Computer-Automated Motivic Analysis of the Weimar Jazz Database

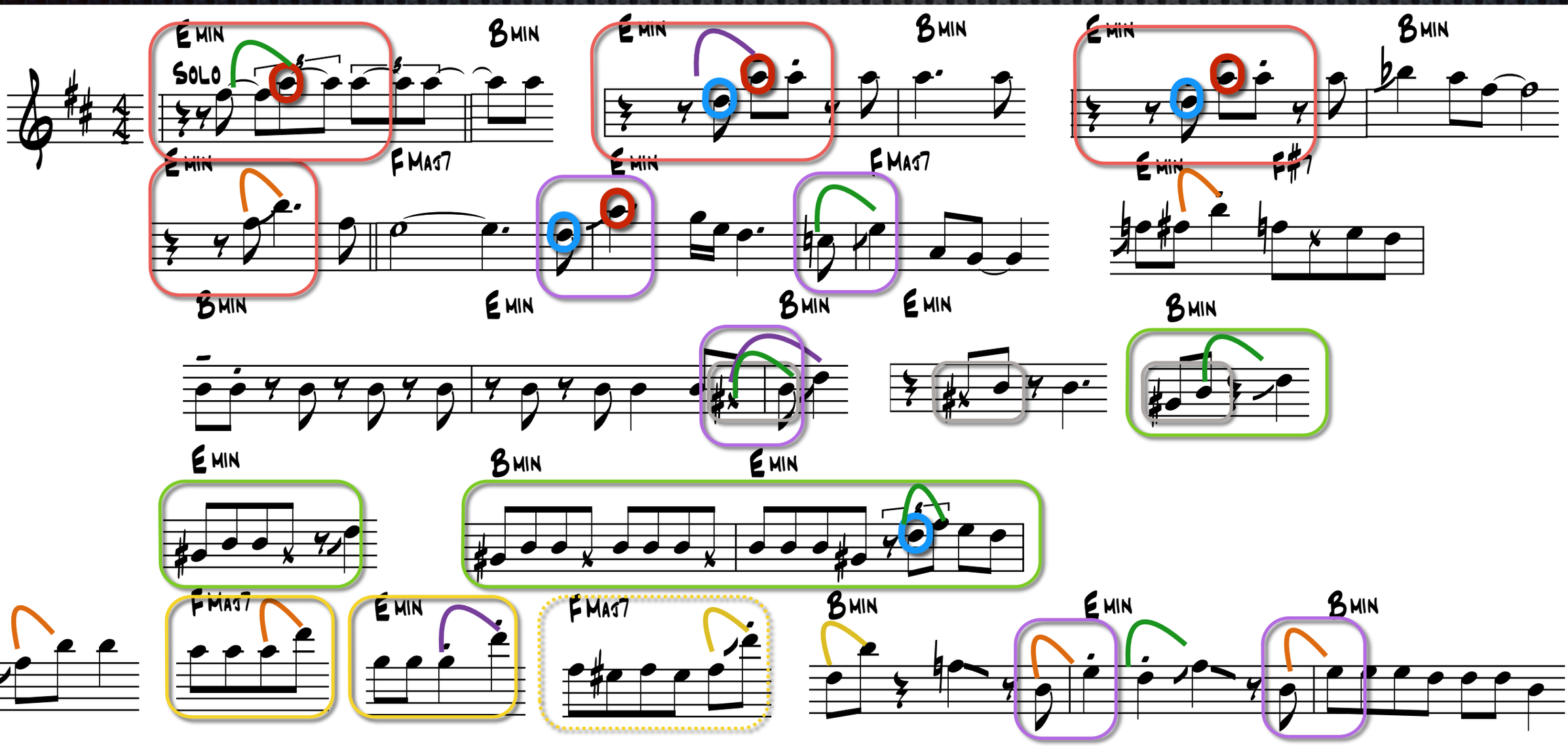
Through Exhaustive Pattern Mining

Olivier Lartillot
Aalborg University, Denmark

Objectives

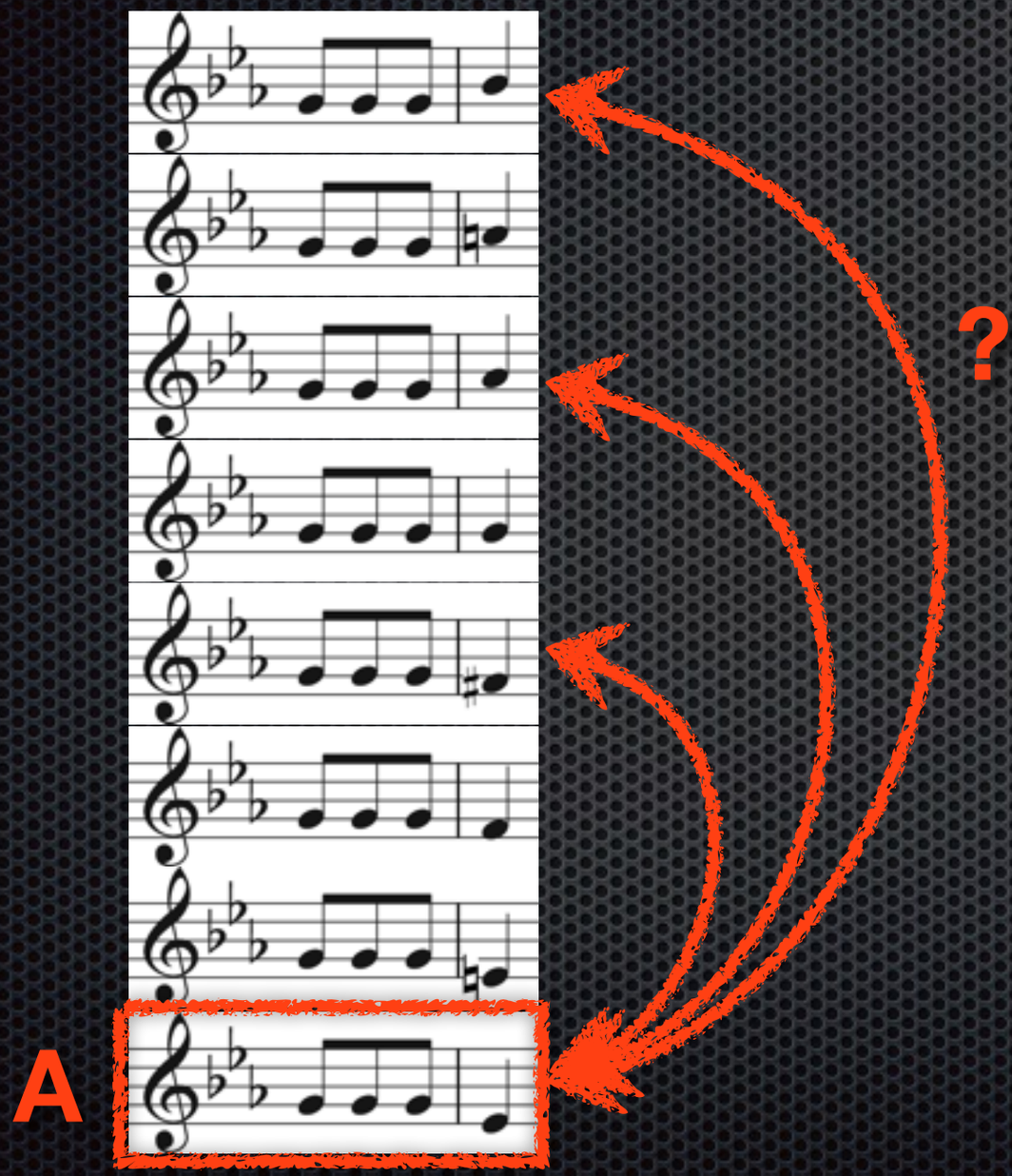
- exhaustive analysis
- synthetic representation
  - any combinaison of musical dimensions
  - ornamentation:
    - repetition hidden behind ornamentation
    - repetition produced by ornamentation

