Performance Style Analysis

Craig Stuart Sapp
craigsapp@stanford.edu
5 May 2020

Mazurka Project

AHRC Research
Centre for the History and Analysis of Recorded Music

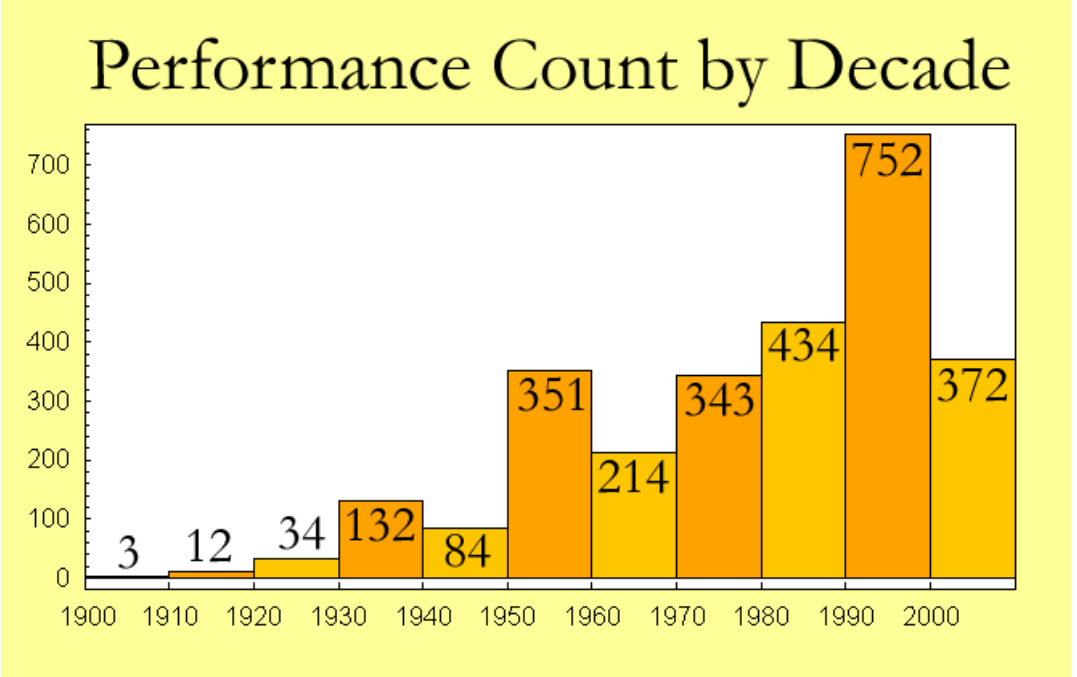
http://charm.rhul.ac.uk

•With Nicholas Cook (Royal Holloway, Univ. of London)

- **2,732 recordings of 49 mazurkas by Frédéric Chopin (1810-1849)**
  = Average of 56 performances/mazurka

- **157 performers**
- **on 209 CDs/records**
- **123 hours of music**

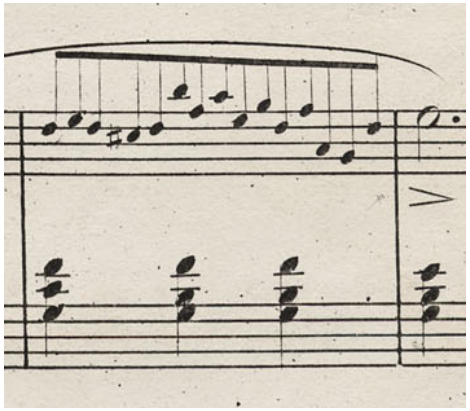
- **Earliest performance from 1902 by Alfred Grünfeld: mazurka 67/4**



Basic Problem

- How to numerically compare different performances?

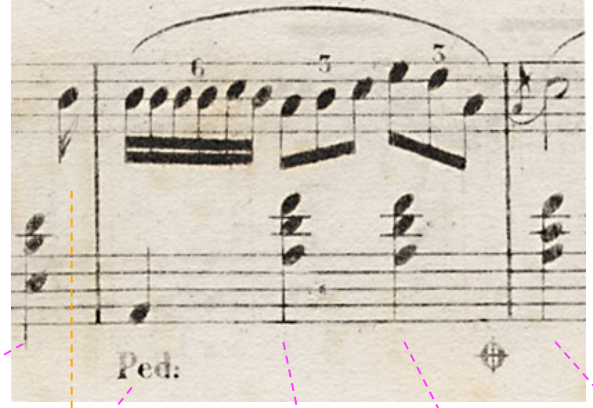
89 performances of mazurka 17/4



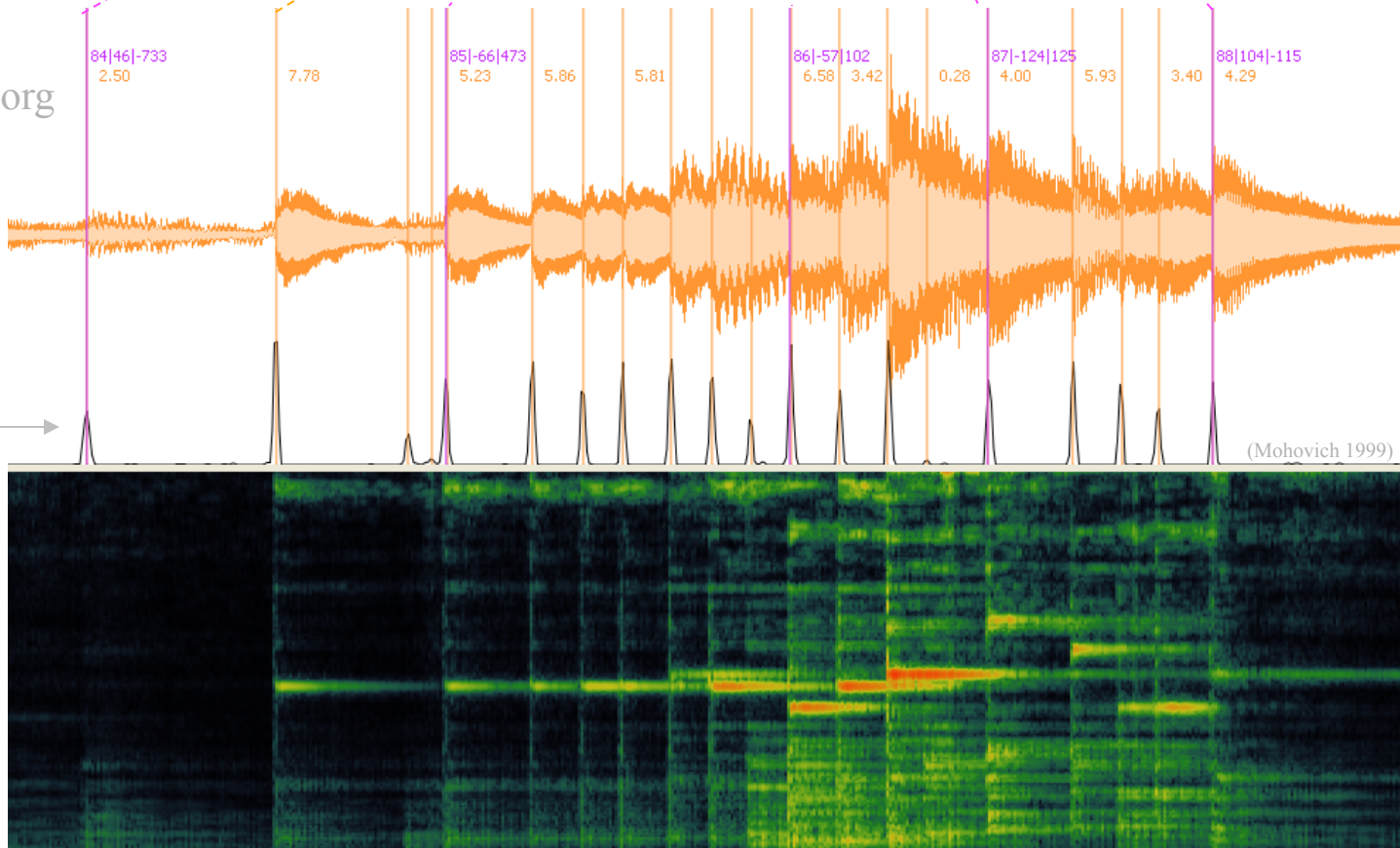
(measure 31)

Afanassiev 2001
Andsnes 1990
Ashkenazy 1981
Bacha 1998
Barbosa 1983
Beliavsky 2004
Ben-Or 1989
Biret 1990
Blet 2003
Block 1995
Brailowsky 1960
Brunhoff 1963
Casadesus 1930
Chiu 1999
Clidat 1994
Cohen 1997
Coop 1987
Cortot 1951
Csalog 1996
Czerny-Stefanska 1949 *live*
Czerny-Stefanska 1949 *studio*
Czerny-Stefanska 1989
Ezaki 2006
Falvay 1989
Ferenczy 1958
Fiorentino 1990
Flière 1977
Fou 1978
François 1956
Gieseking 1938
Ginzburg 1957
Goldmann 1997
Guller 1956
Hatto 1993
Hatto 2006
Horowitz 1971
Horowitz 1985
Indjic 1988
Kapell 1951
Kiepura 1999
Kilenyi 1937
Kissin 1993
Kitain 1937
Kushner 1990
Lévy 1951
Lear 1994
Lefébure 1950
Lilamand 2001
Luisada 1990
Lushtak 2004
Lympany 1968
Lympany 1990
Magaloff 1977
Magaloff 1977b
Magin 1975
Milkina 1970
Mohovich 1999
Nadelmann 1956
Ohlsson 1999
Olejniczac 1990
Olejniczak 1991
Osinska 1989
Pöntinen 2003
Paderewski 1912
Paderewski 1923
Paderewski 1924 *piano roll*
Perahia 1994
Perlemuter 1986
Poblocka 1999
Rangell 2001
Risler 1920
Rosen 1989
Rubinstein 1939
Rubinstein 1952
Rubinstein 1966
Rummel 1943
Shebanova 2002
Simon 1991
Smith 1975
Szpilman 1948
Sztompka 1959
Tanyel 1992
Uninsky 1971
Vardi 1988
Wasowski 1980
Weissenberg 1971
Zecchi 1942
Zecchi 1942b

Performance Extraction



Sonic Visualiser
Audio Editor
http://www.sonicvisualiser.org
(Queen Mary, University of London)



Plugins:

*Mz*SpectralReflux
*Mz*HarmonicSpectrogram

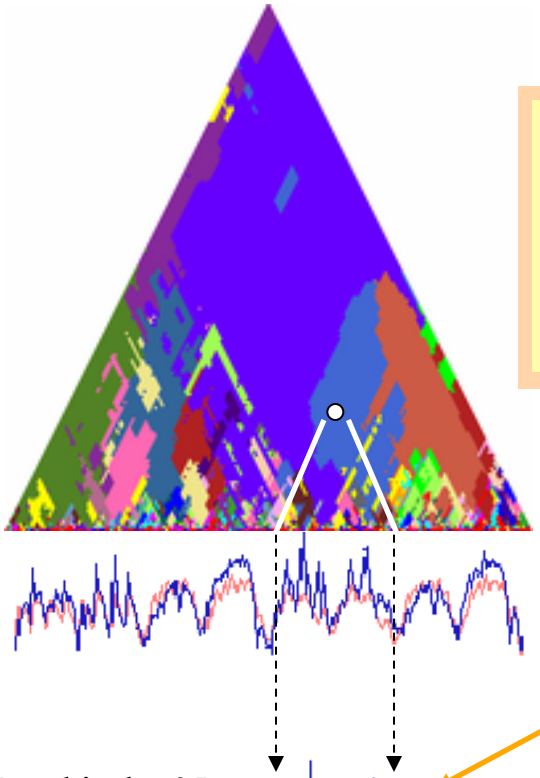
http://sv.mazurka.org.uk
(Royal Holloway, University of London)

