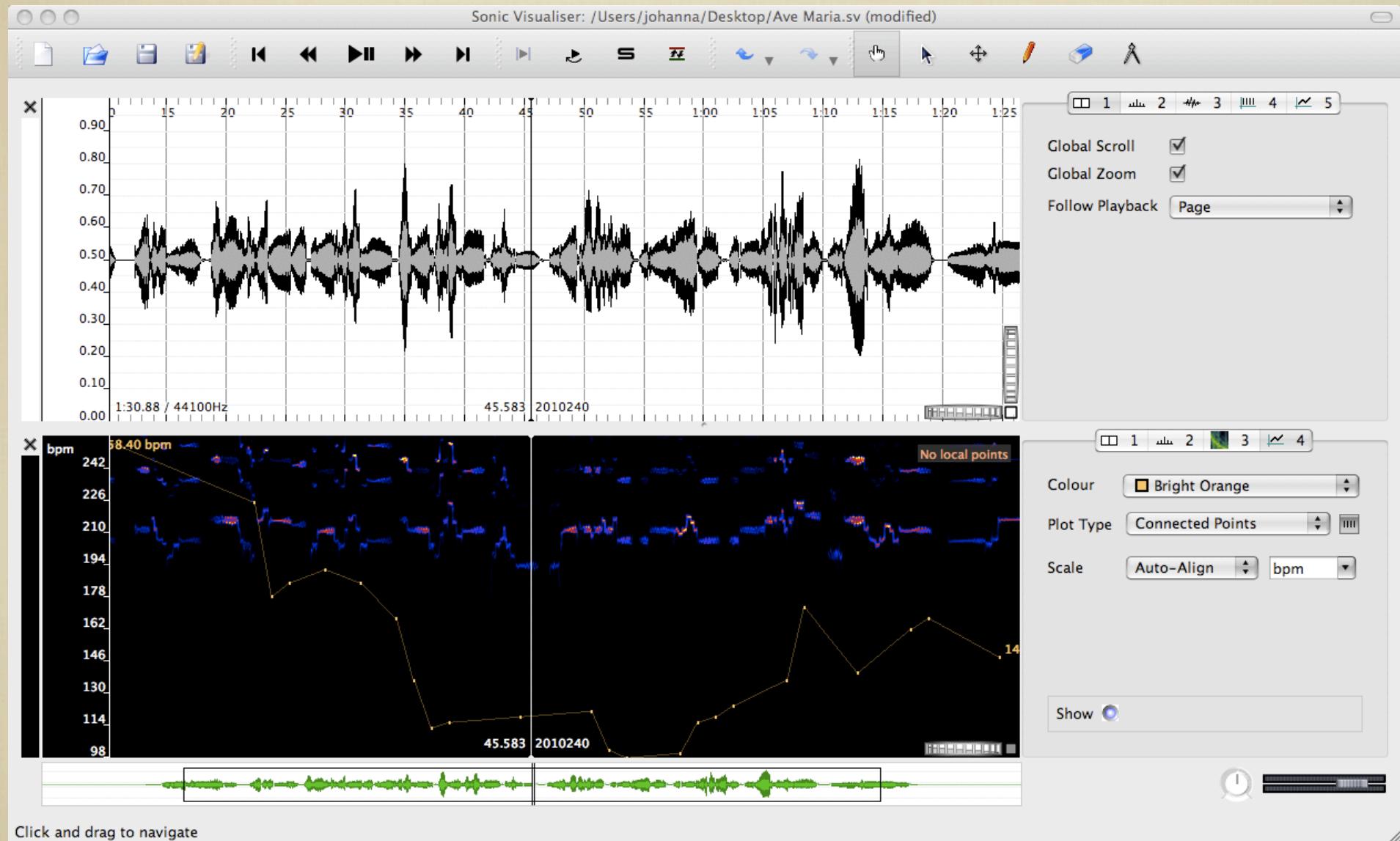
QUEEN MARY NOTE ONSET



QUEEN MARY LOUDNESS ESTIMATOR

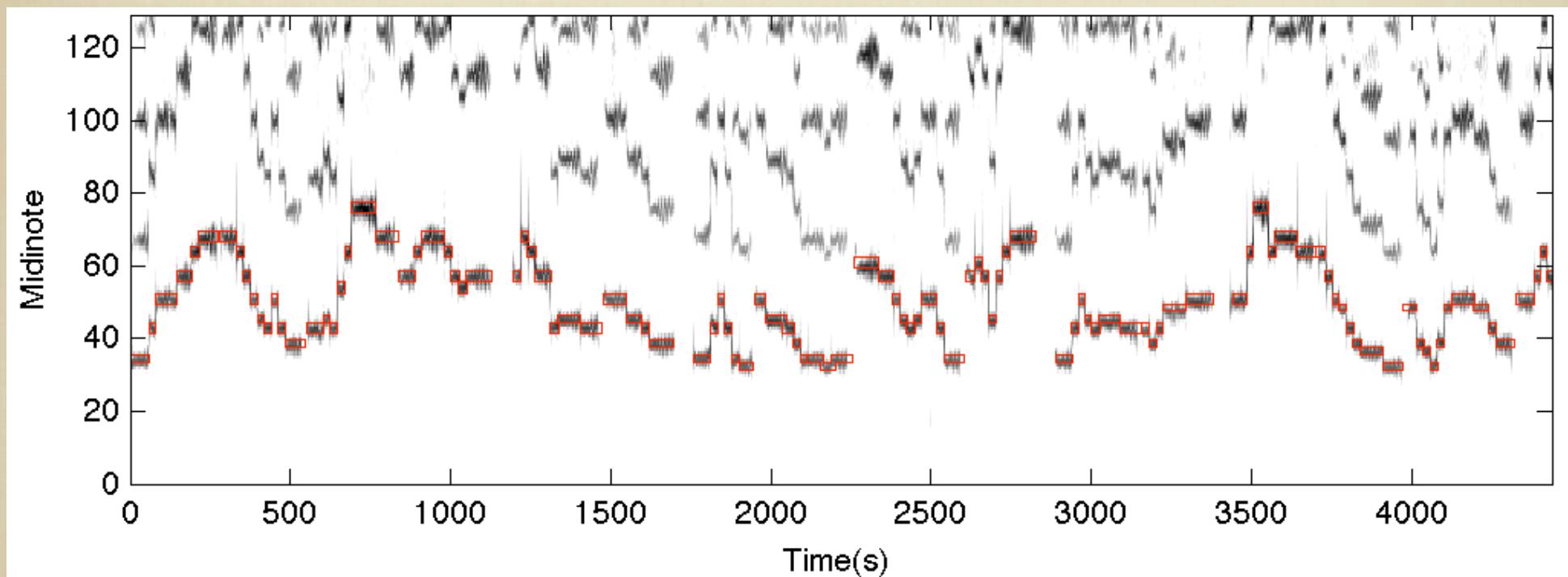


QUEEN MARY TEMPO TRACKER



MIDI/AUDIO ALIGNMENT

AUDIO FILE OVERLAID WITH ALIGNED MIDI FILE



INTEGRATION OF MANUAL AND AUTOMATIC METHODS

