Mazurka Project Update

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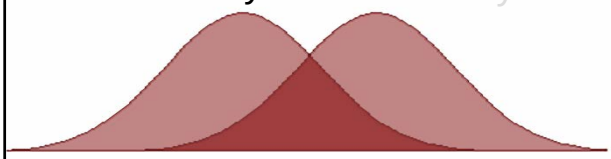
CHARM Symposium
Kings College, University of London
26 January 2006

Data Entry Data Analysis



Source material: mazurka recordings

Mazurka in G minor Op. 24, No. 1

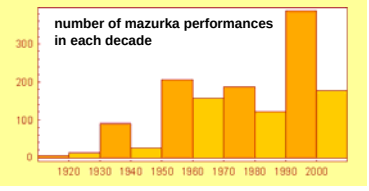
29 performances:

2:48 Ashkenazy (1981)
3:06 Biret (1990)
2:39 Block (1995)
2:04 Bralowsky (1960)
2:49 Chiu (1999)
2:30 Chiat (1994)
2:50 Cortot (1951)
2:44 Fabrey (1989)
3:06 Fiorentino (1962)
3:01 Flère (1977)
1:41 François (1956)
3:12 Hatto (1997)
3:12 Indjic (2001)
2:37 Kapell (1951)
2:52 Luisada (1990)
3:11 Luzhak (2004)
3:12 Magaloff (1977)
2:45 Nezu (2005)
2:47 Poblocka (1999)
3:08 Rosen (1989)
2:03 Rubenstein (1939)
3:32 Rubenstein (1952)
2:48 Rubenstein (1966)
2:57 Shebanova (2002)
3:45 Smith (1975)
3:04 Ts'ong (1993)
2:59 Ts'ong (2005)
2:41 Tsuji (2005)
1:50 Uninsky (1959)

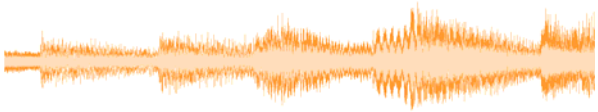
- **1,374 recordings of 49 mazurkas**

  = 28 performances/mazurka on average

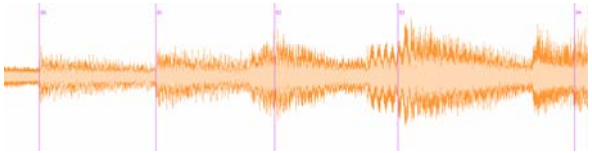
- **65 performers, 73 CDs**



Waveform

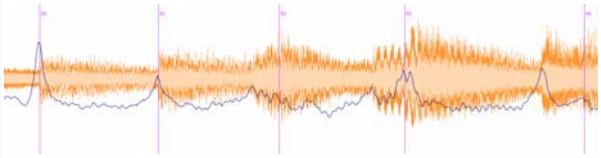


- Where are the notes?
- How many notes are there?
- Where are the beats?



- Reverse conducting (corrected) added to waveform

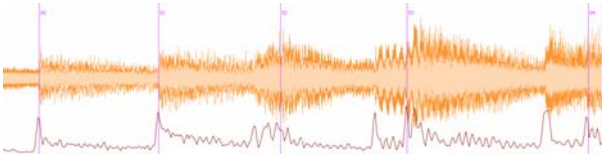
*Mz*PowerCurve



- Started development a few months before first SV release.
- By-product of looking at how to extract note loudnesses from audio.
- Some notes become easy to see.
- Some notes obscured – mostly by beating between harmonics.

http://sv.mazurka.org.uk/MzPowerCurve

*Mz*SpectralFlux



- Implementation of Spectral Flux as described by Simon Dixon:

  Dixon, Simon. "*Onset detection revisited*" in the Proceedings of the 9th International Conference on Digital Audio Effects (DAFx'06). Montreal, Canada; September 18-20, 2006.