Beat Tempo Data

measure	beat	Afanassiev 2001	Ashkenazy 1981	Beliavsky 2004	BenOr 1989	Biret 1990	Blet 2003	Block 1995	Indjic 2001	Hatto 1997	Clidat 1994	Cohen 1997	Coop 1987	Cortot 1951	Czerny 1949	Czerny 1949b	Ezaki 2006
1	2	63	99	68	103	90	101	63	97	97	90	133	73	72	78	100	82
1	3	69	113	92	118	136	150	94	103	105	126	168	97	126	105	104	92
2	1	73	120	99	128	166	158	116	97	100	150	152	97	119	100	103	100
2	2	72	117	93	122	153	150	138	98	95	158	183	111	132	95	97	100
2	3	71	106	90	122	158	125	121	92	91	152	171	94	108	86	80	97
3	1	71	106	73	98	125	120	113	85	86	129	150	87	87	78	86	88
3	2	63	94	51	94	96	85	84	63	63	94	154	86	65	65	68	79
3	3	49	60	71	86	67	55	60	79	78	86	107	67	52	63	60	59
4	1	47	32	41	48	43	65	33	56	55	45	133	42	36	24	29	43
4	2	46	36	66	58	64	30	26	35	35	38	85	34	38	46	43	52
4	3	46	36	66	58	64	30	26	35	35	38	85	34	38	46	43	52
5	1	58	51	79	77	76	75	49	58	57	61	93	57	55	57	59	57
5	2	72	74	107	75	91	122	85	105	103	89	143	86	120	107	102	87
5	3	78	72	103	107	130	103	85	115	115	69	99	104	80	104	94	97
6	1	67	91	95	120	93	100	64	97	96	91	203	73	61	102	105	87
6	2	82	98	153	113	132	86	102	91	90	118	133	76	91	170	179	107
6	3	81	97	157	125	140	92	122	109	107	120	149	91	125	129	131	83
7	1	77	96	138	130	141	122	86	109	109	118	148	109	122	125	118	98
7	2	75	94	103	102	87	87	67	87	86	95	136	98	80	102	103	98
7	3	67	67	73	83	73	60	48	75	75	70	120	73	49	62	64	67
8	1	65	101	88	94	83	92	74	100	96	87	122	77	64	92	98	71
8	2	72	107	120	109	128	122	76	92	94	107	143	97	105	115	122	97
8	3	65	89	128	79	130	89	69	77	76	109	130	75	109	125	128	94
9	1	70	106	113	94	125	78	92	88	87	95	122	87	68	91	90	76
9	2	73	125	120	100	128	111	92	94	94	92	154	88	106	97	97	80
9	3	76	111	125	94	95	120	107	118	119	113	158	86	143	133	134	102
10	1	66	117	100	105	92	111	111	97	95	84	146	91	97	105	103	97
10	2	63	125	112	111	115	103	80	107	105	91	136	94	113	98	100	92
10	3	59	102	86	102	83	67	88	102	103	82	141	63	90	134	116	79
11	1	61	122	75	120	74	130	111	100	98	78	139	75	69	97	96	62
11	2	77	135	121	120	119	128	79	109	109	115	162	107	58	103	110	98
11	3	62	100	114	116	88	95	100	109	110	105	168	111	85	145	140	103
12	1	57	93	88	121	61	118	74	95	92	145	139	97	82	106	102	86
12	2	65	87	87	107	103	81	70	100	101	91	130	82	83	103	105	83
12	3	55	71	85	93	67	61	56	72	71	91	122	58	119	130	152	70
13	1	59	80	108	92	74	91	50	83	83	103	109	62	84	98	92	78
13	2	73	87	74	120	71	92	95	111	109	110	120	92	104	115	112	102
13	3	62	67	65	82	53	88	44	74	75	108	102	77	59	75	73	65
14	1	65	101	100	107	92	120	68	100	99	115	117	76	76	92	104	87
14	2	67	113	157	113	100	111	100	107	103	128	153	98	141	143	131	100
14	3	49	82	136	113	59	113	83	97	97	105	114	82	105	103	110	100
15	1	53	73	98	100	75	91	86	78	78	132	132	95	85	90	97	72
15	2	73	69	161	92	57	105	48	79	79	103	115	92	120	125	128	79
15	3	60	87	137	111	85	66	34	73	72	83	121	71	58	60	70	87
16	1	59	104	92	104	92	89	69	85	85	97	120	88	65	93	102	68
16	2	70	129	133	120	125	133	90	100	96	116	133	95	95	107	115	94
16	3	67	121	122	113	115	118	92	87	87	120	125	75	121	105	113	109
17	1	55	115	111	103	110	100	60	67	66	107	93	75	99	74	79	98
17	2	71	128	128	97	75	130	61	92	91	85	159	97	85	92	97	95
17	3	70	106	100	97	98	75	69	103	105	112	167	85	152	126	114	112
18	1	65	85	85	89	78	87	48	82	82	108	107	71	84	83	110	97
18	2	59	94	88	93	93	111	62	92	87	76	145	88	148	104	100	88
18	3	38	81	59	75	69	129	65	92	94	75	142	69	84	85	78	85
19	1	59	83	59	80	83	106	56	94	93	90	104	86	81	78	75	85
19	2	55	77	109	98	102	83	52	94	93	107	140	109	60	69	67	76
19	3	64	76	85	95	115	65	75	87	86	121	122	90	114	69	67	77
20	1	56	79	72	92	107	102	52	74	72	112	122	78	95	75	82	59
20	2	53	108	105	82	72	105	53	80	80	103	113	76	69	95	107	85

Correlation Comparisons

(ISMIR 2007)

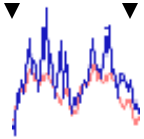


Pearson correlation:

output range: -1.0 to +1.0

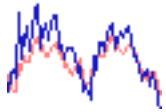
$$\frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

Yaroshinsky 05 tempo in measures 32-48:



Uninsky 71 **0.72**

Biret 90 **0.64**



Jonas 47 **0.56**

Luisada 90 **0.46**

Magaloff 77 **0.37**

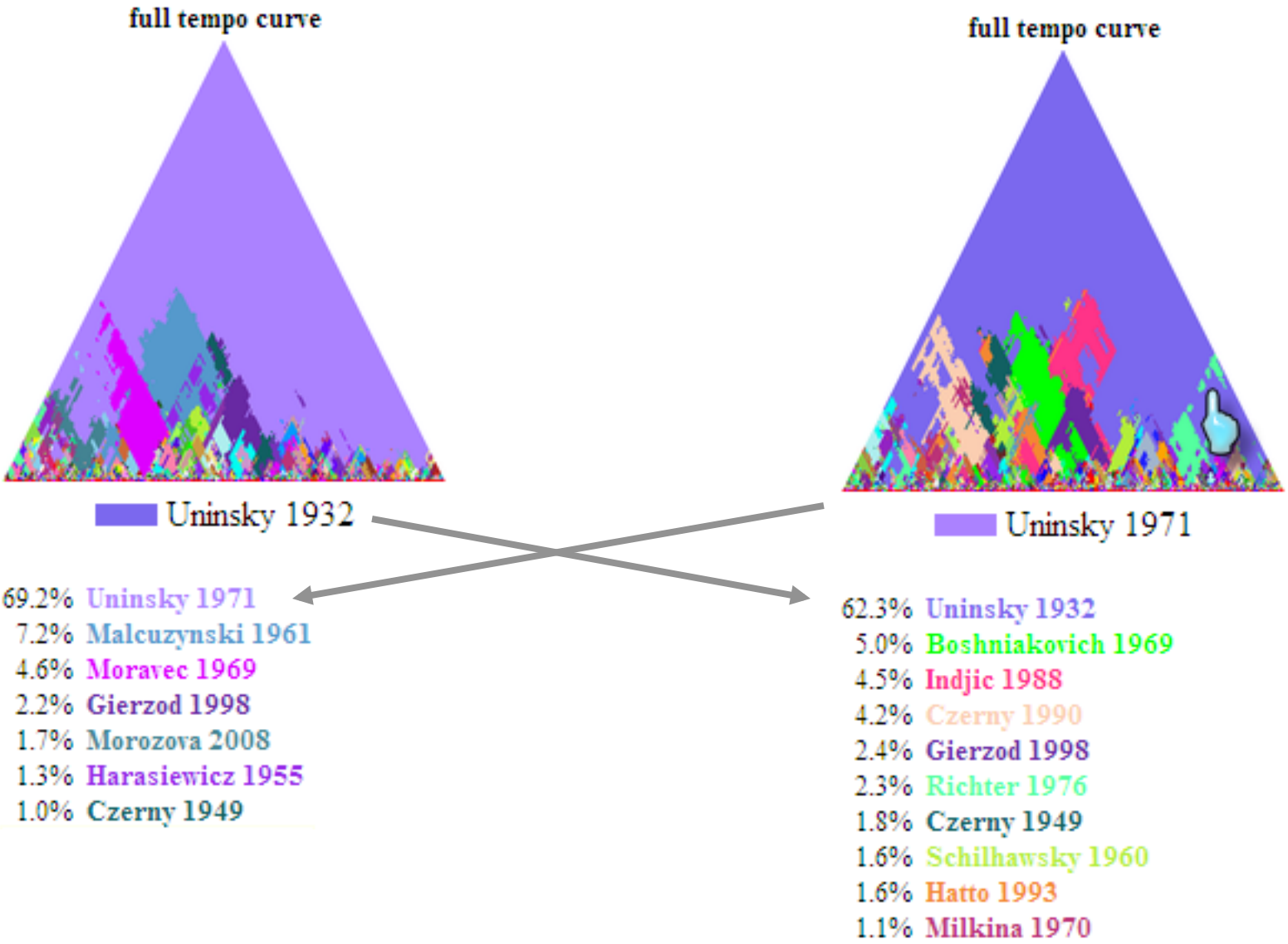
Rubinstein 66 **0.22**

Brailowsky 60 **0.09**

(better matches)

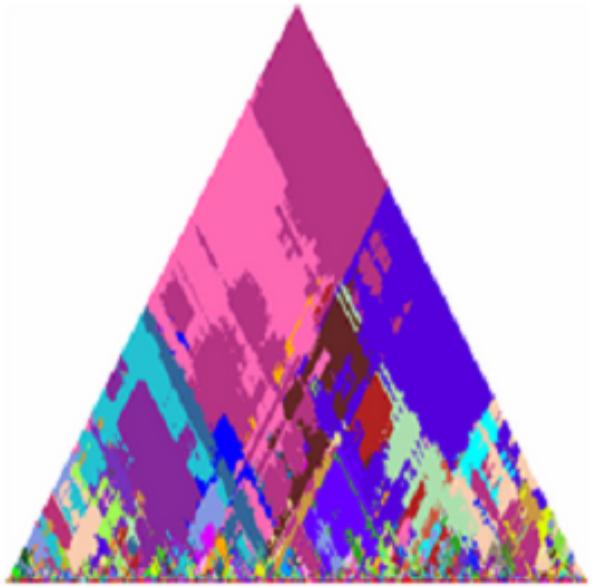
(worse matches)

Sometimes Clear Meaning



Sometimes Unclear Meaning

- Plots have to show some match at all points
  -- not necessarily a good one



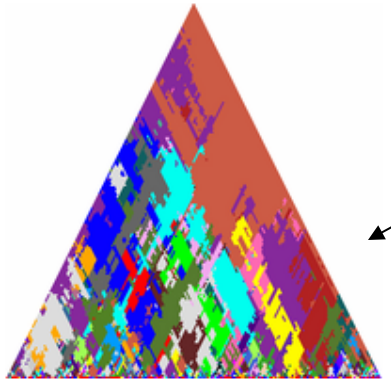
Uninsky 1971

23.6% Lushtak 2004
15.5% Falvay 1989
15.0% Osinska 1989
5.9% Kiepura 1999
4.8% Wasowski 1980
4.1% Czerny 1949
3.8% Kissin 1993
3.6% Fliere 1977
2.9% Beliavsky 2004
2.7% Hatto 1997
2.1% Clidat 1994
1.9% Milkina 1970
1.6% Perahia 1994
1.3% Poblocka 1999
1.2% BenOr 1989
1.1% Ezaki 2006

- indicates who the nearest neighbor is
- doesn't indicate how close the nearest neighbor is.
- does **not** mean he plays 23.6% like Lushtak, 15.5% like Falvay, etc.