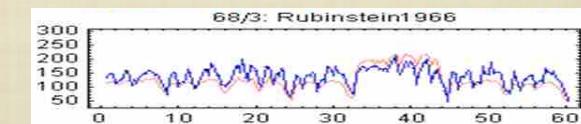
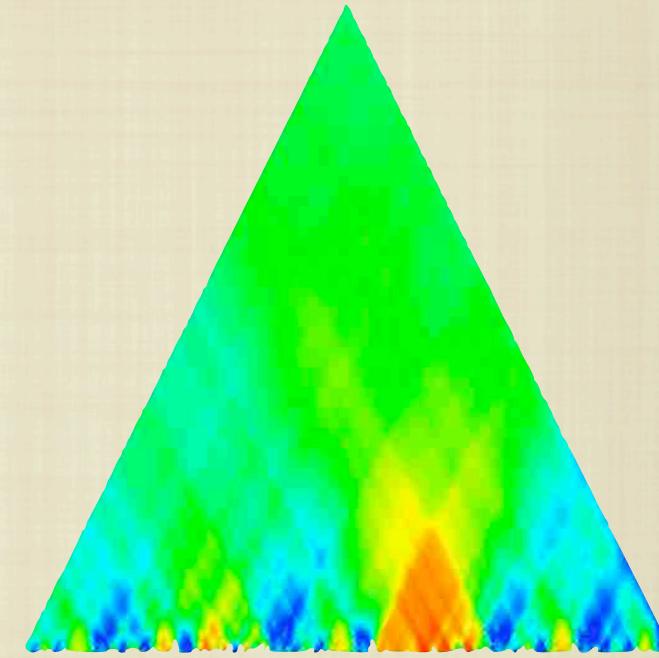
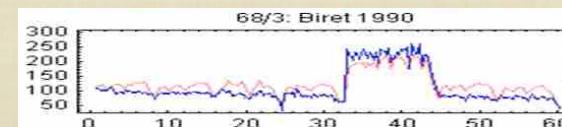
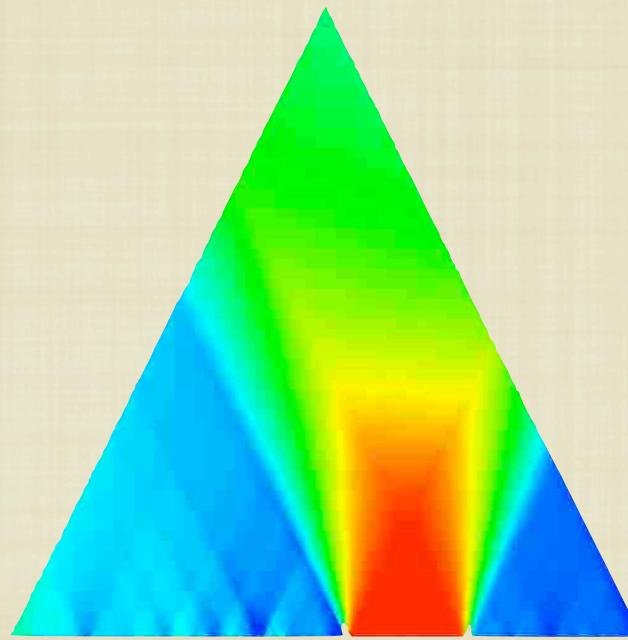
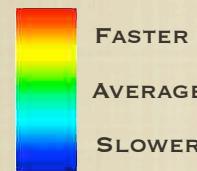
- Use a combination of automatic methods and tapping (<http://mazurka.org.uk/cgi-bin/tapsnap>)