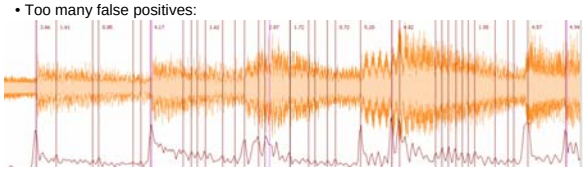
- Component of the MATCH program.
- Similar to the power curve idea, but measurements done on the spectrum.
- Only frequency bins gaining energy are considered.
- Gets rid of ½ of the harmonic beating problem.

http://sv.mazurka.org.uk/MzSpectralFlux

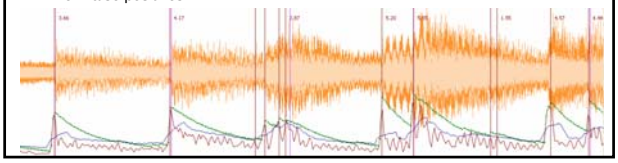
Spectral flux peak finding

Sensitive to parameter settings:

• Too many false positives:

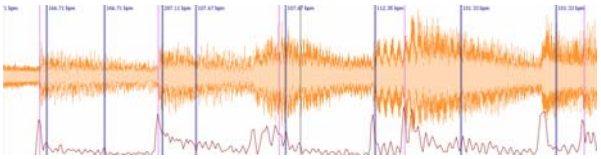


• A few false positives:



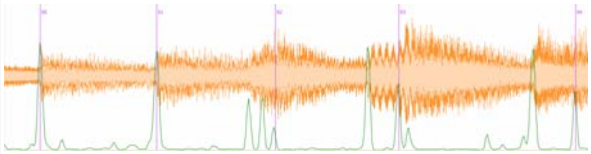
Spectral difference

• Tempo Tracker plugin from QUML C4DM uses same technique as Spectral Flux
• But called “Spectral Difference”
• Onset or Difference function not available as outputs from the plugin
• Only beat locations, shown as blue lines:



• Blue vertical lines mark automatically identified beat locations.
• Pink vertical lines are human-identified beat locations.
• Notice relation between blue lines and pink lines.

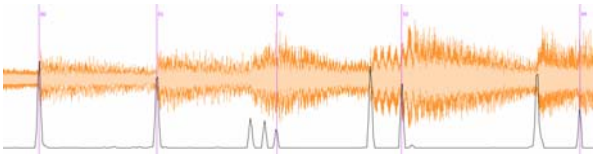
*Mz*Attack



• Developed July 2006 after last colloquia
• Clear indications of note onsets
• Noise peaks are difficult to separate from onset peaks, so usually used in conjuction with *Mz*PowerCurve.
• Allows for precise manual correction of reverse conducting to go from ~6 hours/performance to ~1 hour/performance.

http://sv.mazurka.org.uk/MzAttack

*Mz*SpectralReflux

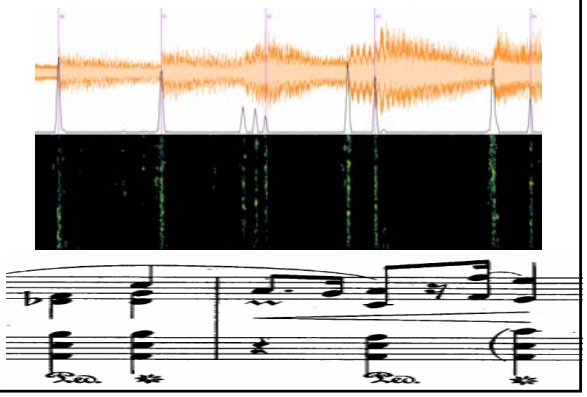


• Update on the MzAttack technology based on studying Spectral Flux.
• Very low noise due to harmonic beating,
• Only noise left is from clicks, pops, etc., and non-musical sounds in audio.
• Slightly less sensitive to parameter settings than spectral flux.
• Working on reverse conducting correction time on the order of ~15-30 minutes/performance (compared to current ~1 hour/performance).

http://sv.mazurka.org.uk/MzSpectralReflux

http://mazurka.org.uk/cgi-bin/tapsnap = Move taps to nearest onset

Peek Under the Hood (Bonnet)



Possible additions

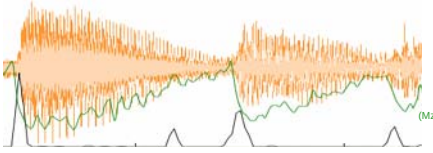
$$\text{spectral flatness} = \frac{\text{geometric mean}}{\text{arithmetic mean}} = \frac{\sqrt[N]{\prod_k x(k)}}{\frac{1}{N}\sum_k x(k)}$$

example: {2, 3}

arithmetic mean = (2 + 4) / 2 = 3
geometric mean = sqrt(2 * 4) = 2.8

spectral flatness = 2.8 / 3 = 0.94

Used to distinguish between noise and pitched sound



note noise note note

Performance data extraction

Reverse conducting

- Listen to recording and tap to beats.
- Tap times recorded in *Sonic Visualiser* by tapping on computer keyboard.