Purely Random Matches

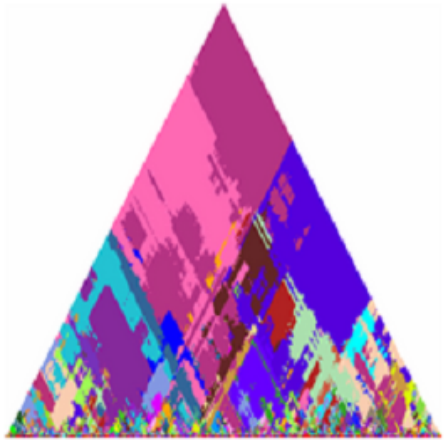
- Small color regions, inverted triangles & broken borders = poor matches



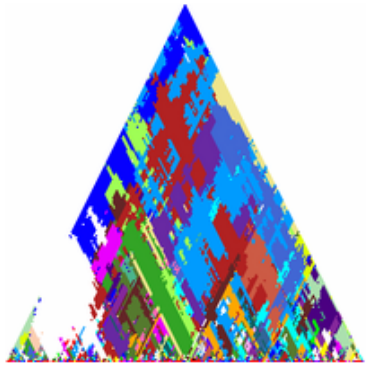
two white-noise sequences

Random1

22.7% Jonas 1947
14.1% Shebanova 2002
8.3% Blet 2003
8.0% Chiu 1999
7.3% Random2
6.0% Tsong 2005
4.8% Mohovich 1999
4.4% Fiorentino 1962
3.3% Cortot 1951
2.5% Fliere 1977
2.4% Lushtak 2004
2.1% Michelangeli 1971
2.1% Smith 1975
2.1% Sofronitsky 1960
1.7% Tsong 1993
1.6% Ferenczy 1956
1.4% Ashkenazy 1981



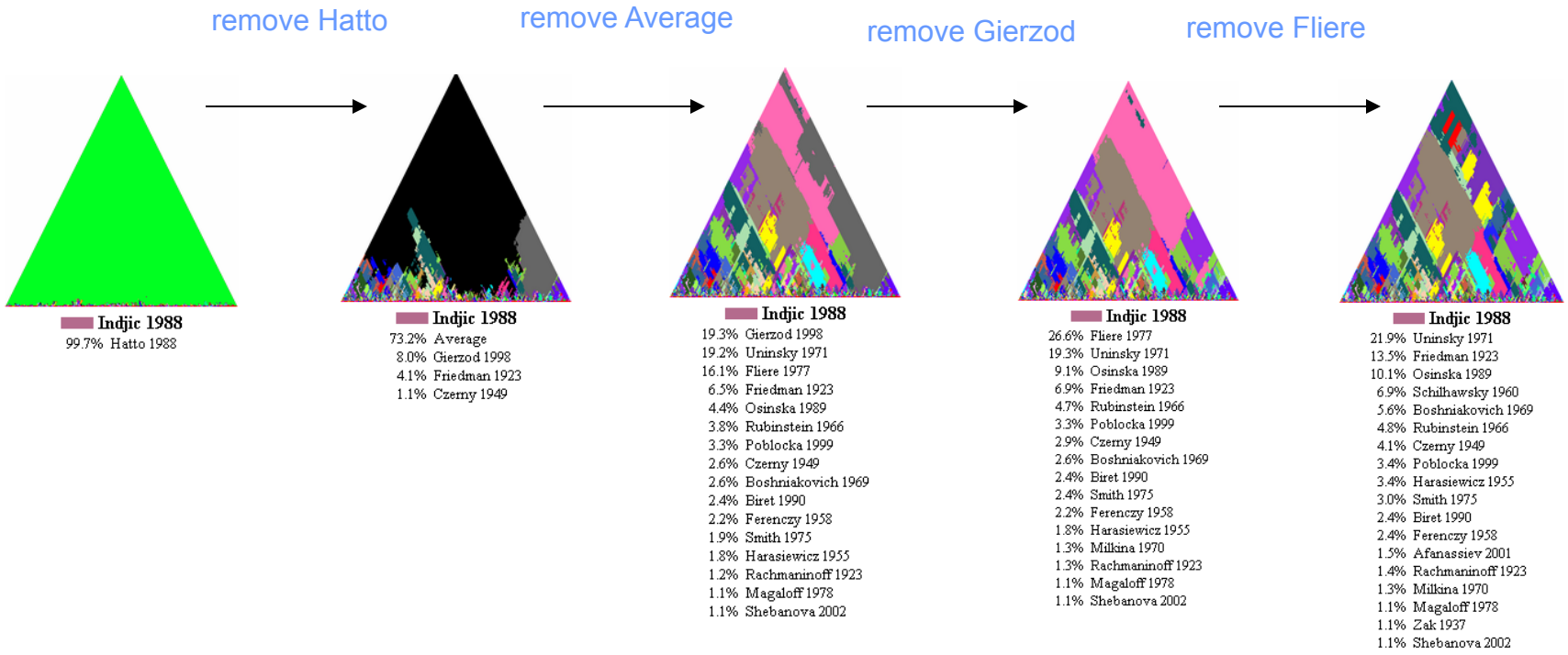
Uninsky 1971
23.6% Lushtak 2004



Random2

17.7% Brailoswky 1960
13.8% Fiorentino 1962
10.1% Random1
7.6% Blet 2003
7.1% Uninsky 1971
6.9% Yaroshinsky 2005
4.8% Rangell 2001
3.8% Sofronitsky 1960
3.7% Clidat 1994
3.1% Francois 1956
3.0% Jonas 1947
2.8% Tsong 2005
2.2% Magaloff 1977
1.9% Ferenczy 1956
1.8% Ashkenazy 1982
1.6% Luisada 1990
1.5% Indjic 2001
1.2% Shebanova 2002

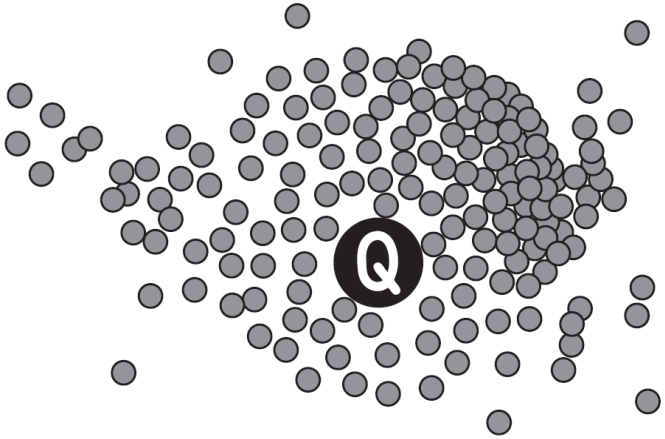
Peeling Back the Layers

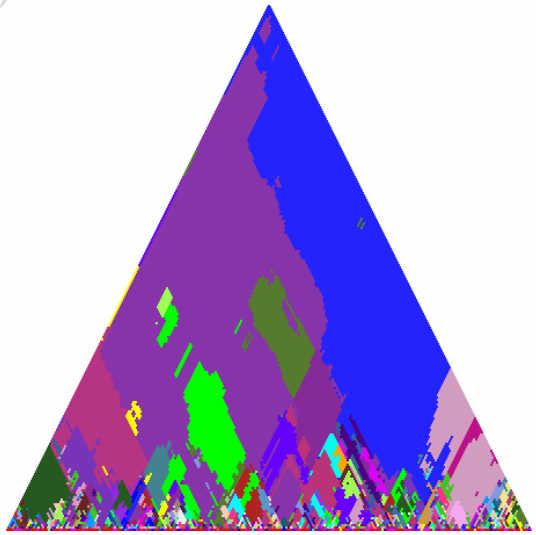


- Eventually noise-like display

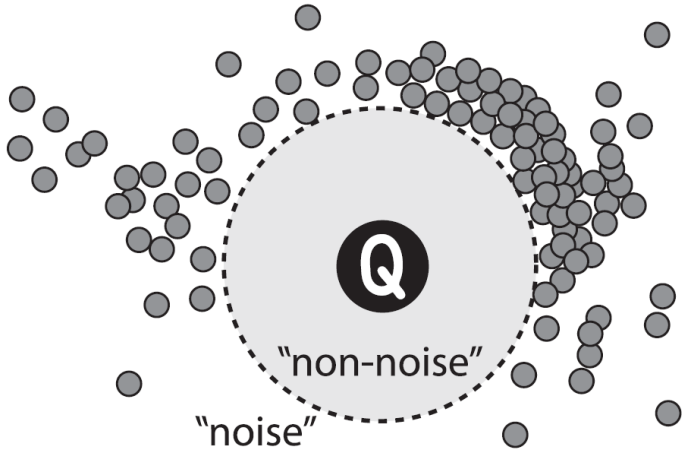
Noise Floor Definition

(ISMIR 2008)



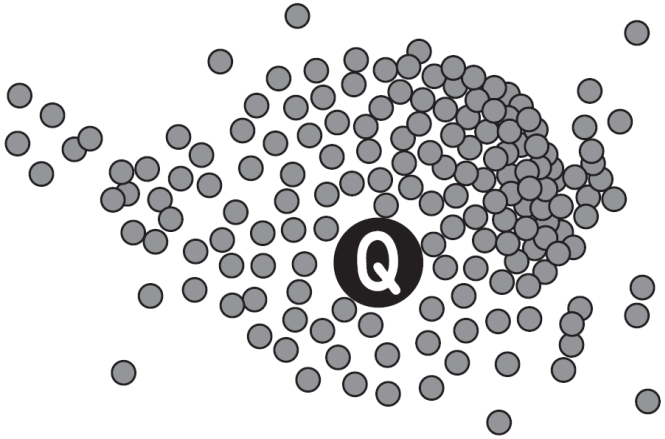


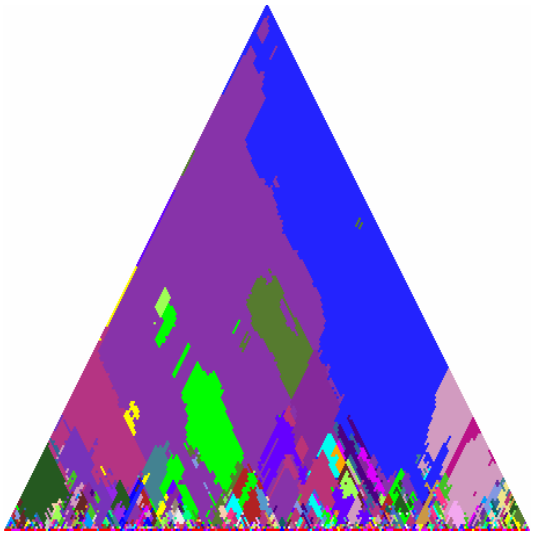
Horowitz 1949 dynamics



- Peel off first half of performances
- Other half defined as "noise floor"

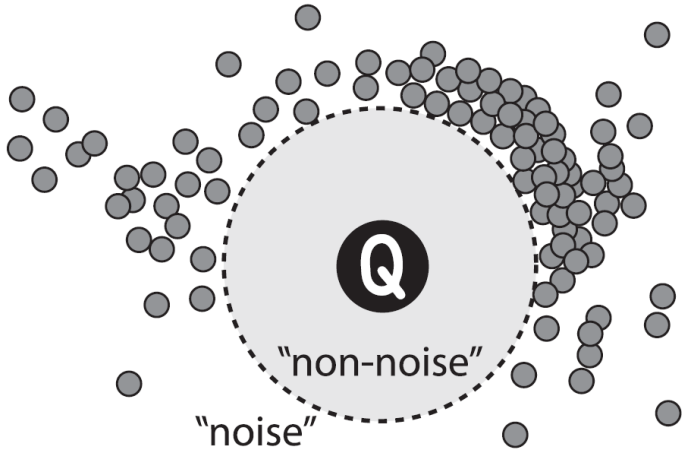
Noise Floor Definition (2)

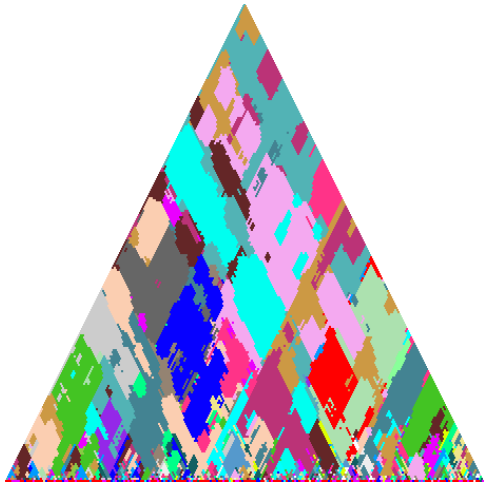




Horowitz 1949 dynamics

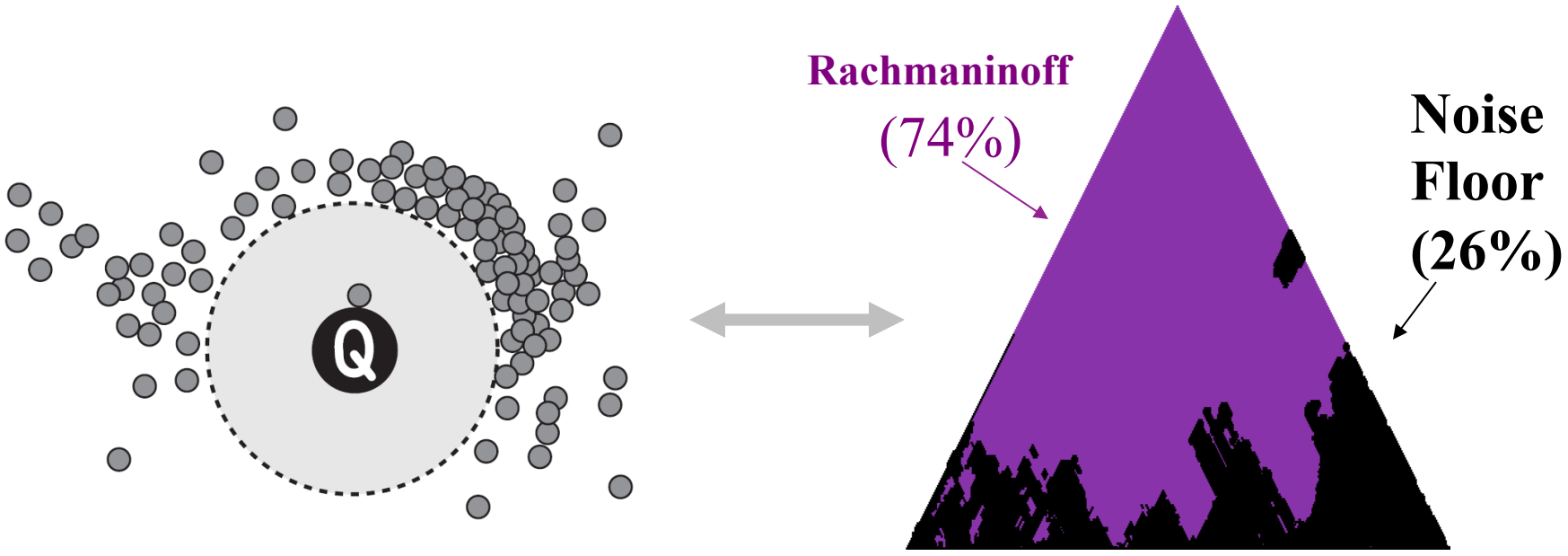
Remove better matches:





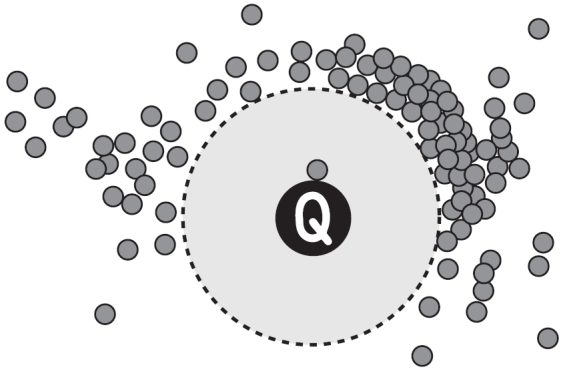
Horowitz's noise-floor

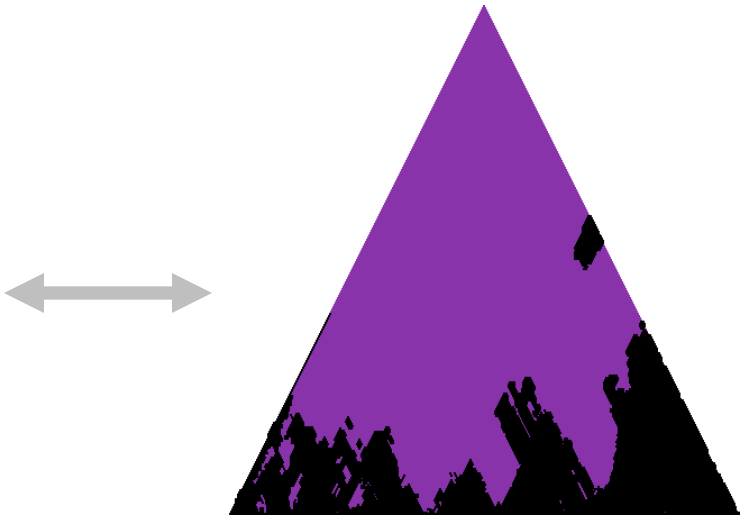
Reintroduce Better Matches



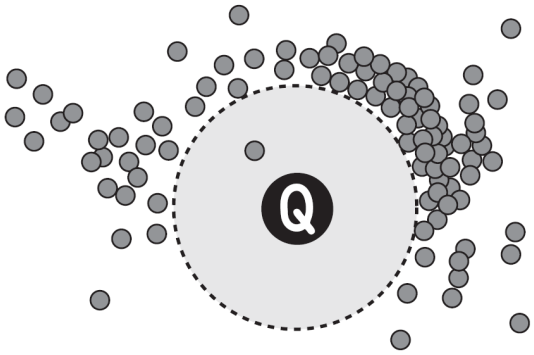
= Rachmaninoff's correlations exceed noise-floor in 74% of sub-sequences.

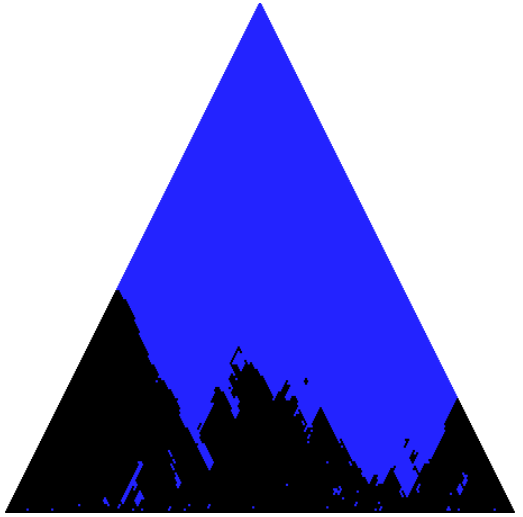
Overlay Other Performers with “Noise”





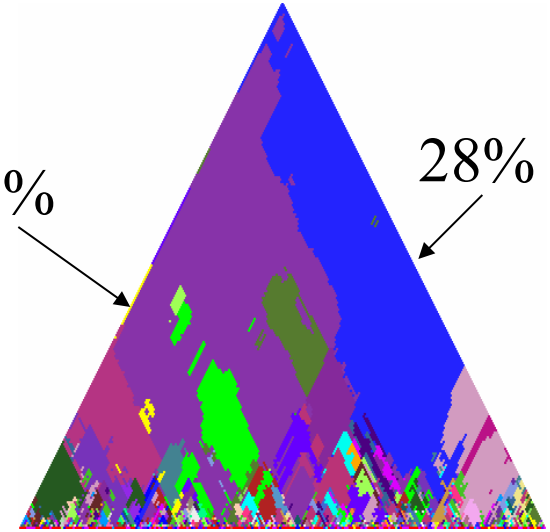
Rachmaninoff | Horowitz



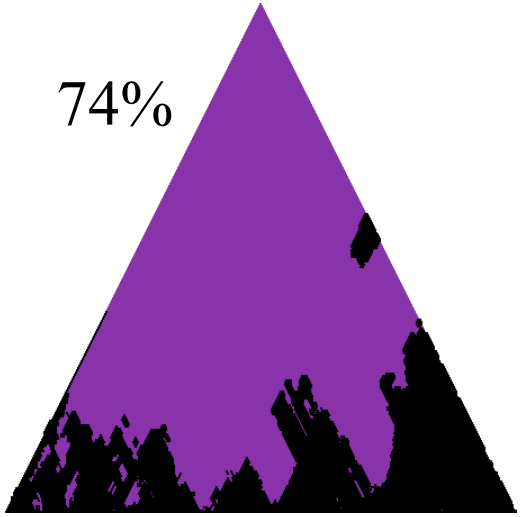


Zak | Horowitz

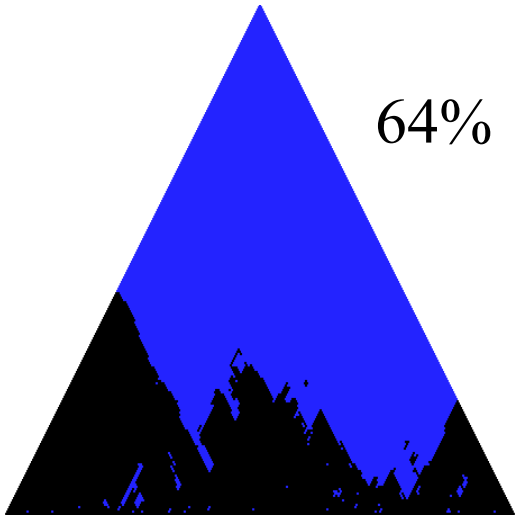
Non-Overlapped Similarity



Horowitz 1949 dynamics



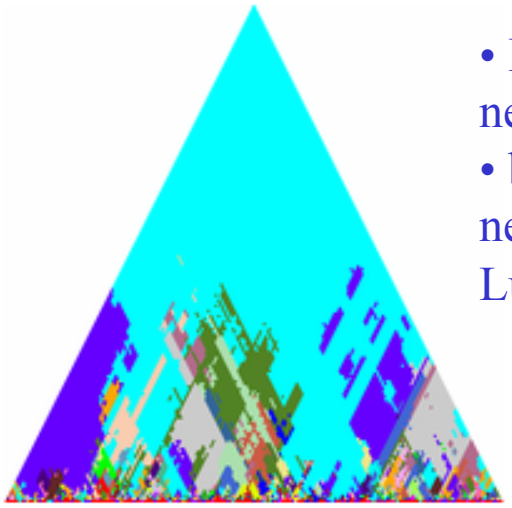
S_3



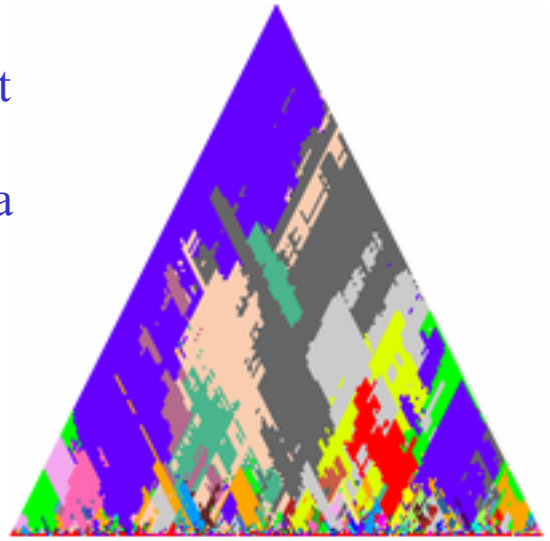
Rachmaninoff | Horowitz

Zak | Horowitz

Asymmetric Matches



- Luisada often a nearest neighbor of Brailowsky
- but Brailowsky never a nearest neighbor of Luisada…



Brailowsky 1960

60.1% Luisada 1990
13.2% Biret 1990
6.2% Olejniczac 1990
6.2% Smith 1975
2.4% Indjic 2001
1.8% Milkina 1970
1.7% Rubinstein 1952
1.3% Jonas 1947
1.3% Uninsky 1971

Luisada 1990

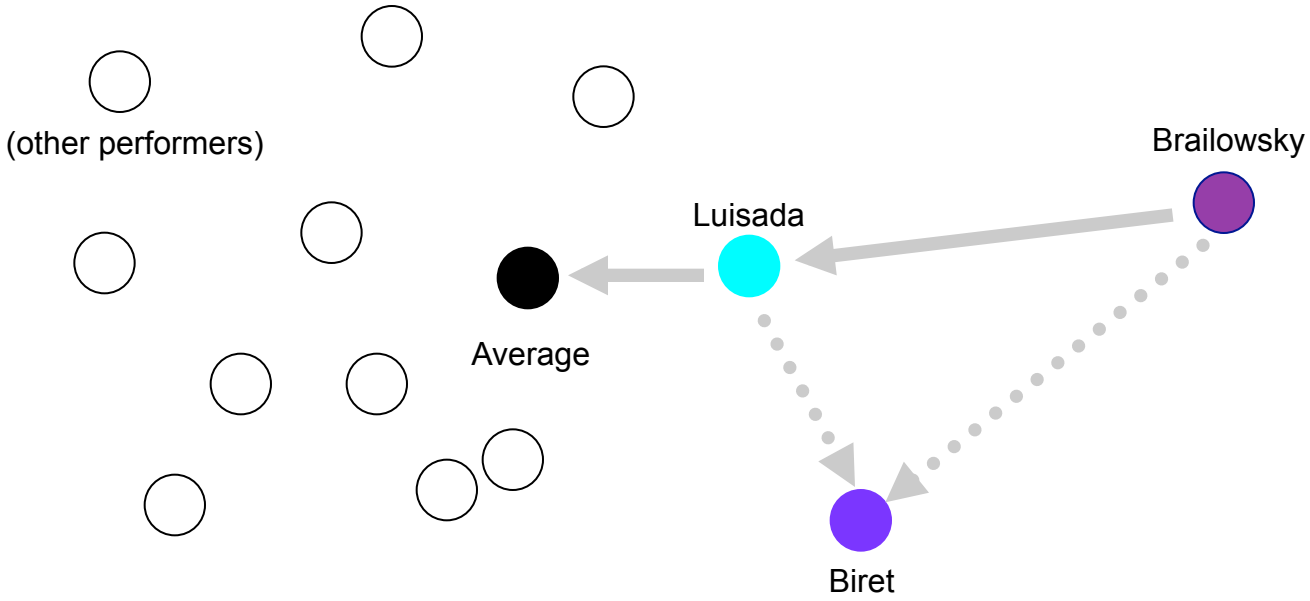
32.2% Biret 1990
20.3% Mohovich 1999
10.4% Milkina 1970
9.0% Olejniczac 1990
5.2% Rubinstein 1939
4.0% Hatto 1997
3.6% Fliere 1977
3.1% Ashkenazy 1981
2.8% Ferenczy 1956
2.6% Rubinstein 1952
1.6% Lushtak 2004
1.1% Tsong 1993

?