- Manually correct automatic method's output in an audio editor

SOME RECENT STUDIES

MAZURKAS PROJECT (CHARM)

CRAIG SAPP AND NICOLAS COOK

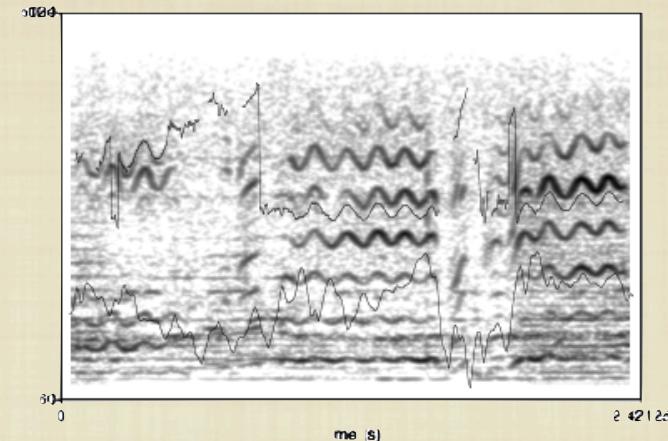
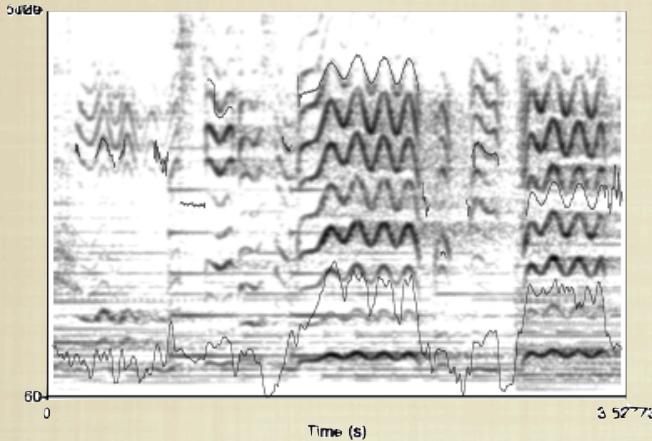
PATTERNS OF TEMPO OR DYNAMIC CHANGE ACROSS THE PERFORMANCE