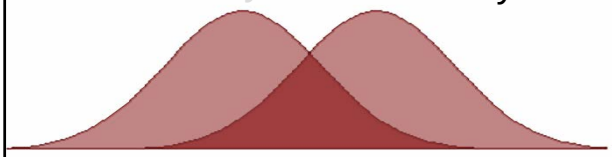
Align taps to beats → **tempo by beat**

- Reverse conducting is real-time response of listener, not actions of performer.
- Adjust tap times to correct beat locations.
- A bit fuzzy when RH/LH do not play in sync, or for tied notes.

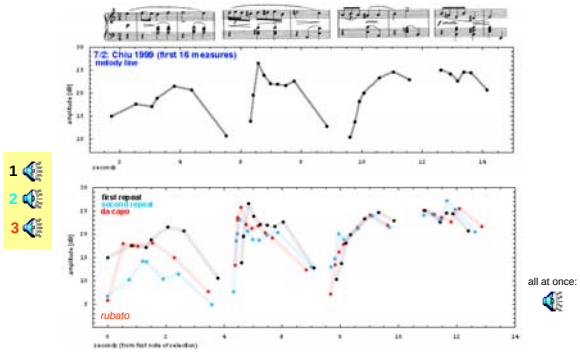
Automatic feature extraction

off-beat timings | **individual note timings** | **individual note loudnesses**

Data Entry Data Analysis

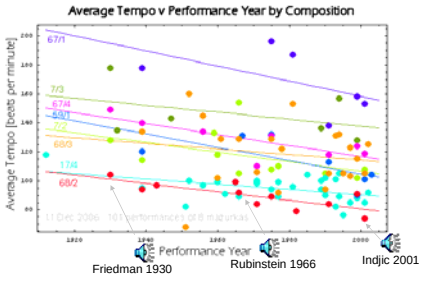


Dynamics & Phrasing



Average tempo over time

- Performances of mazurkas slowing down over time:

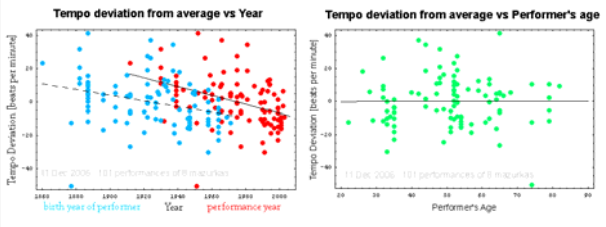


- Slowing down at about 3 BPM/decade

Laurence Picken, 1967: "Centeral Asian tunes in the Gagaku tradition" in *Festschrift für Walter Wiora*. Kassel: Bärenreiter, 545-51.

Average Tempo over time (2)

- **The slow-down in performance tempos is unrelated to the age of the performer**



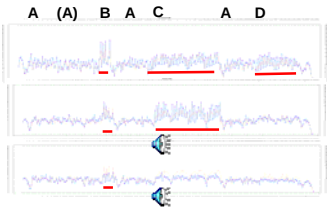
Tempo graphs

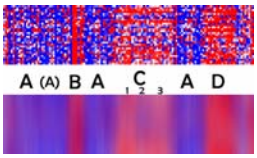
http://mazurka.org.uk/ana/tempograph

Mazurka Meter

- **Stereotypical mazurka rhythm:**
  - **First beat short**
  - **Second beat long**