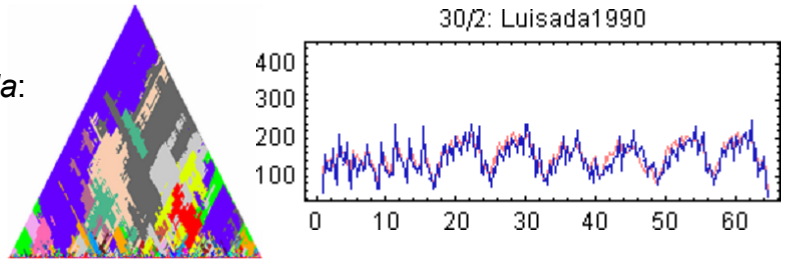
$S_3 = 0.82$

$S_3 = 0.17$

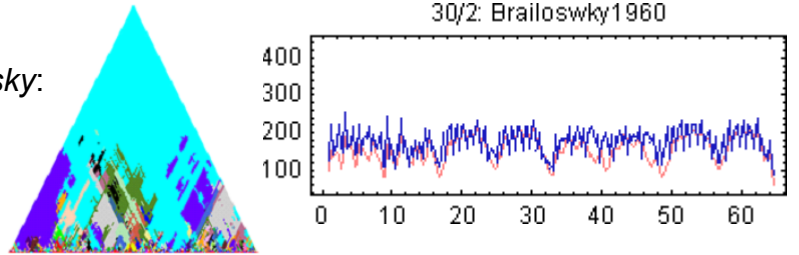
Rough Performance Map Schematic



Luisada:

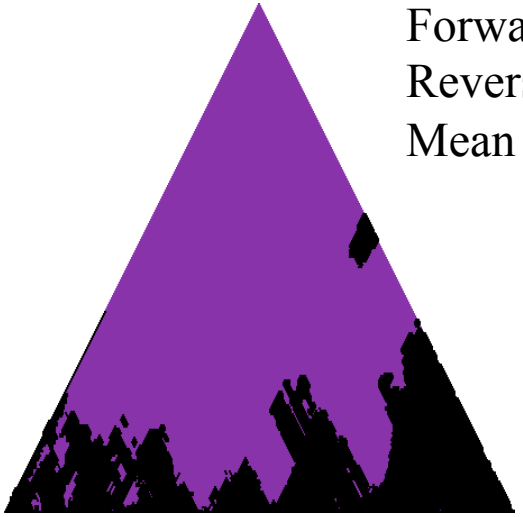


Brailowsky:



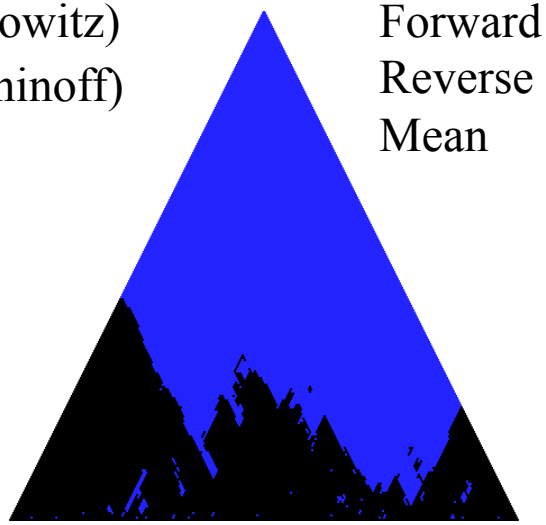
Distant Neighbor Suppression

$$
\begin{aligned}
S_3 &= A \Rightarrow B \text{ measurement} \\
S_{3\mathrm{r}} &= A \Leftarrow B \text{ measurement} \\
S_4 &= \sqrt{S_3\ S_{3\mathrm{r}}}
\end{aligned}
$$



Forward = 74% (Rachmaninoff|Horowitz)
Reverse = 77% (Horowitz|Rachmaninoff)
Mean = 75%

Rachmaninoff | Horowitz



Forward = 64%
Reverse = 57%
Mean = 60%

Zak | Horowitz

Evaluation

• Arthur Rubinstein – 3 performances for each mazurka:

1939

1952

1966

→ also, more variable between performances than other pianists

• How well can 2 of his performances be identified with the third?

Query: Rubinstein 1952 (smoothed tempo)

1:	0.65	Rubinstein 1939
2:	0.60	Rubinstein 1966
	0.59	Tomsic 1995
	0.56	Falvay 1989

Average rank: **1.5**

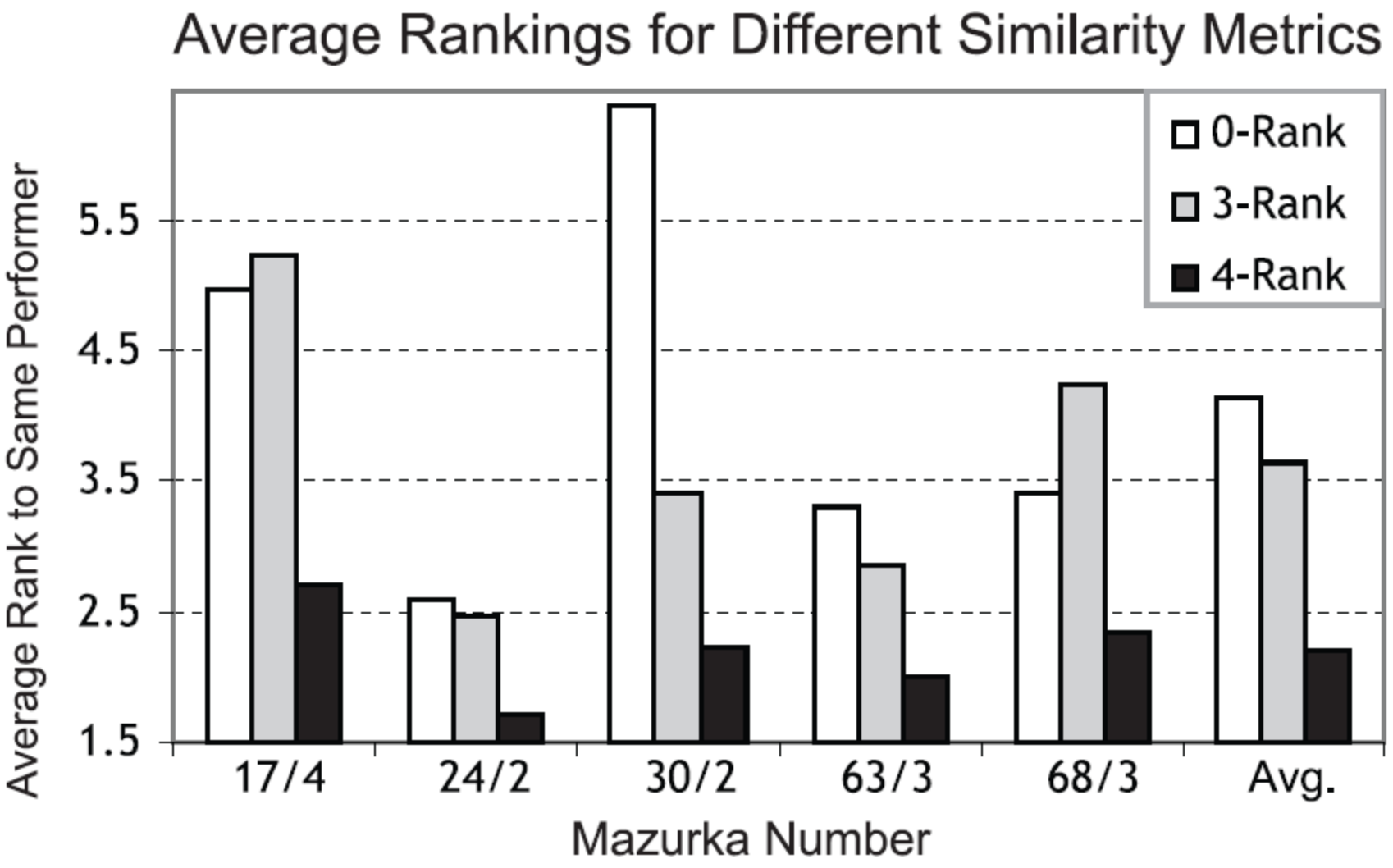
Query: Rubinstein 1952 (full dynamics)

1:	0.65	Rubinstein 1966
	0.62	Milkina 1970
	0.60	Csalog 1996
	0.60	Kissin 1993
	0.56	Fou 1978
	0.56	Cohen 1997
7:	0.56	Rubinstein 1939

Average rank: **4.0**

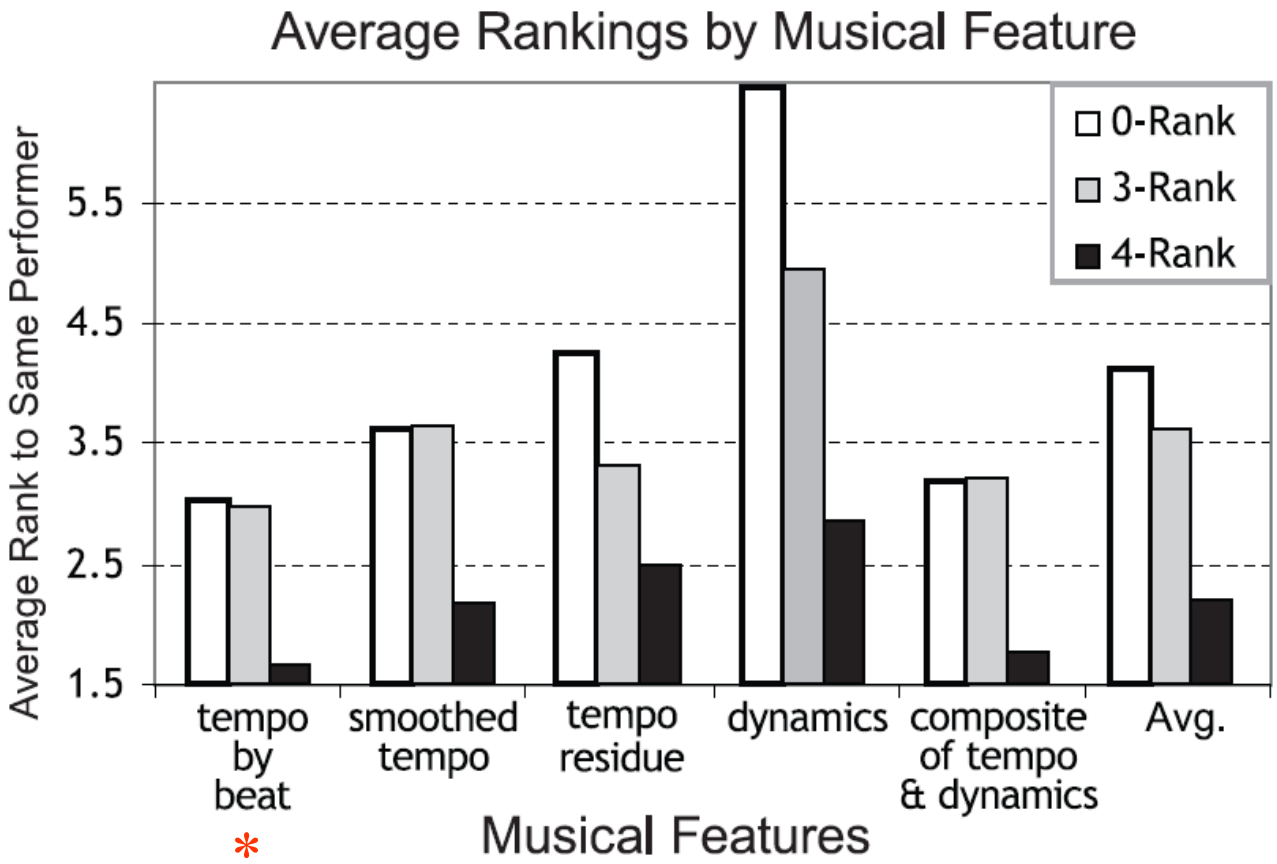
Results by Composition

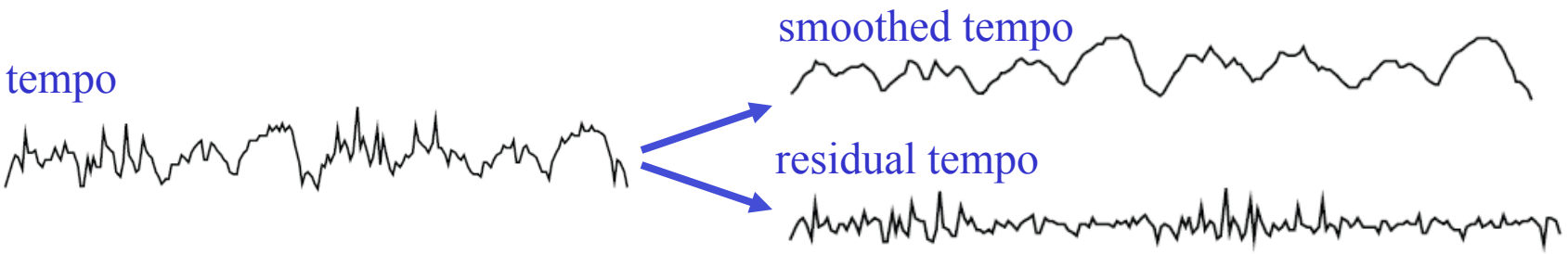
(using Rubinstein performances)