Multidimensional heterogeneous identification



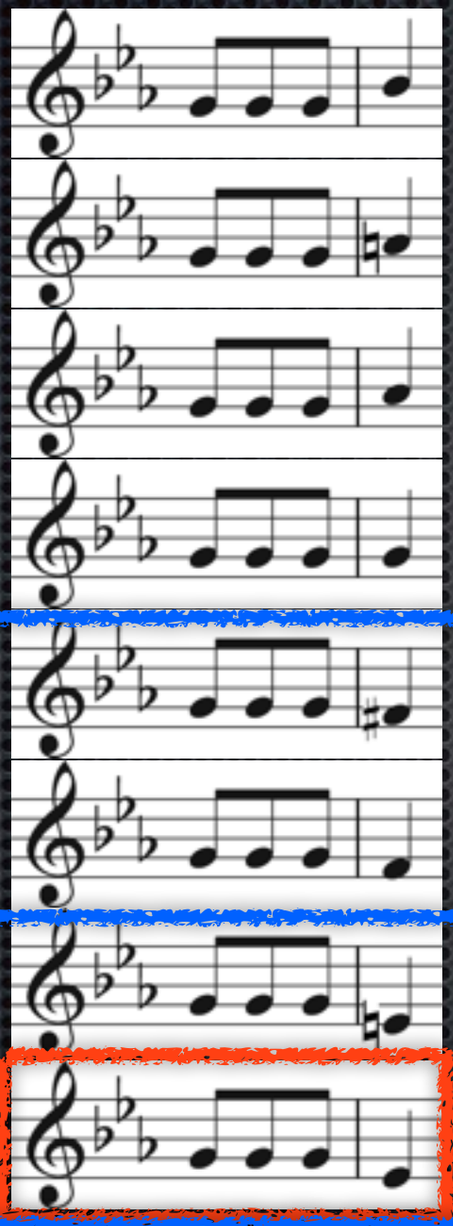
Kenny Garrett, *Brother Hubbard*

Motivic analysis
How to identify?



Which of these motifs are "***similar***" to motif **A**?

Motivic analysis
How to identify?



+3 semitones

+2

+1

0

-1

-2

-3

A

-4 semitones

or how much?

no definite answer

or maybe 3 semitones?

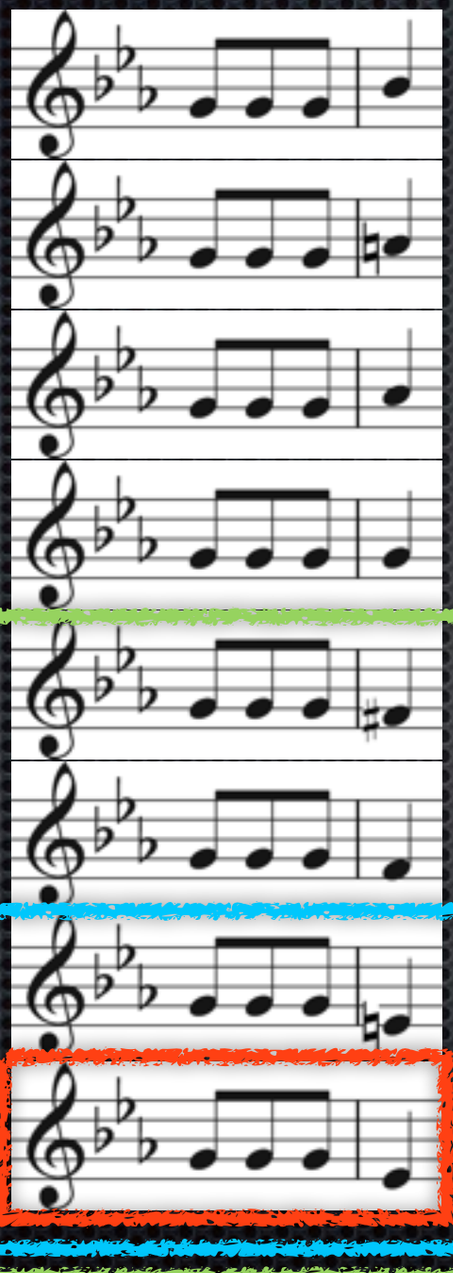
similar if just 1 semitone difference?

fuzzy clusters cannot be clearly described

Motivic analysis
How to identify?

identification based on clear categories

same rhythm



+ 3rd m

+ 2nd M

+ 2nd m

unison

- 2nd m

- 2nd M

- 3rd m

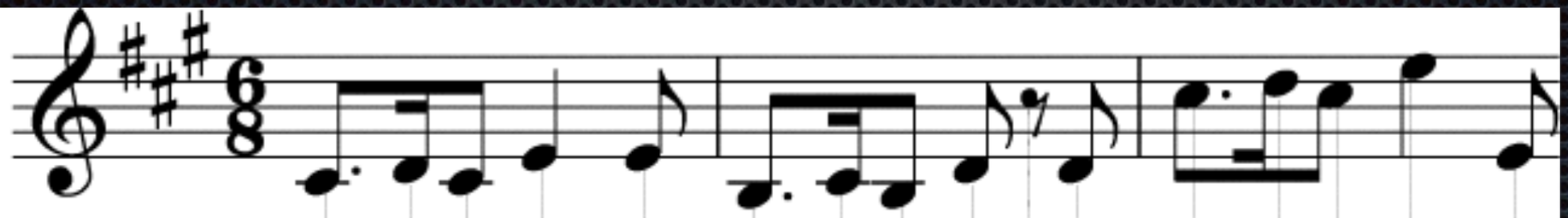
- 3rd M

A

- 3rd

- (decreasing gross contour)