Mazurka in A minor
Op. 17, No. 4

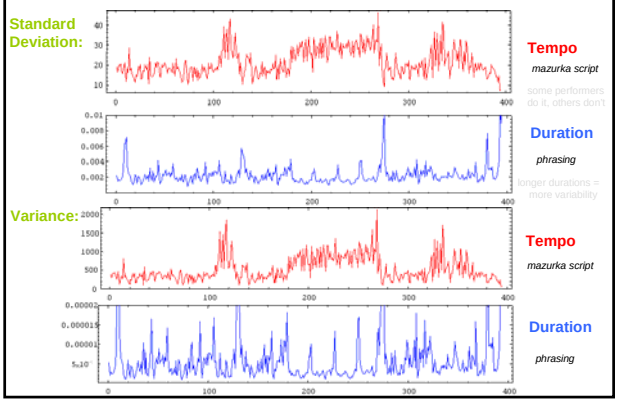




measure with longer second beat
measure with longer first beat

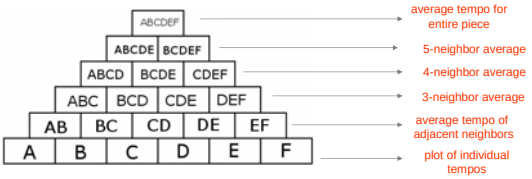
- blurred image to show overall structure

Standard Deviation & Variance

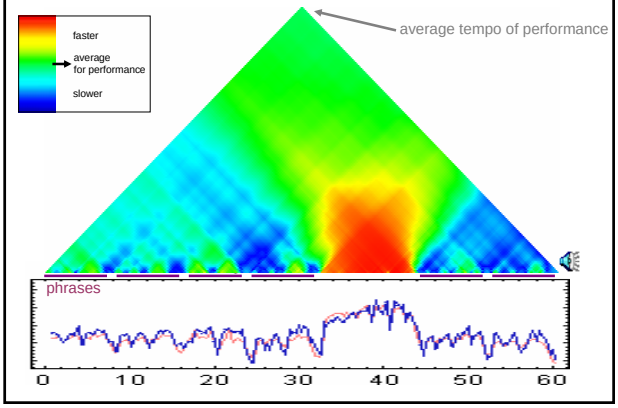


Timescapes

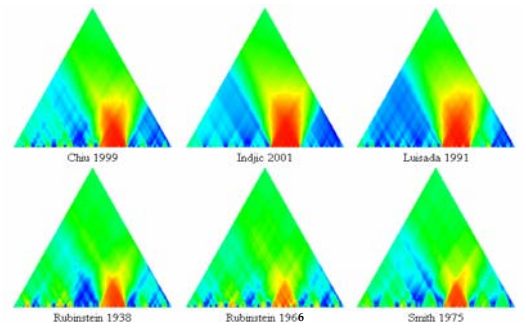
- Examine the internal tempo structure of a performances
- Plot average tempos over various time-spans in the piece
- Example of a piece with 6 beats at tempos A, B, C, D, E, and F:



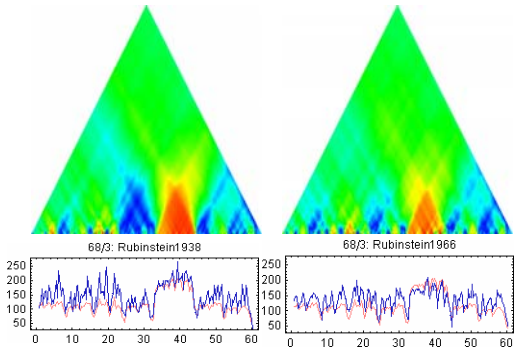
Timescapes (2)



Comparison of performers



Same performer



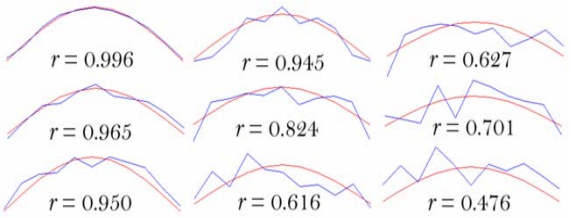
Correlation

Pearson correlation:

$$\frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

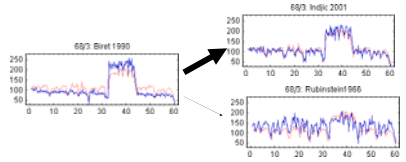
- **Measures how well two shapes match:**

r = 1.0 is an exact match.
r = 0.0 means no relation at all.