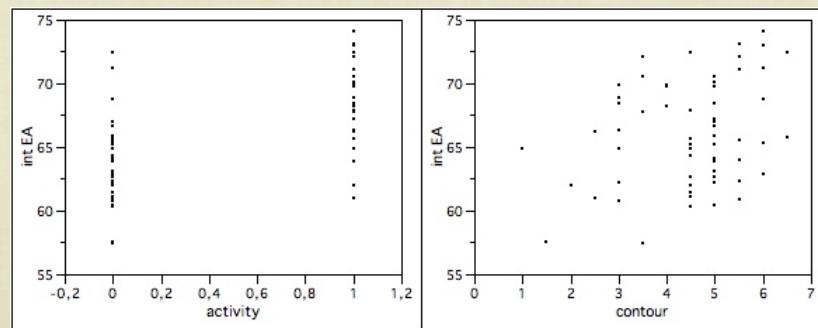
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GESTURE IN SCHUBERT (CHARM)

DANIEL LEECH-WILKINSON AND RENEE TIMMERS



SPECTROGRAM REPRESENTATIONS OF SUNG EXCERPTS WITH PITCH AND LOUDNESS MARKED IN PRAAT



LOUDNESS VARIATIONS PLOTTED AGAINST EMOTIONAL ACTIVITY (LEFT)
AND MELODIC CONTOUR (RIGHT)

WWW.CHARM.RHUL.AC.UK/PROJECTS/P2_2_3.HTML

CONCLUSIONS

- Performance data can be (relatively) reliably extracted manually
- Automatic methods hold great promise but are not yet fully developed
 - There is a significant amount of work being done by researchers in the Music Information Retrieval community to improve automatic methods
- How to interpret the collected data?

REFERENCES

- Bengtsson, I., & Gabrielsson, A. (1980). Methods for analyzing performance of musical rhythm. *Scandinavian Journal of Psychology*, 21, 257-68.
- Bengtsson, I., & Gabrielsson, A. (1983). Analysis and synthesis of musical rhythm. *Studies of Musical Performance*, 27-60.
- Clarke, E. (1989). The perception of expressive timing in music. *Psychological Research*, 51, 2-9.
- Gabrielsson, A. (1999). The performance of music. In D. Deutsch (Ed.) *The Psychology of Music* (2nd ed.) (pp. 501-602). San Diego, CA: Academic Press.
- Gabrielsson, A. (2003). Music performance research at the millennium. *Psychology of Music*, 31, 221-72.
- Repp, B. (1992). Diversity and commonality in music performance: An analysis of timing microstructure in Schumann Trumerei, *Journal of the Acoustical Society of America*, 92(5), 254-68.
- Repp, B. (1997). The aesthetic quality of a quantitatively average music performance: two preliminary experiments. *Music Perception*, 14(4), 419-44.
- Palmer, C. (1997). Music performance. *Annual Review of Psychology*, 48, 115-38.
- Seashore, C. (1936). *Objective Analysis of Musical Performance*. Iowa City, IA: University of Iowa Press.
- Seeger, Charles. (1957). Toward a Universal Music Sound-Writing for Musicology. *Journal of the International Folk Music Council* 9, 63-66.
- Todd, N. (1985). A model of expressive timing in tonal music. *Music Perception*, 3(1), 33-58.
- Todd, N. (1989). The dynamics of dynamics: A model of musical expression. *Journal of the Acoustical Society of America*, 91(6), 354-50.