Musical Dimensions



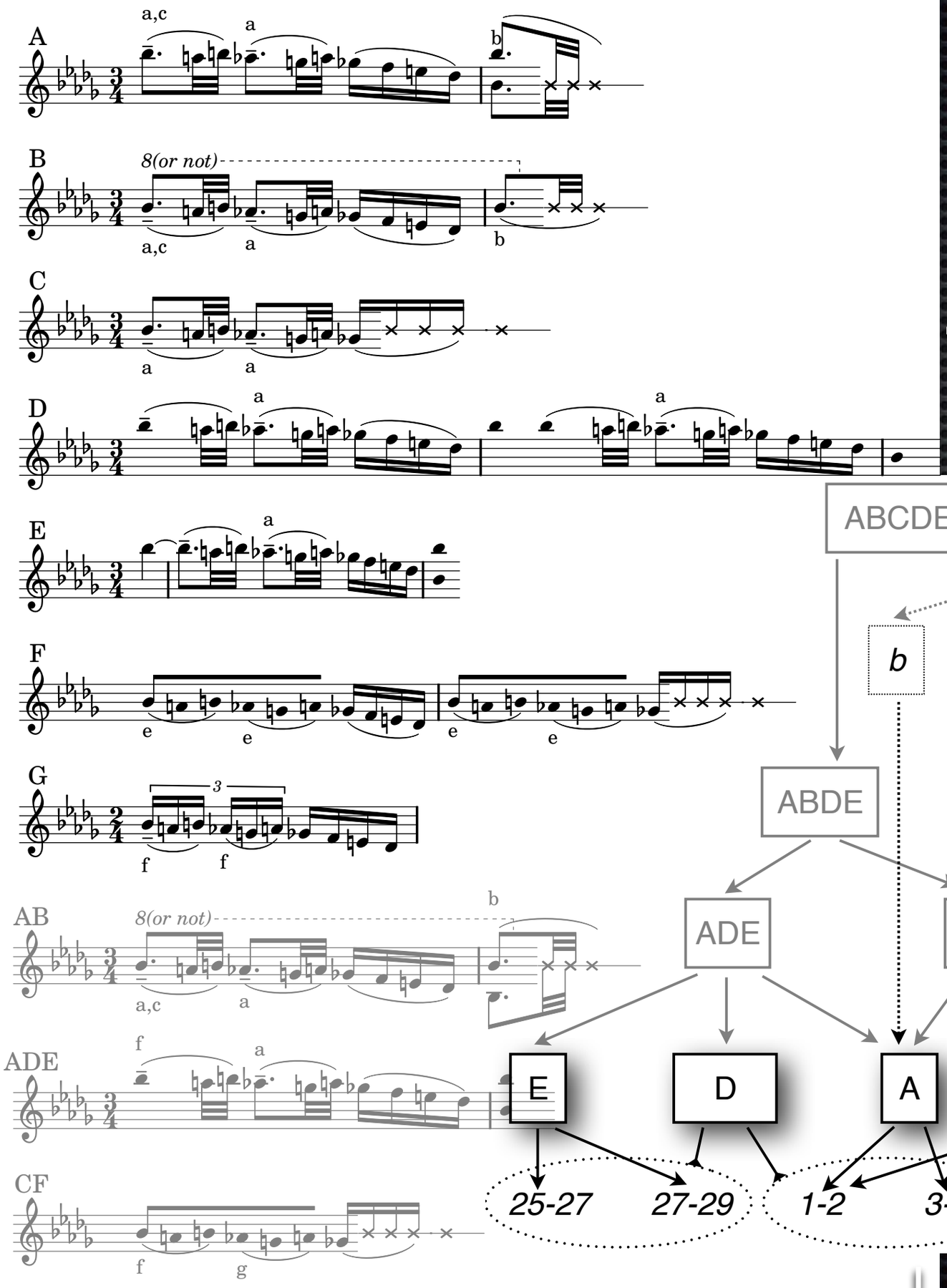
theoretical pitch	C#	D	C#	E		E		B	C#	B		D		D		C#	D	C#	E		E		
octave	0	0	0	0		0		0	0	0		0		0		1	1	1	1		0		
absolute diatonic pitch	2	3	2	4		4		1	2	1		3		3		9	10	9	11		4		
diatonic interval (*diat*)		+1	-1	+2		0	-3		+1	-1		+2		0			+1	-1	+2		-7		
diatonic pitch class (*diat-pc*)	2	3	2	4		4		1	2	1		3		3		2	3	2	4		4		
diatonic interval class		+1	-1	+2		0	-3		+1	-1		+2		0			+1	-1	+2		0		
absolute chromatic pitch	61	62	61	64		64		59	61	59		62		62		73	74	73	76		64		
chromatic interval (*chro*)		+1	-1	+3		0			+2	-2		+3		0			+1	-1	+3		-12		
chromatic pitch class	1	2	1	4		4		11		11		2		2		1	2	1	4		4		
chromatic interval class		+1	-1	+3		0			+2	-2		+3		0			+1	-1	+3		0		
gross contour (*cont*)		+	-	+		0	-		+	-		+		0			+	-	+		-		
pulsation (*puls*)	1	2.5	3	1		3		1	2.5	3		1	(2)	3		1	2.5	3	1		3		
inter-onset (*rhyt*)	3/2	1/2	1	2		1		3/2	1/2	1		2		1		3/2	1/2	1	2		1		