Overall performance correlations

	Bi	Br	Ch	Fl	In	Lu	R8	R6	Sm	Un
Biret	1.	0.92	0.81	0.83	0.95	0.85	0.62	0.5	0.55	0.86
Brailowsky	0.92	1.	0.81	0.86	0.91	0.84	0.66	0.55	0.65	0.85
Chiu	0.81	0.81	1.	0.86	0.86	0.81	0.76	0.74	0.67	0.89
Friere	0.83	0.86	0.86	1.	0.88	0.84	0.73	0.7	0.74	0.89
Indjic	0.95	0.91	0.86	0.88	1.	0.88	0.66	0.59	0.63	0.9
Luisada	0.85	0.84	0.81	0.84	0.88	1.	0.67	0.61	0.56	0.89
Rubinstein 1938	0.62	0.66	0.76	0.73	0.66	0.67	1.	0.77	0.62	0.75
Rubinstein 1966	0.5	0.55	0.74	0.7	0.59	0.61	0.77	1.	0.59	0.69
Smith	0.55	0.65	0.67	0.74	0.63	0.56	0.62	0.59	1.	0.64
Uninsky	0.86	0.85	0.89	0.89	0.9	0.89	0.75	0.69	0.64	1.



Highest correlation to Biret 1990

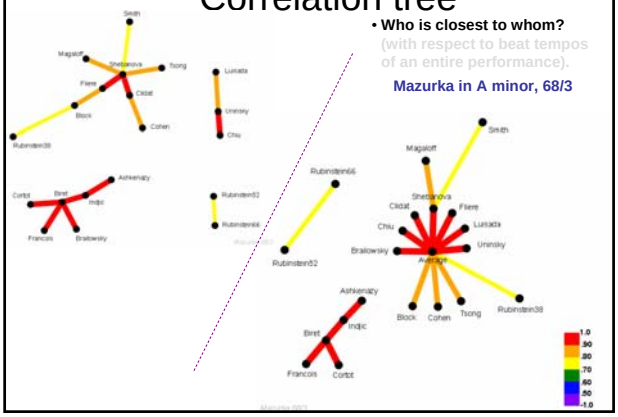
Lowest correlation to Biret 1990

Correlation tree

- **Who is closest to whom?**

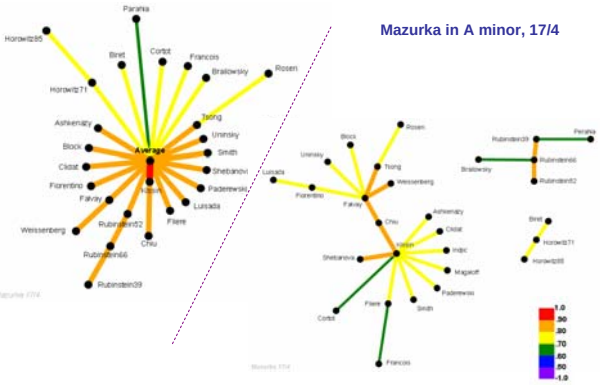
(with respect to beat tempos of an entire performance).

Mazurka in A minor, 68/3



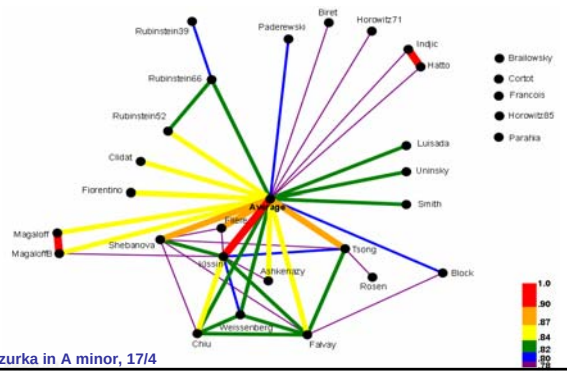
Correlation tree (2)

Mazurka in A minor, 17/4



Correlation network

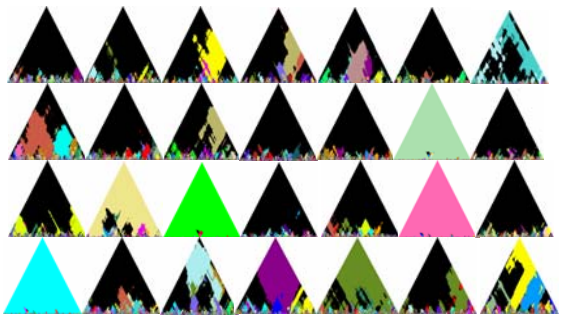
- **How close is everyone to everyone else?**