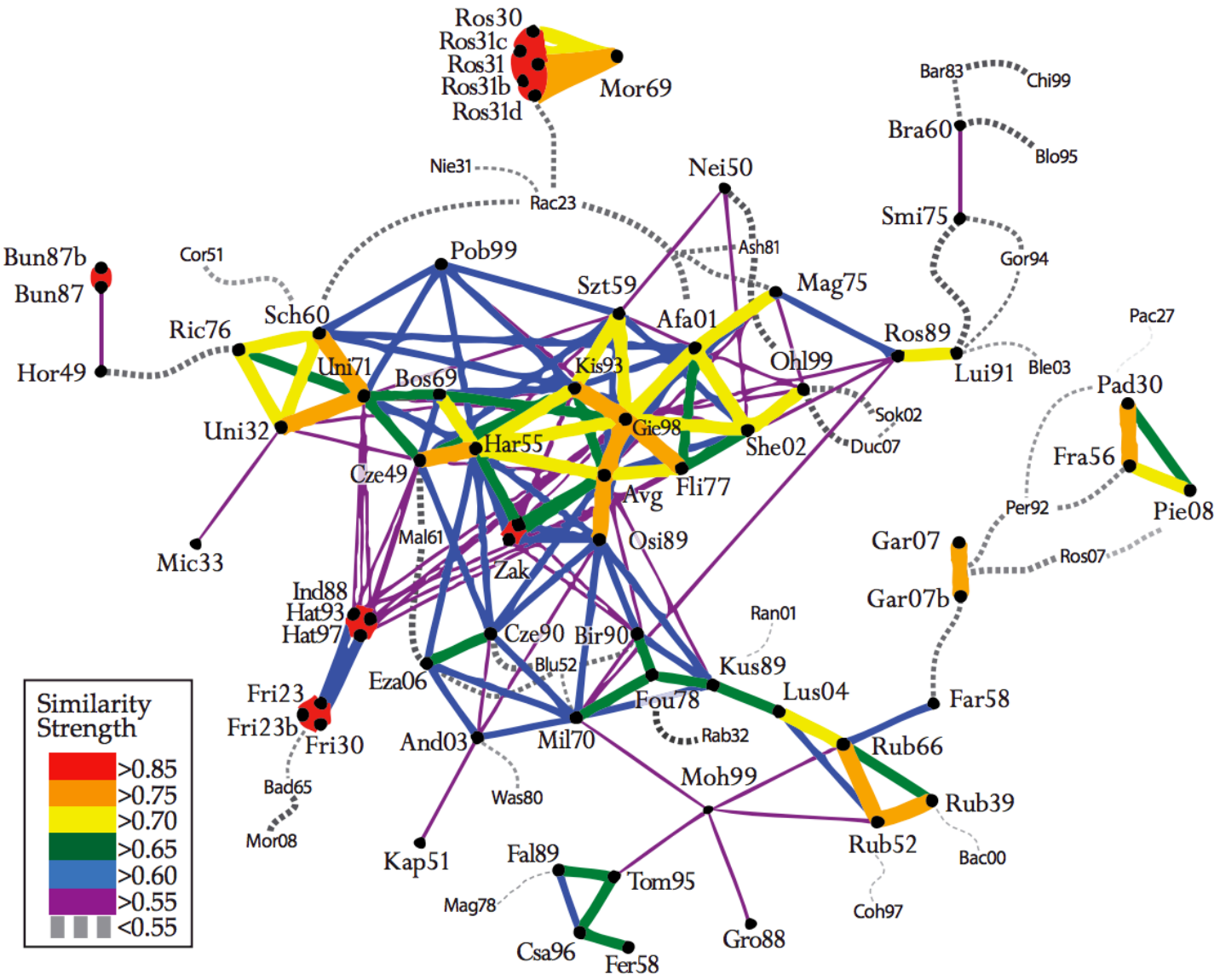
Results by Feature

(using Rubinstein performances)

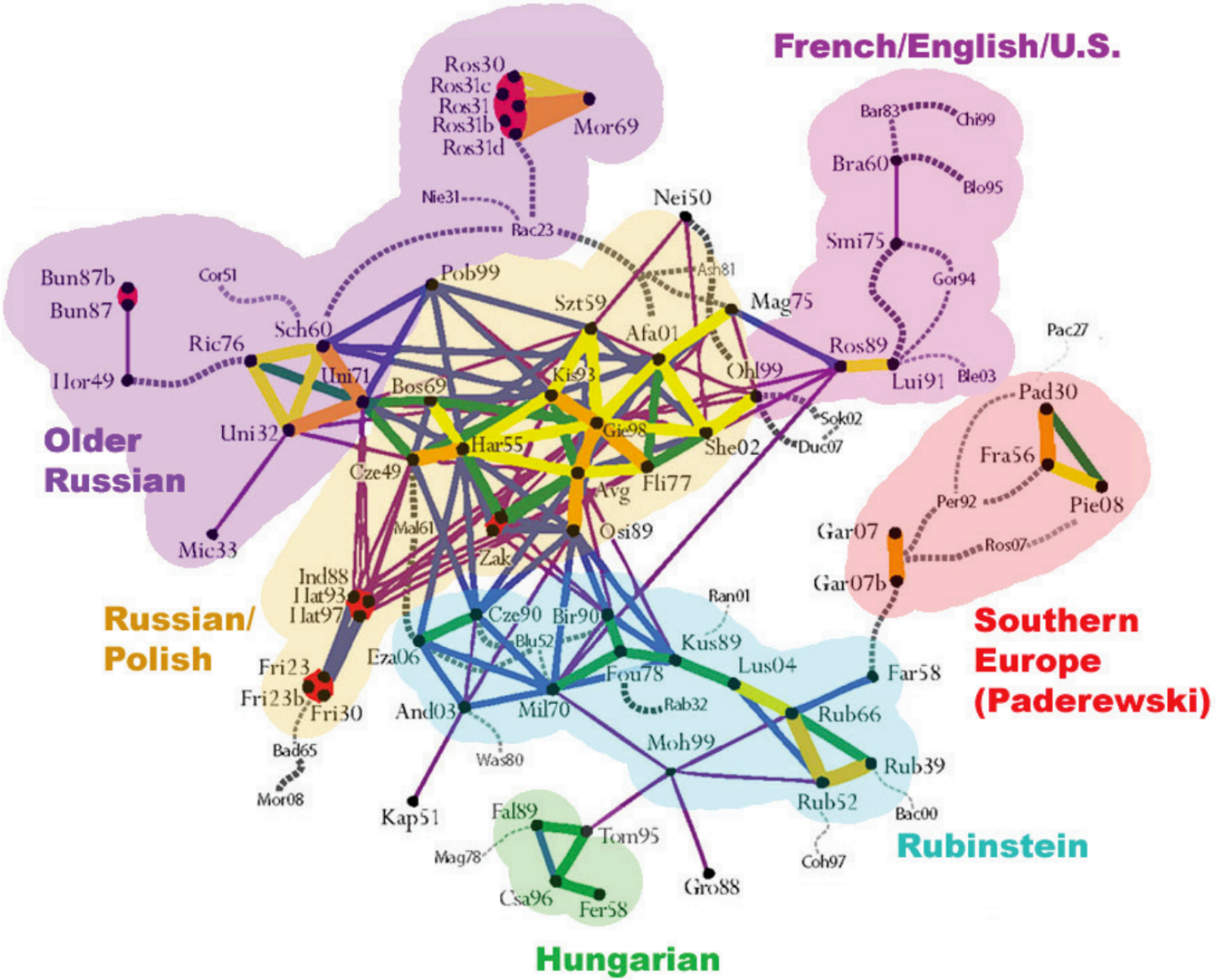




Performance Map (using S_4)



Performance Map Interpretation



1. Hatto Hoax

Background

LETTER FROM ENGLAND

FANTASIA FOR PIANO

Joyce Hatto's incredible career.

BY MARK SINGER

2003-2006: ~100 CDs covering a wide range of classical piano repertoire.

TOP CDs OF 2005
Richard Dyer, Boston Globe:

10. Brahms: Piano Music. Joyce Hatto, piano *Concert Artist/Fidelio Recordings*. **Hatto, a British pianist now in her mid-70s, was my great discovery of 2005**. Although illness has kept her off the concert platform for decades, she has made well over 100 CDs surveying virtually the major piano repertory. None of the 50 or so I have heard is disappointing, and the best join the company of the best piano record ever made. A particular favorite is this Brahms volume that includes the "Paganini" Variations.

(Matti Raekallio)

January 2006, *Gramophone*, Jeremy Nicholas:

"the world's unrivaled authority on classical music since 1923"

2007:
- 80 CDs identified in whole or part from other commercial CDs
- 90 pianists represented on Hatto CDs.

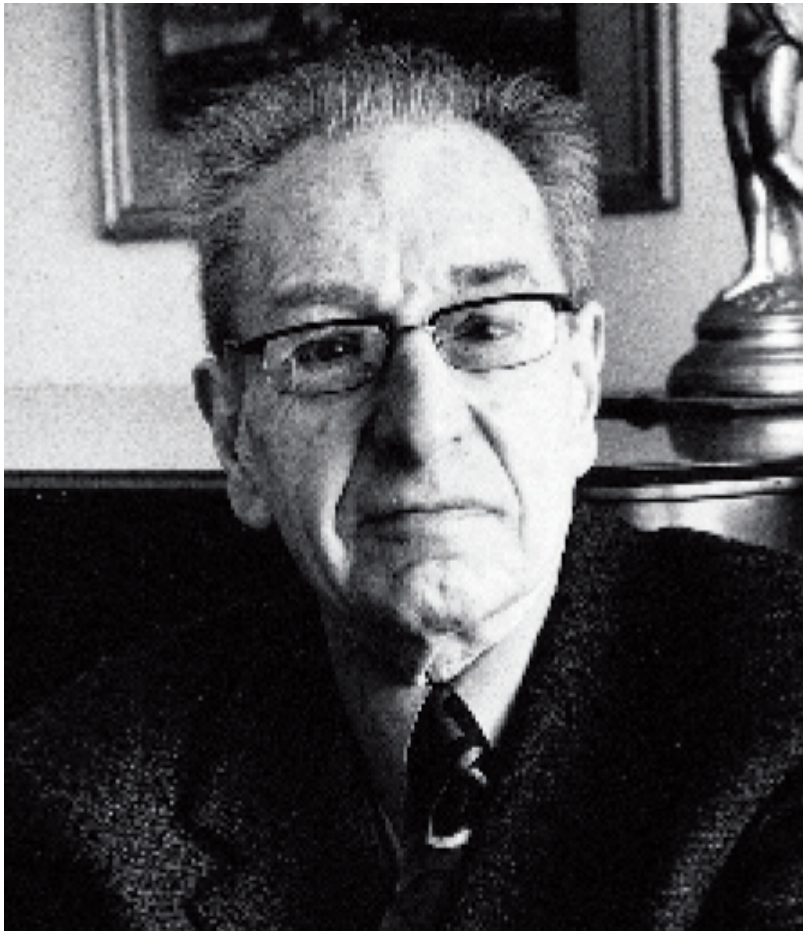
http://www.farhanmalik.com/hatto/main.html

Best overview:

Sept. 17, 2007 issue of the *New Yorker*

http://www.newyorker.com/reporting/2007/09/17/070917fa_fact_singer

William Barrington-Coupe



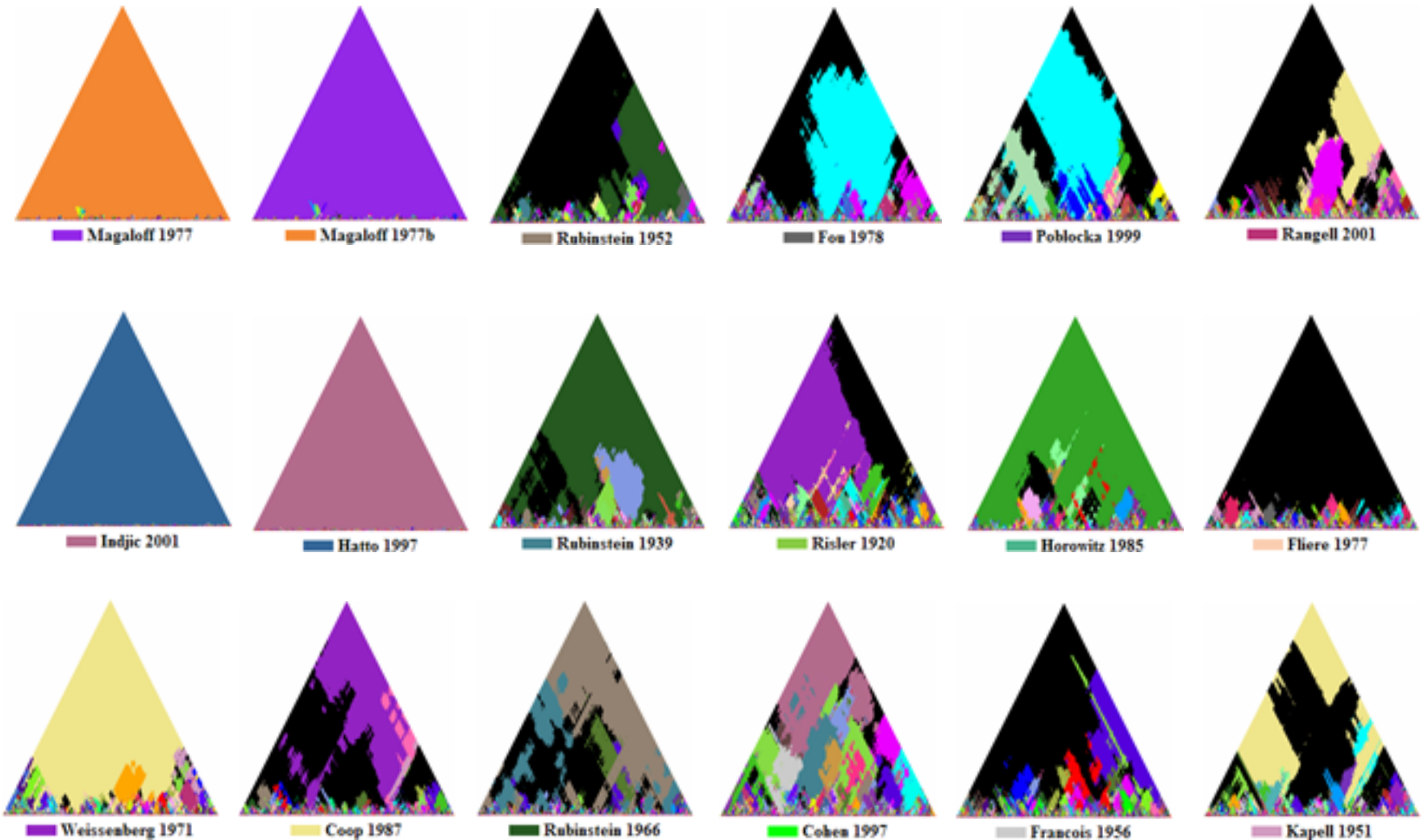
"Barry"