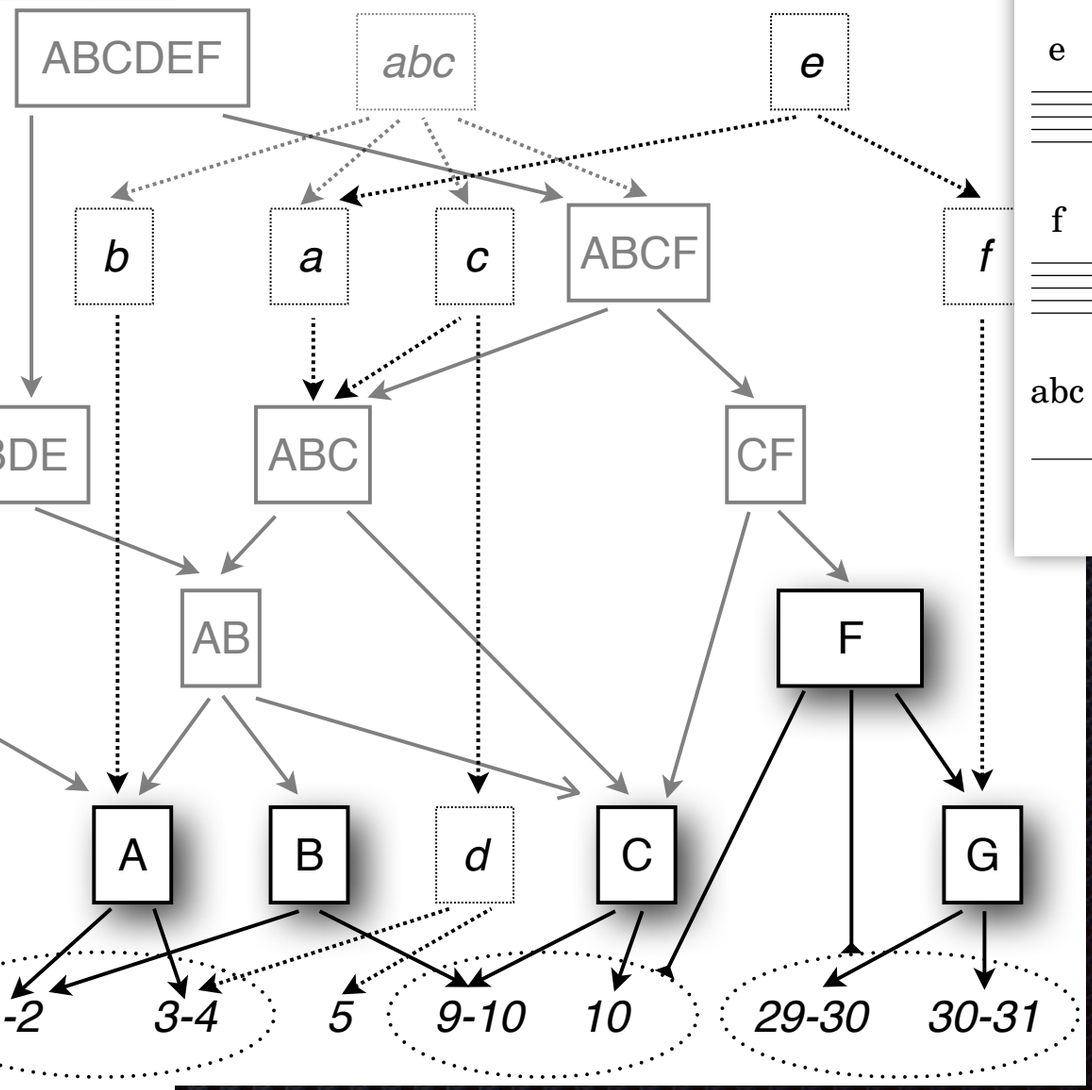
Syrinx, Debussy

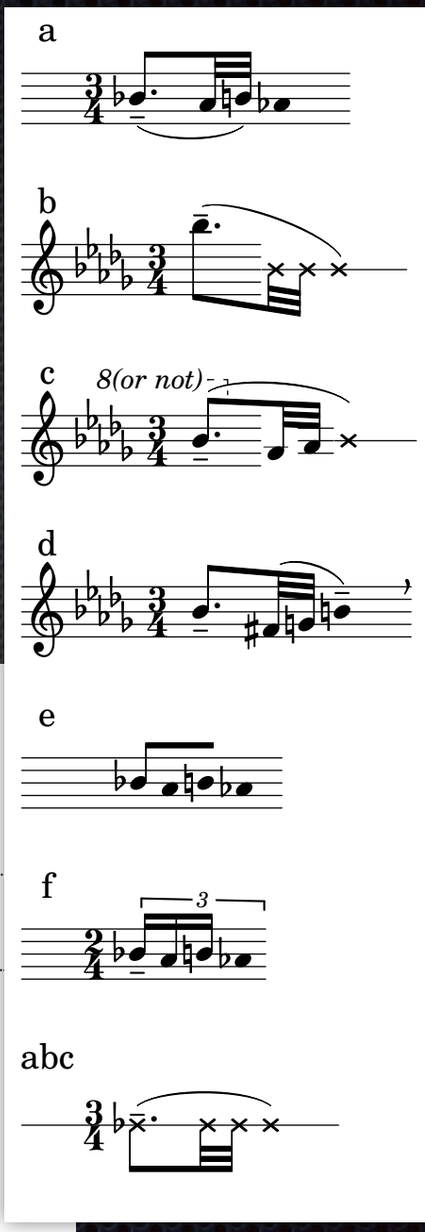
Lartillot, *JNMR*, DF4B, 2009

Syrinx, Debussy

Motivic Taxonomy

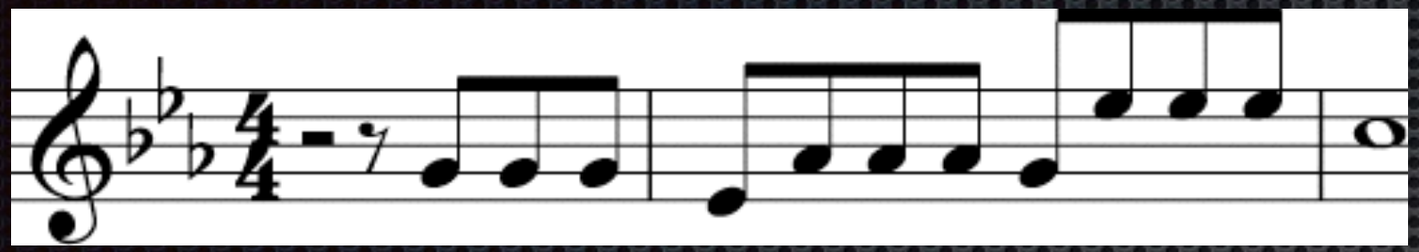




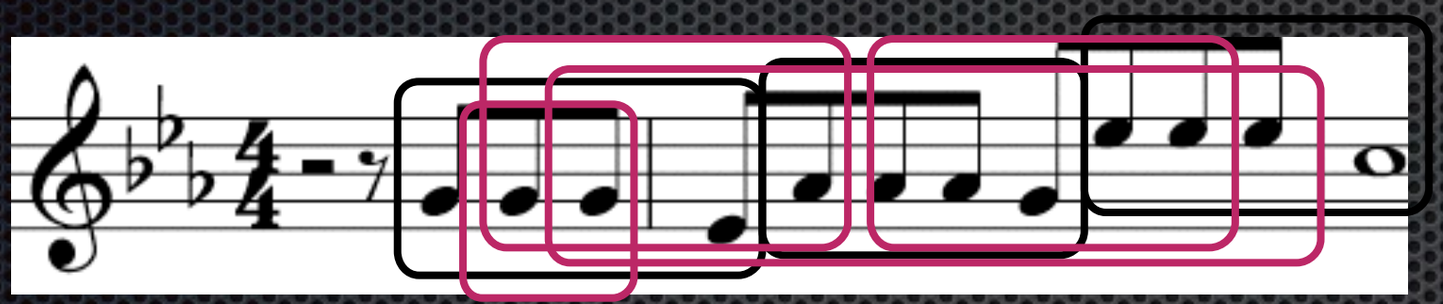


Lartillot, *JNMR*, DF4B, 2009

Structure Complexity



Pattern extraction



Pattern selection
(longest, frequent, ...)

- Large set of unrelevant structures during extraction phase
  - cannot be computed extensively
- Imperfections of the selection phase:
  - expected patterns accidentally deleted
  - insufficiently selective

➡ Improvement of the extraction process

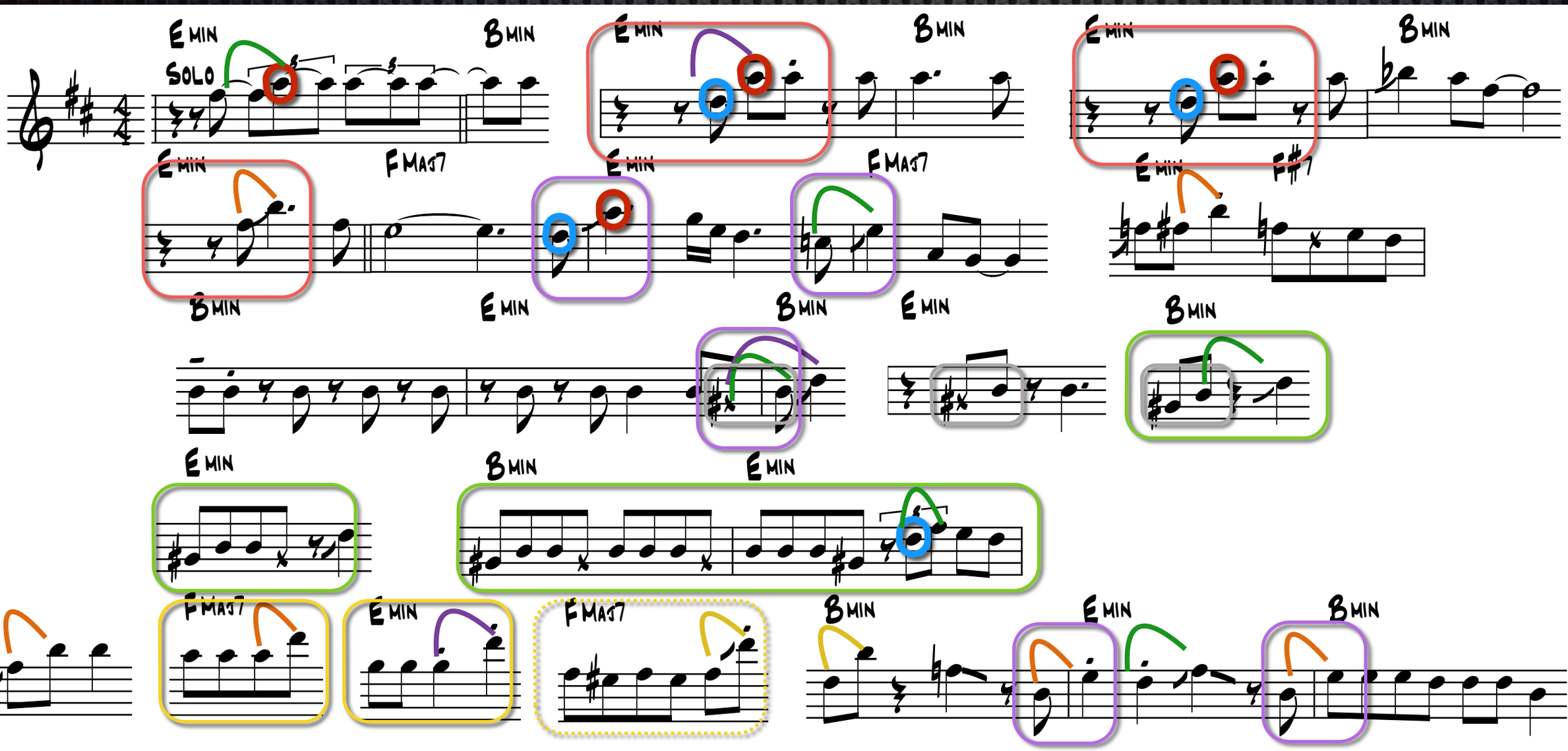
Cambouropoulos (2006), Conklin & Anagnostopoulou (2001), Rolland (1999)