Mazurka in A minor, 17/4

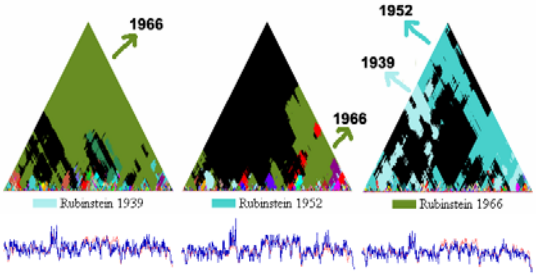
Correlation scapes

- **Who is most similar to a particular performer at any given region in the music?**



Same performer over time

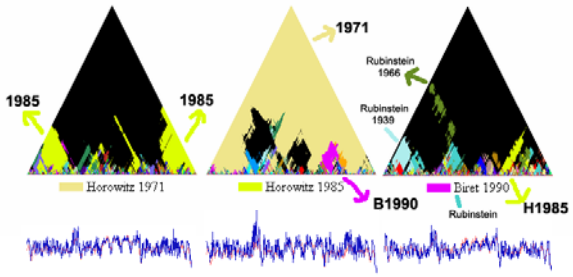
3 performances by Rubinstein of mazurka 17/4 in A minor



(30 performances compared)

Same performer (2)

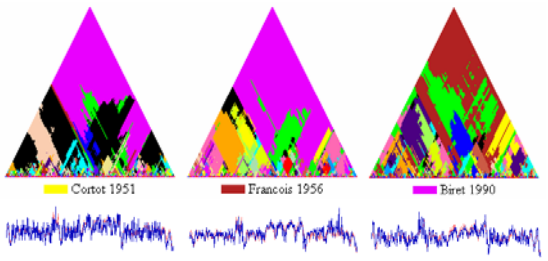
2 performances by Horowitz of mazurka 17/4 in A minor
plus Biret 1990 performance.



(30 performances compared)

Student/Teacher

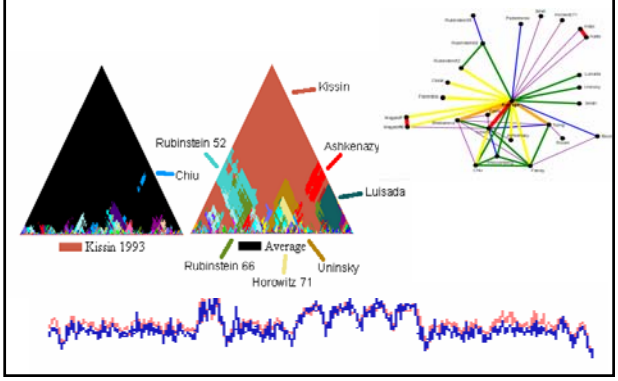
Mazurka in F major 68/3



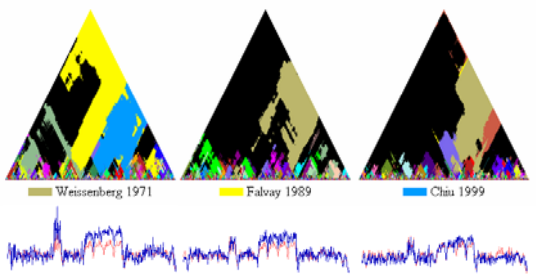
• Francois and Biret both studied with Cortot,

(20 performances compared)