- Hatto's Husband
- In recording industry since 1950's (Saga/Lyrique/Delta/Triumph labels)
- Concert Artist/Fidelio Recordings

http://concertartistrecordings.com

Mazurka 17/4 Correlation

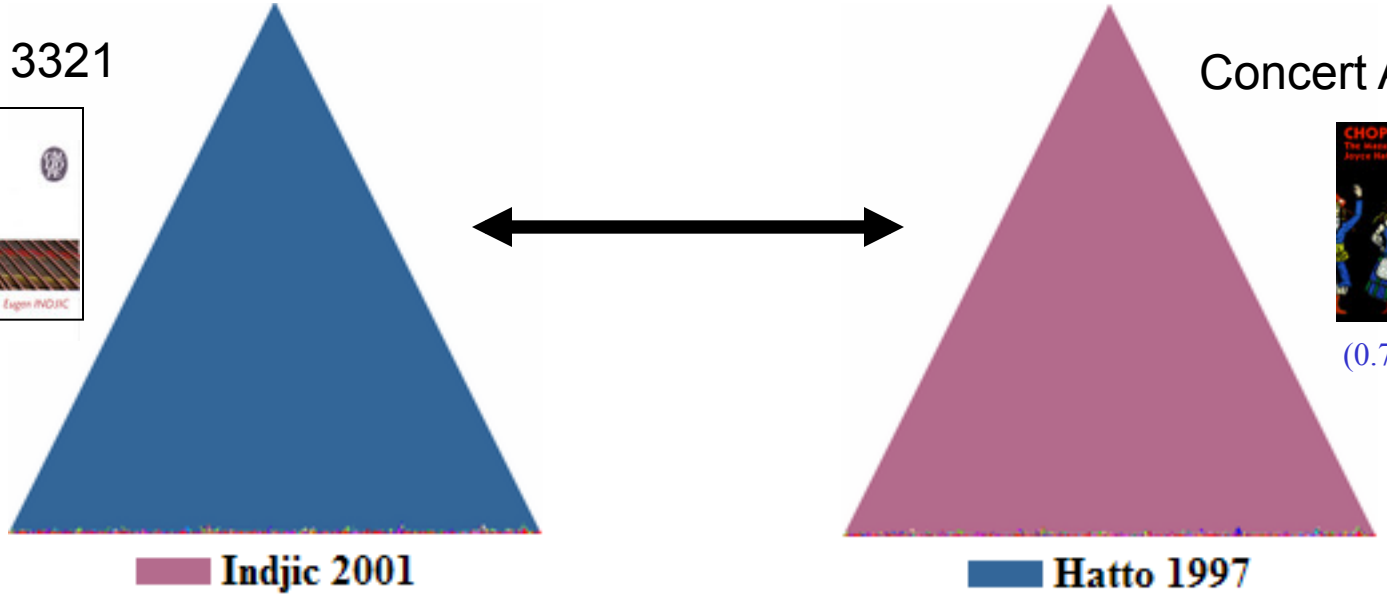
http://mazurka.org.uk/ana/pcor/mazurka17-4



Hatto / Indjic

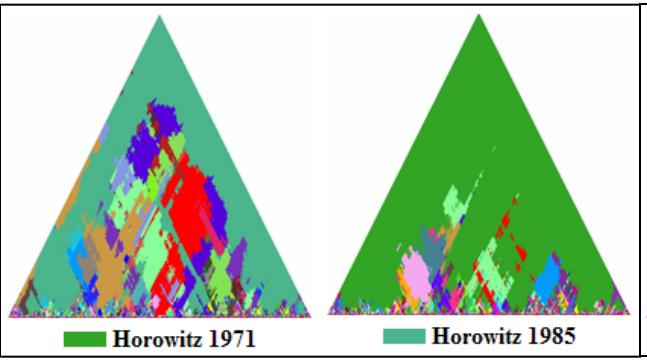
Two different performances from two different performers on two different record labels from two different countries…

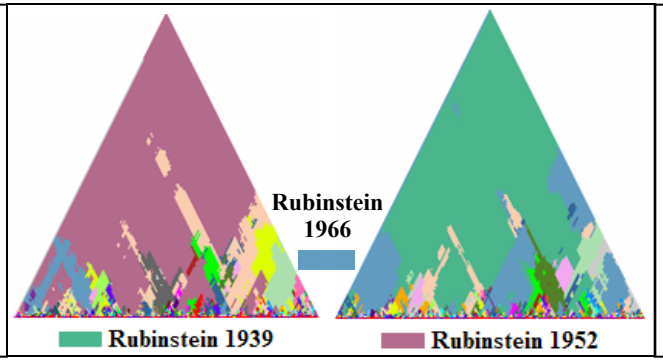
Calliope 3321

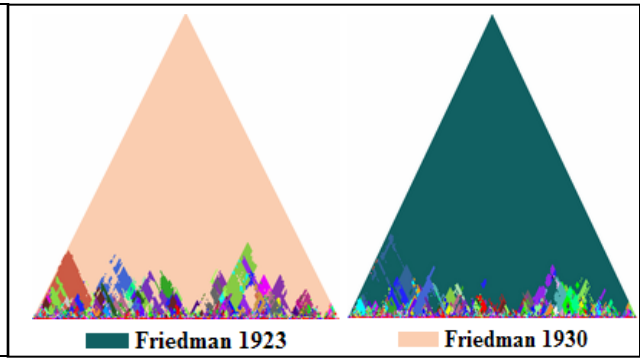


Concert Artist 20012

(0.7% slower)







Hatto Mazurka Cassette

- Hatto mazurka performances released on 3 Cassettes in 1993.
  (Fidelio FED4-TC-0116/8)

- Ernst Lumpe sent copy of cassettes to Christopher Howell (May 2007), and turns out they are also Indjic's 1988 performances.

- Slight differences between the CD / cassette releases, such as:

  Mazurka 7/2 in A minor:
  - 1988 Indjic: bars 1-16 not repeated
  - 1993 Hatto: bars 1-16 repeated
  - 2005 Hatto: bars 1-16 not repeated

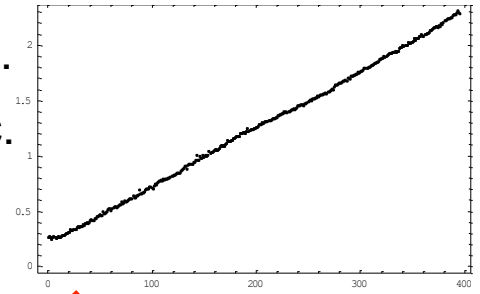
- Concert Artist mischief occurring since at least 1993, not 2002…

Beat-Event Timing Differences

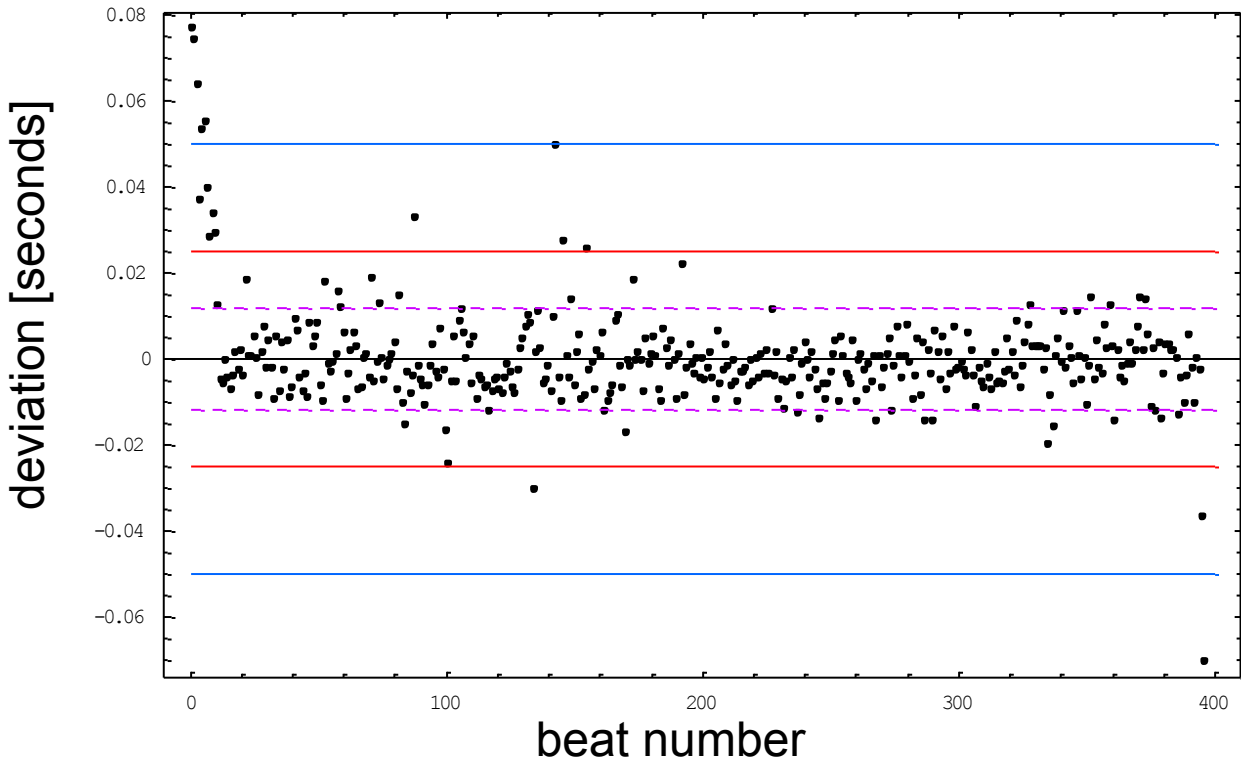
Hatto beat location times: 0.853, 1.475, 2.049, 2.647, 3.278, etc.