Closed pattern

ABCDE CDE ABCDE CDE

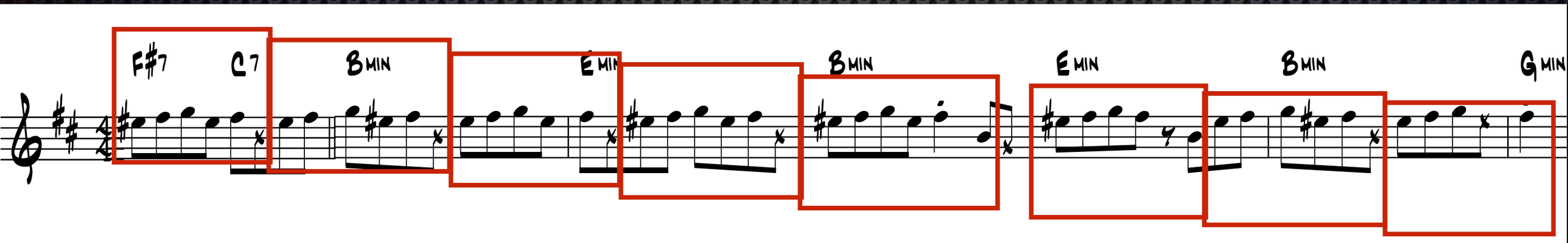
Complete and compact description of pattern repetition

Heterogeneous closed patterns



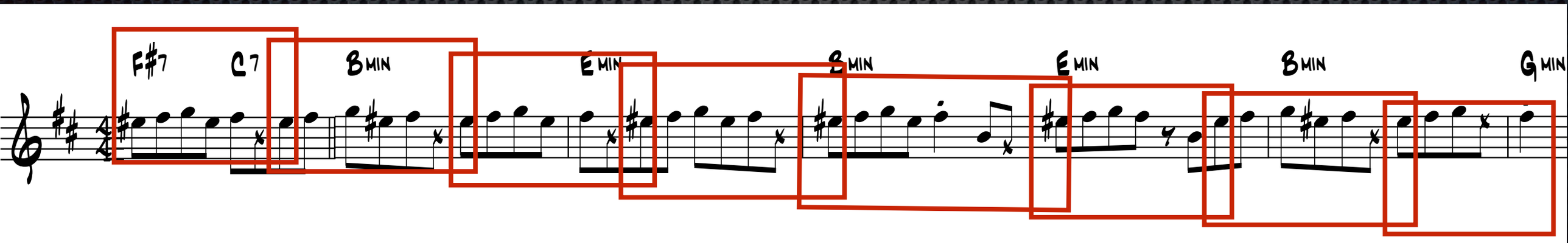
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



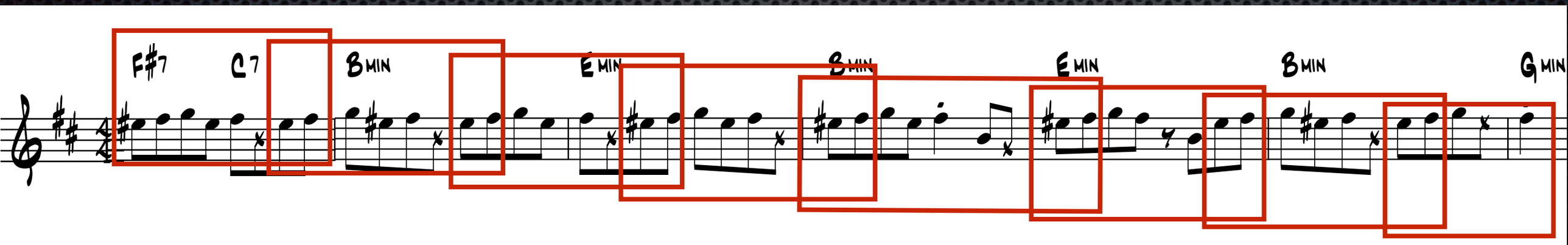
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



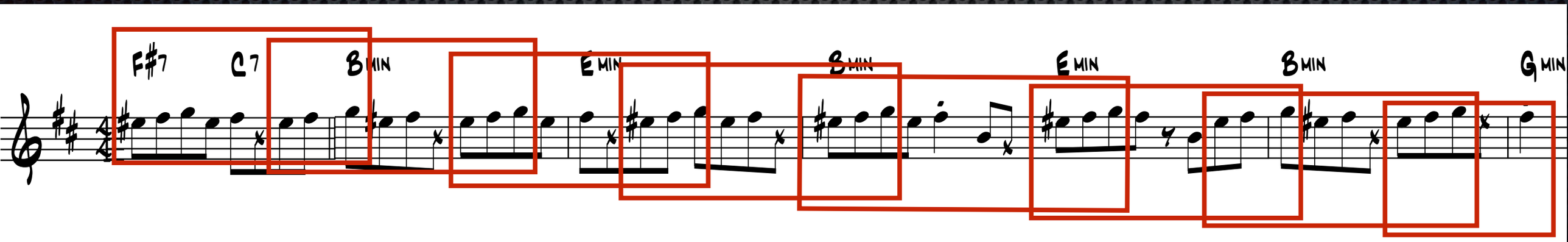
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



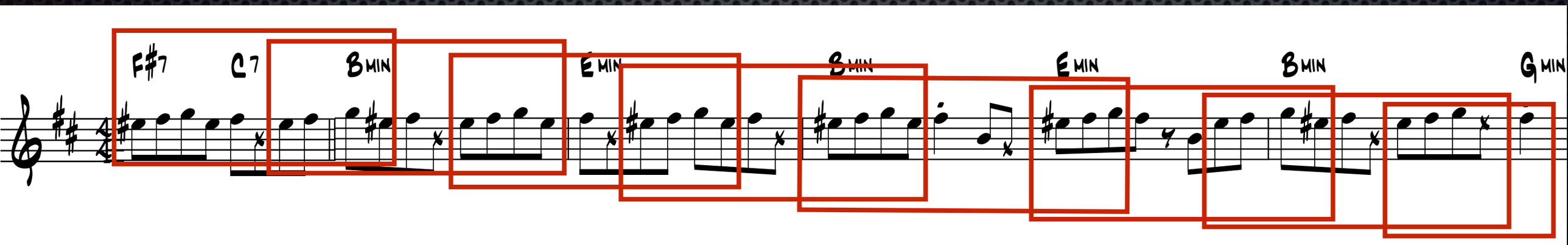
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



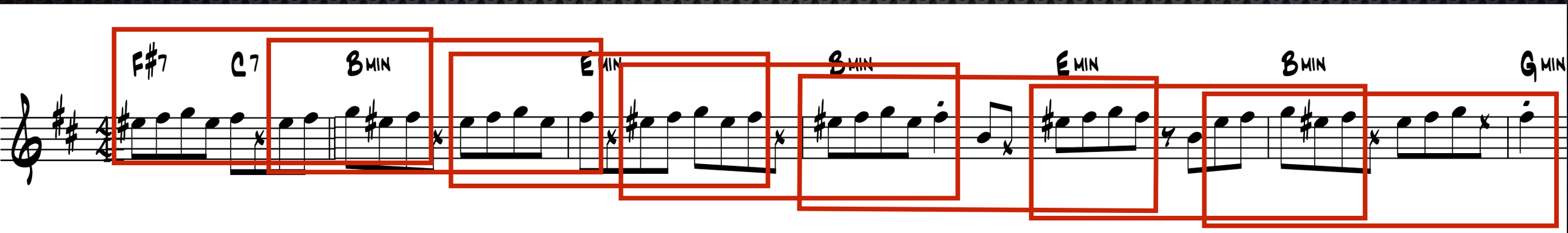
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