Correlation to average



Possible influences



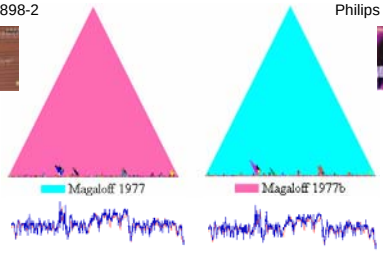
Same source recording

The same performance by Magaloff on two different CD releases

mazurka 17/4 in A minor

Philips 456 898-2

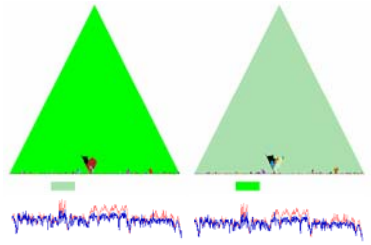
Philips 426 817/29-2



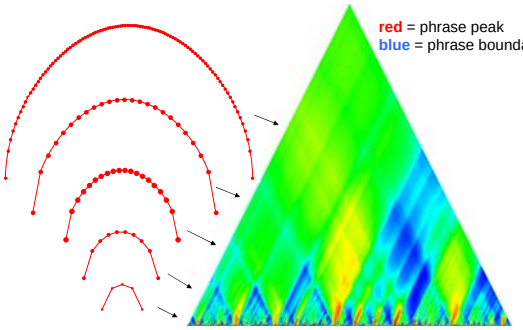
• Structures at bottoms due to errors in beat extraction or interpreted beat locations (no notes on the beat).

Purely coincidental

Two difference performances from two different performers on two different record labels from two different countries.



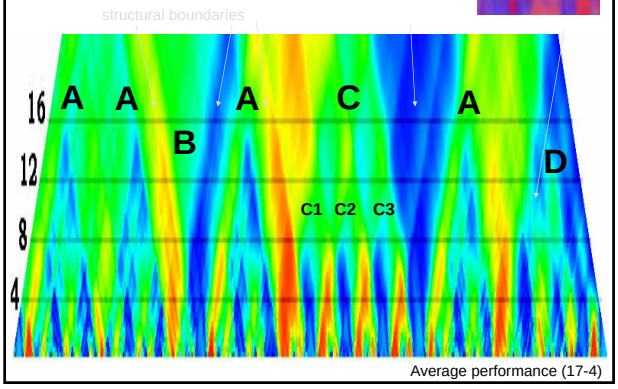
Arch Correlation



make your own plots at http://mazurka.org.uk/software/online/scape

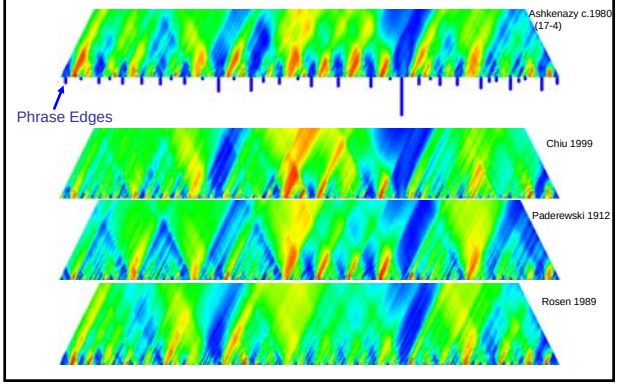
Paderewski 1912 (17-4)

Phrase Measure Level

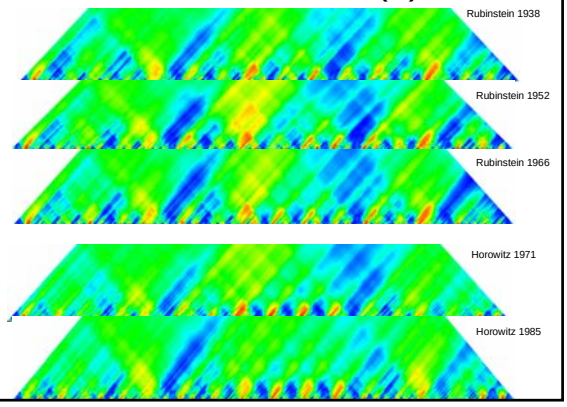


Average performance (17-4)

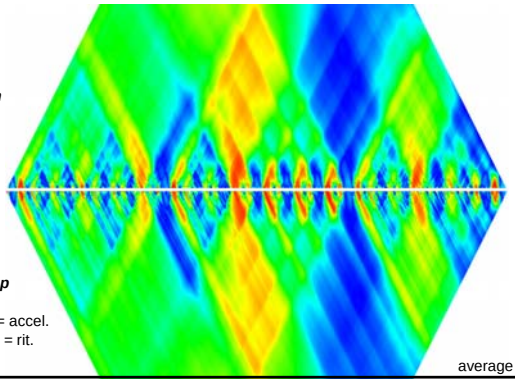
Phrase Identification/Characterization



Arch Correlation (2)



Ramp Correlation



average 17-4