Indjic beat location times: 0.588, 1.208, 1.788, 2.408, 3.018, etc.

difference plot



Hatto / Indjic beat time deviations

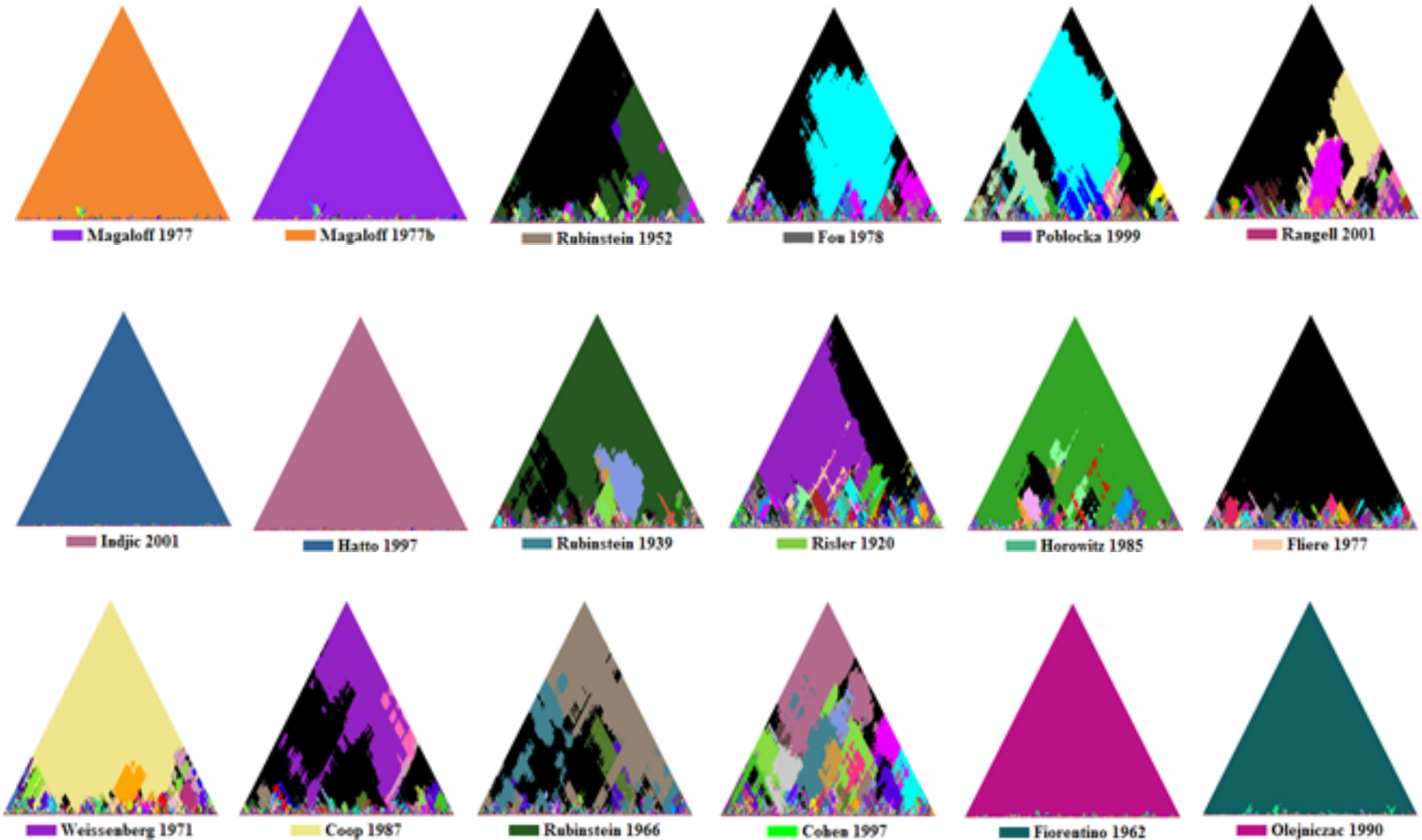


remove 0.7% timeshift

2. Fiorentino Fakes

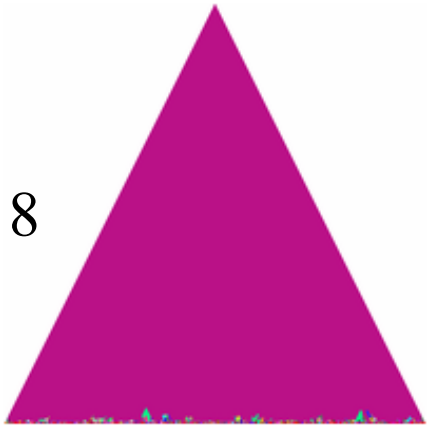
Mazurka 17/4 Correlations

http://mazurka.org.uk/ana/pcor/mazurka17-4



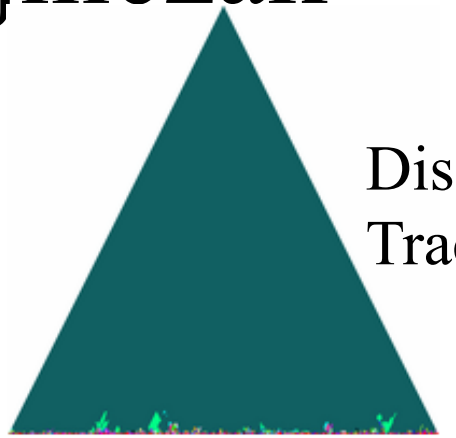
Fiorentino / Olejniczak

Track 8



Fiorentino 1962

Con. Artist CD 9200-2



Disc 2
Track 17

Olejniczac 1990

Naïve OP20002

Also mazurkas 7/1, 7/3, 7/4, 24/4, 30/4 match between two CDs…

"I faked my wife's recordings to please her"

AudioDB

- Developed by Michael Casey @ Goldsmiths College, University of London (now at Dartmouth College, Vermont).

- http://omras2.doc.gold.ac.uk/software/audiodb

QUERY=9065-12 WORK=24.4

9065-12 **2759** Fiorentino | 24.4 in B min
9100b-13 **651** Olejniczak | 24.4 in B min
9081-05 **56** Nezu | 24.4 in B min
9054-17 **44** Smith | 24.4 in B min
9070-25 **41** François | 24.4 in B min

Fiorentino Ghost Performers

Sergio Fiorentino

Con. Artist CACD 9200-2
(2003)

Mazurka 6/2
Mazurka 7/1
Mazurka 7/2
Mazurka 7/3
Mazurka 7/4
Mazurka 7/5
Mazurka 17/2
Mazurka 17/4
Mazurka 24/1
Mazurka 24/2
Mazurka 24/3
Mazurka 24/4
Mazurka 30/1
Mazurka 30/2
Mazurka 30/3
Mazurka 30/4
Mazurka 33/1
Mazurka 33/3
Mazurka 33/4
Mazurka 50/2
Mazurka 50/3
Mazurka 56/3
Mazurka 59/1
Mazurka 59/2
Mazurka 59/3
Mazurka 63/2

Janusz Olejniczak

Naïve/OPUS 111: OP20002 (1991)

Idil Biret

Naxos 8.550358 (1990)

Anna Malikova

Classical Records CR-053 (1999)

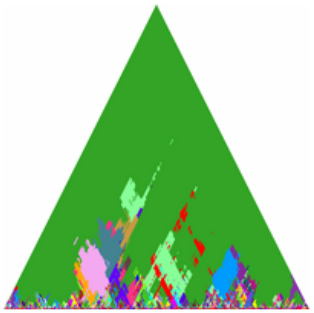
3. Questionable Cortot

Performance Features

- Visualizations not intended to find exact matches
- Designed for finding similar performances

Such as different performances by same pianist:

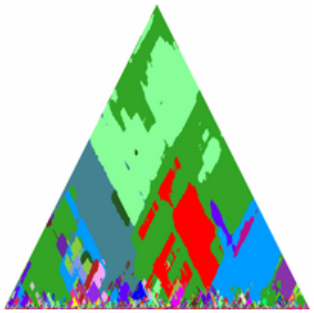
tempo



Horowitz 1985

78.4% Horowitz 1971
4.0% Nadelmann 1956
2.5% Kitain 1937
2.1% Rubinstein 1939
1.9% Biret 1990
1.4% Afanassiev 2001
0.86 Horowitz 1971

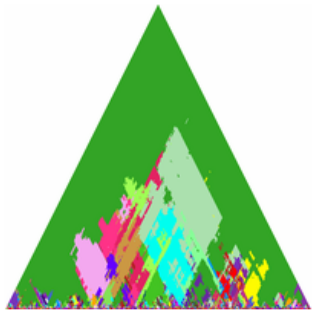
phrasing



Horowitz 1985

34.1% Horowitz 1971
21.1% Nadelmann 1956
11.2% Biret 1990
11.0% Rubinstein 1939
8.9% Afanassiev 2001
1.6% Beliavsky 2004
1.1% Ohlsson 1999
1.0% Risler 1920
0.59 Horowitz 1971

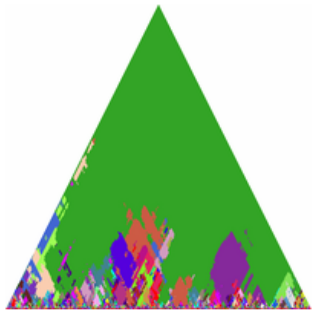
accentuation



Horowitz 1985

59.5% Horowitz 1971
12.2% Czerny 1949
4.3% Blet 2003
3.5% Kitain 1937
2.5% Uninsky 1971
2.4% Perahia 1994
2.3% Block 1995
2.0% Mohovich 1999
1.4% Brailowsky 1960
1.3% Nadelmann 1956
1.2% Magin 1975
0.84 Horowitz 1971
0.63 Czerny 1949
0.60 Kiepura 1999
0.59 Block 1995
0.55 Uninsky 1971

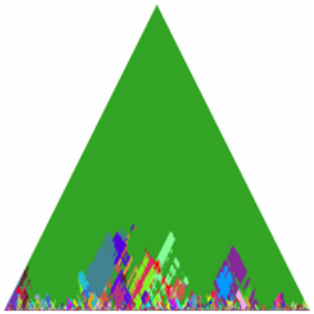
dynamics



Horowitz 1985

73.2% Horowitz 1971
4.1% Kiepura 1999
3.8% Czerny 1949b
2.0% Osinska 1989
1.5% Fliere 1977
1.5% Levy 1951
1.3% Rubinstein 1939
1.1% Uninsky 1971
1.1% Block 1995
1.0% Kapell 1951
0.83 Horowitz 1971

T+D



Horowitz 1985

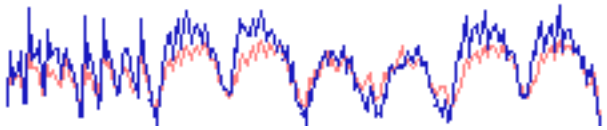
81.9% Horowitz 1971
2.8% Rubinstein 1939
1.8% Kiepura 1999
1.5% Nadelmann 1956
1.2% Smith 1975
0.90 Horowitz 1971

See: http://mazurka.org.uk/ana/pcor-perf

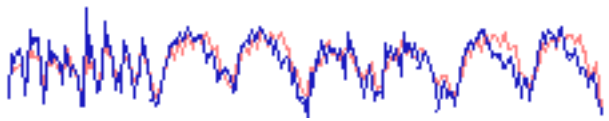
Same Performer Identification

Mazurka	*Query*	*Target*	*T*	T_s	T_d	*D*	*TD*	
17/4	Cze49	Cze49b	1	1	1	1	1	*(live)*
17/4	Cze49b	Cze49	1	1	1	1	1	*(studio)*
63/3	Fri23	Fri30	1	1	1	1	1	
63/3	Fri30	Fri23	1	1	1	1	1	
17/4	Hor71	Hor85	1	1	1	1	1	
17/4	Hor85	Hor71	1	1	1	1	1	
30/2	Fou78	Fou05	1	1	17	2	1	
30/2	Fou05	Fou78	1	1	6	2	1	
63/3	Uni32	Uni71	1	1	1	1	1	*(40 years)*
63/3	Uni71	Uni32	1	1	1	1	1	

Fou 1978 30/2 tempo curve



Fou 2005 30/2 tempo curve



Cortot Mazurkas

http://www.idilbiret.org/ENG/IBe13.htm

"A most important happening during this period [*c*1990] was the discovery in succession of some extraordinary Chopin recordings Biret had not known about by three great pianists; performances which greatly inspired her. First came the complete **51 Mazurkas by Alfred Cortot on three cassettes bought privately in the UK**. These were recorded by Cortot in the late 1950s and never released for unknown reasons."

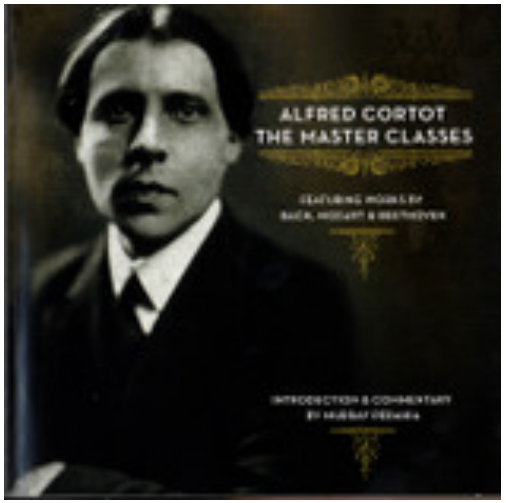
Concert Artist/Fidelio Recordings CE4-TC-7001

Idil Biret

Cortot Mazurka Performances

Concert Artists CD 91802
(2005)

Complete (51) mazurka performances



Sony Classical S3K89698
(2005)

Partial performances of 5 mazurkas:
24/1, 24/2, 24/4, 30/1, 30/2

Cortot Similarity Ranks

Mazurka	*Query*	*Target*	*T*	T_s	T_d	*D*	*TD*
17/4	Cze49	Cze49b	1	1	1	1	1
17/4	Cze49b	Cze49	1	1	1	1	1
63/3	Fri23	Fri30	1	1	1	1	1
63/3	Fri30	Fri23	1	1	1	1	1
17/4	Hor71	Hor85	1	1	1	1	1
17/4	Hor85	Hor71	1	1	1	1	1
30/2	Fou78	Fou05	1	1	17	2	1
30/2	Fou05	Fou78	1	1	6	2	1
63/3	Uni32	Uni71	1	1	1	1	1
63/3	Uni71	Uni32	1	1	1	1	1
30/2	CorCA	CorMC	31	26	32	33	35
30/2	CorMC	CorCA	33	24	35	32	34

(36 performances of mazurka 30/2 used in comparison)

Summary

Concert Artist Hatto recordings at least 80% fakes starting by 1993.

Concert Artist Fiorentino mazurka recordings -- All CA issues of Fiorentino after 1998 are now suspect.

Lots of smoke surrounding Concert Artist's Cortot mazurka recordings – "real" performer not yet identified.