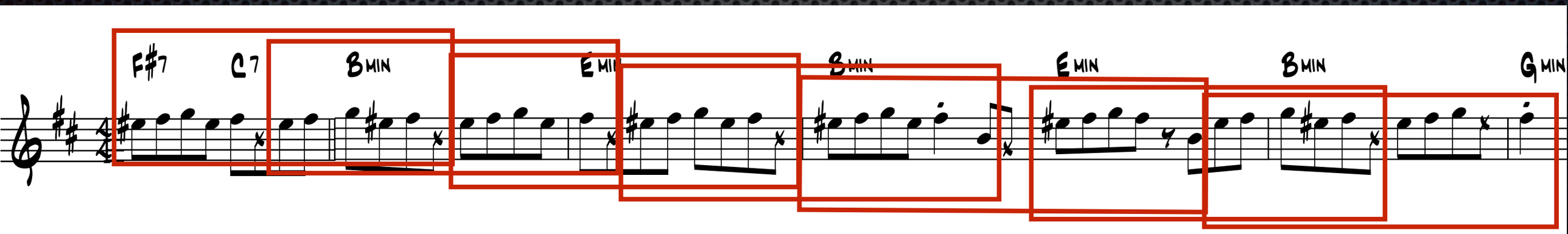
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



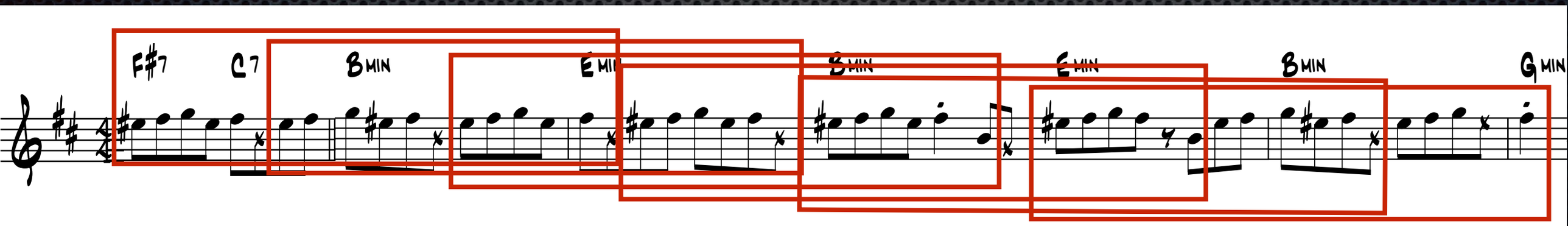
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



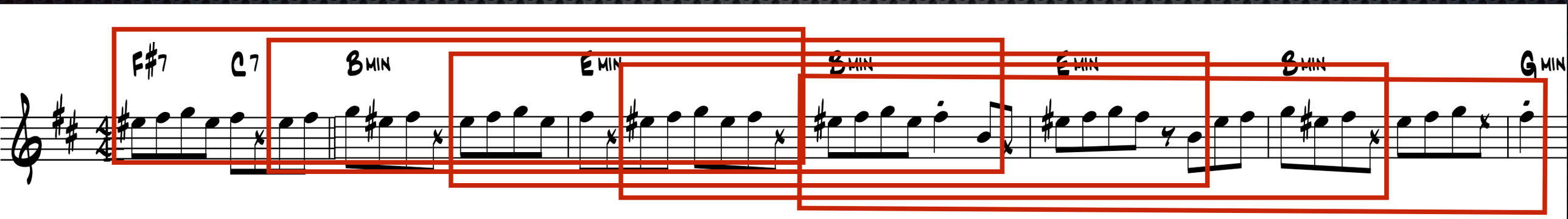
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



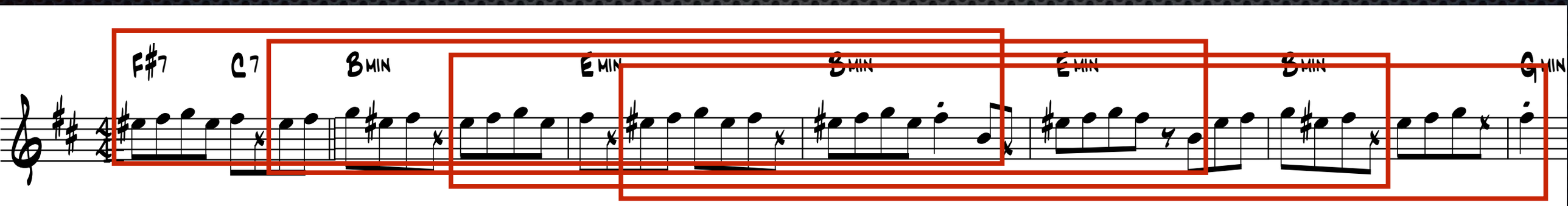
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



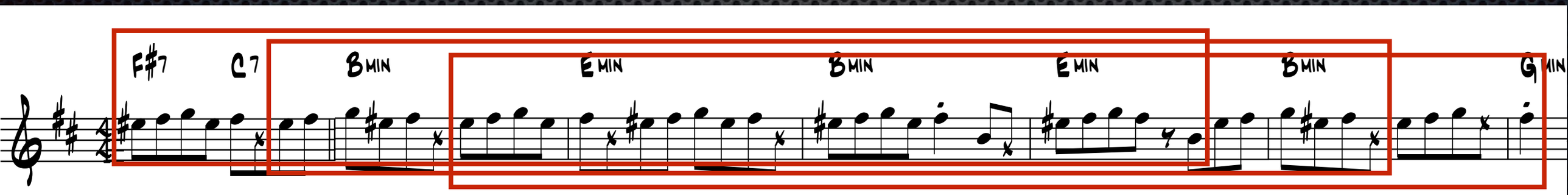
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



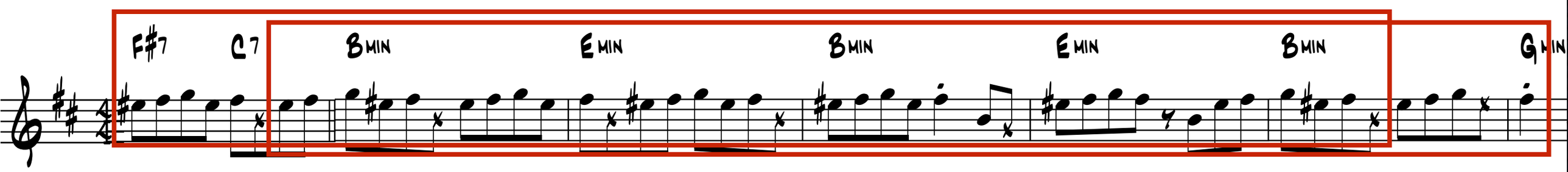
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



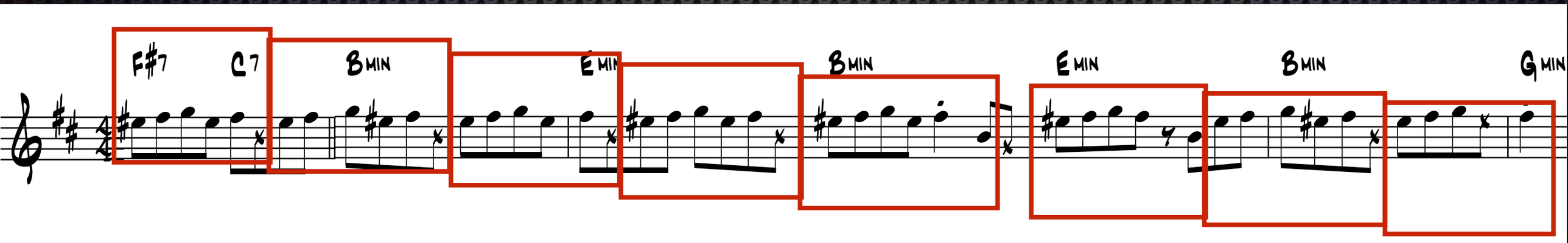
Kenny Garrett, *Brother Hubbard*

Pattern cyclicity



Kenny Garrett, *Brother Hubbard*

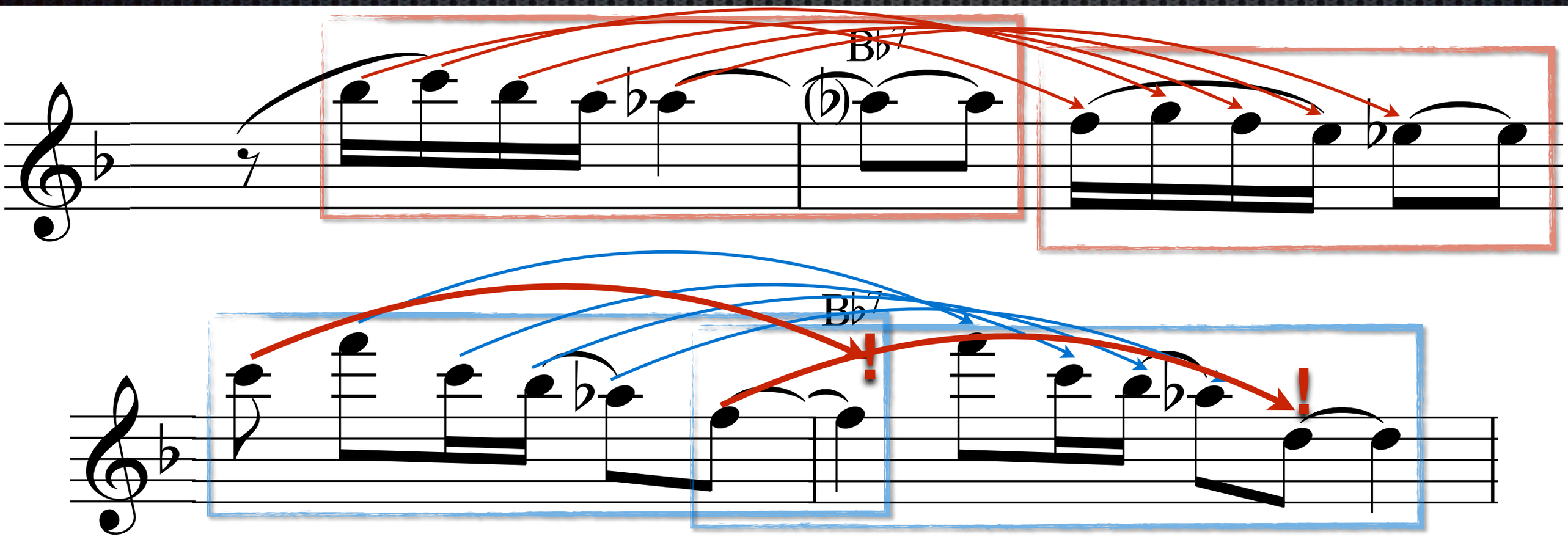
Pattern cyclicity



Kenny Garrett, *Brother Hubbard*

How to find repetitions?

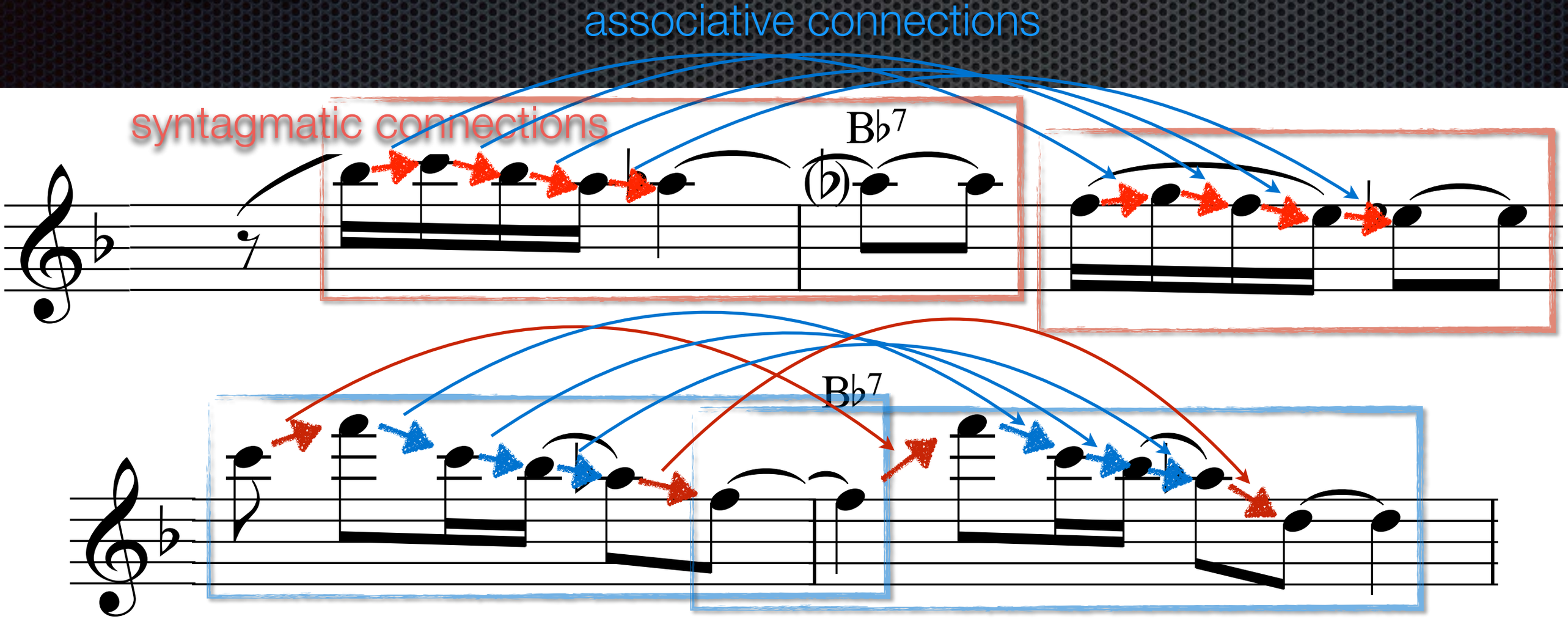
Maximal Translatable Patterns (Meredith)



Charlie Parker, *Billie's Bounce*

How to find repetitions?

Aggregation of intervals

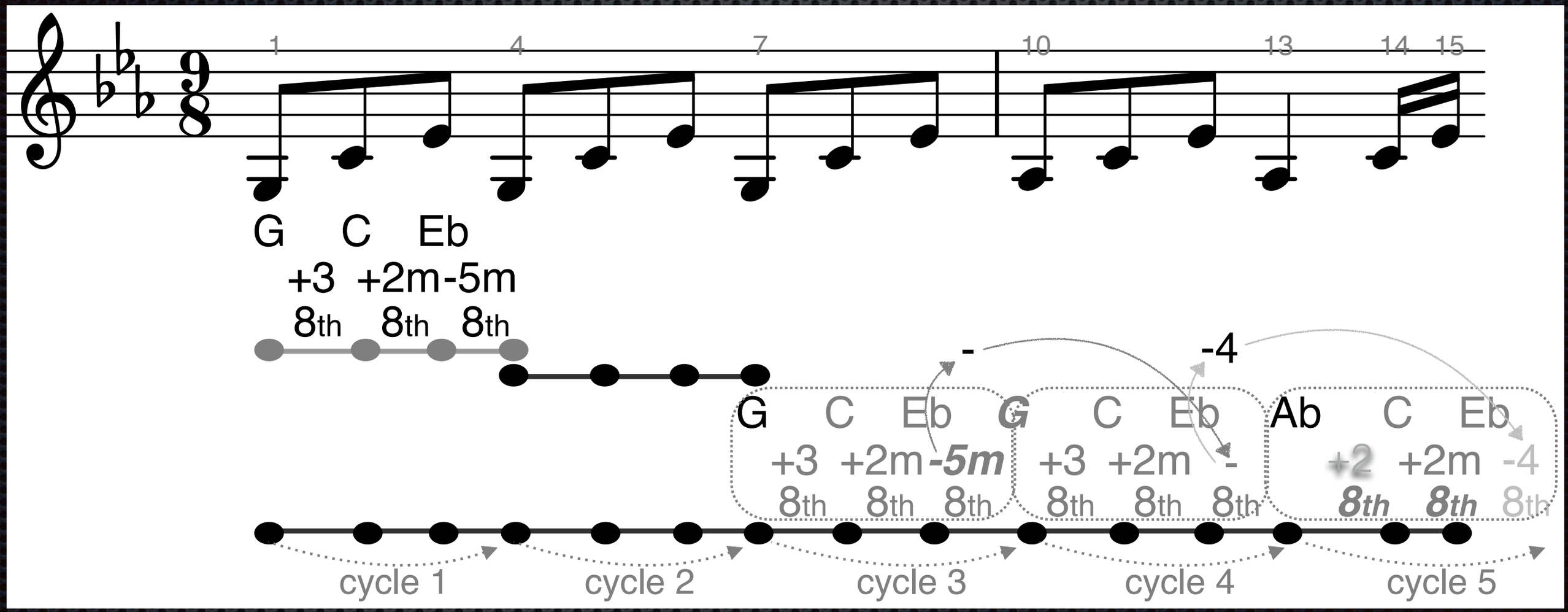


Charlie Parker, *Billie's Bounce*

Incremental approach

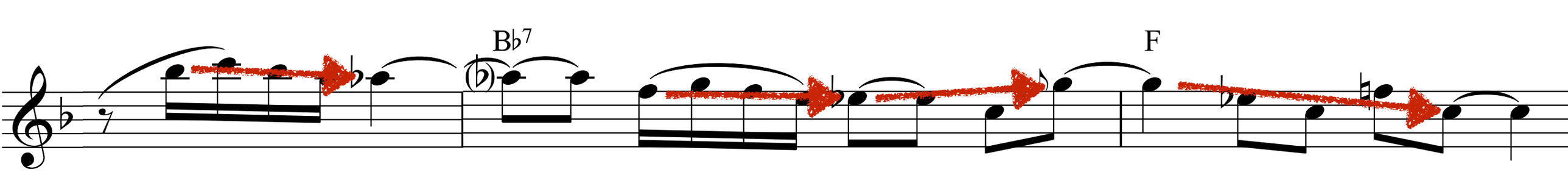
Lartillot, ISMIR 2014

Heterogeneous Pattern Cycle



Lartillot, ISMIR 2014

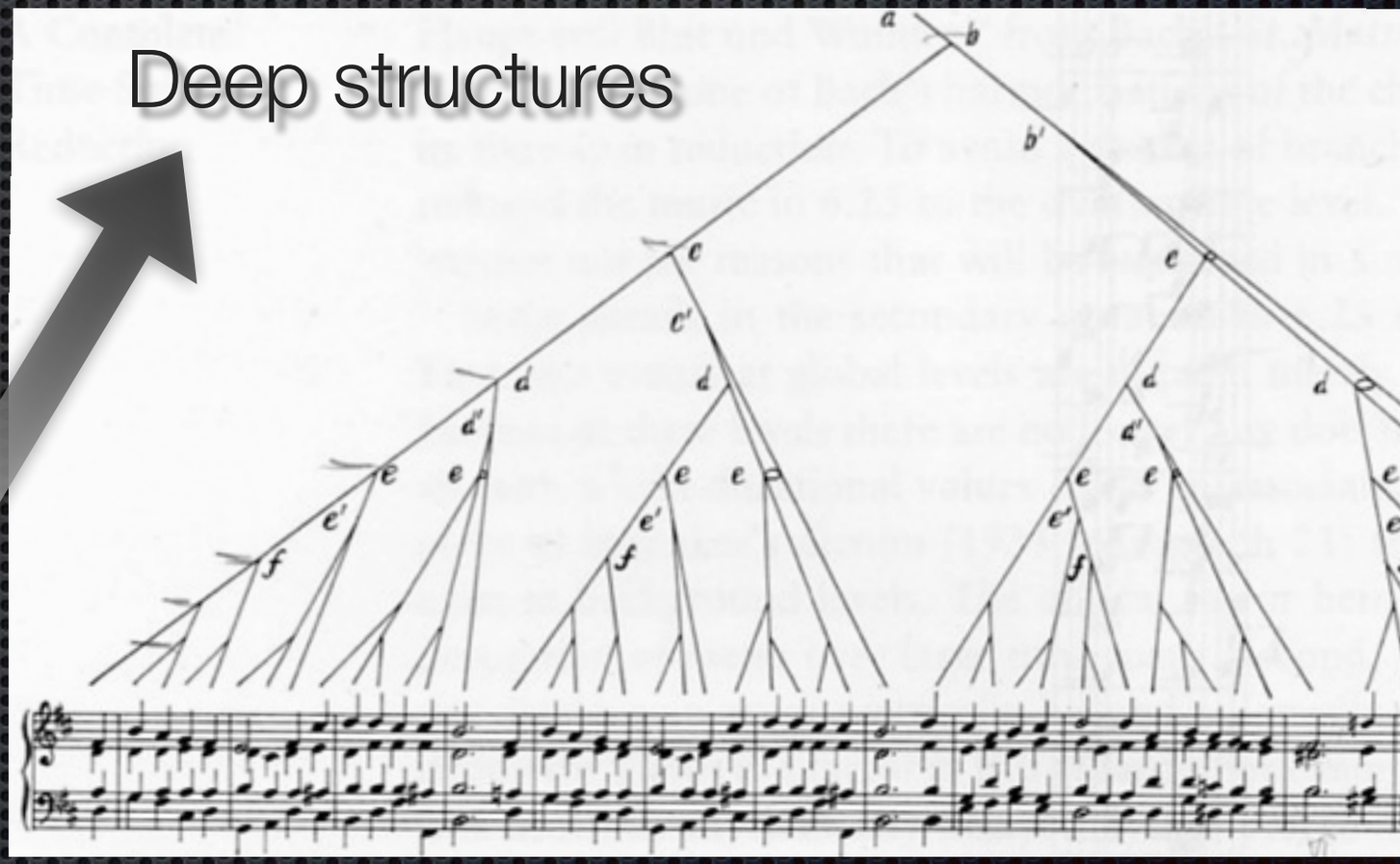
Ornamentation reduction



Charlie Parker, *Billie's Bounce*

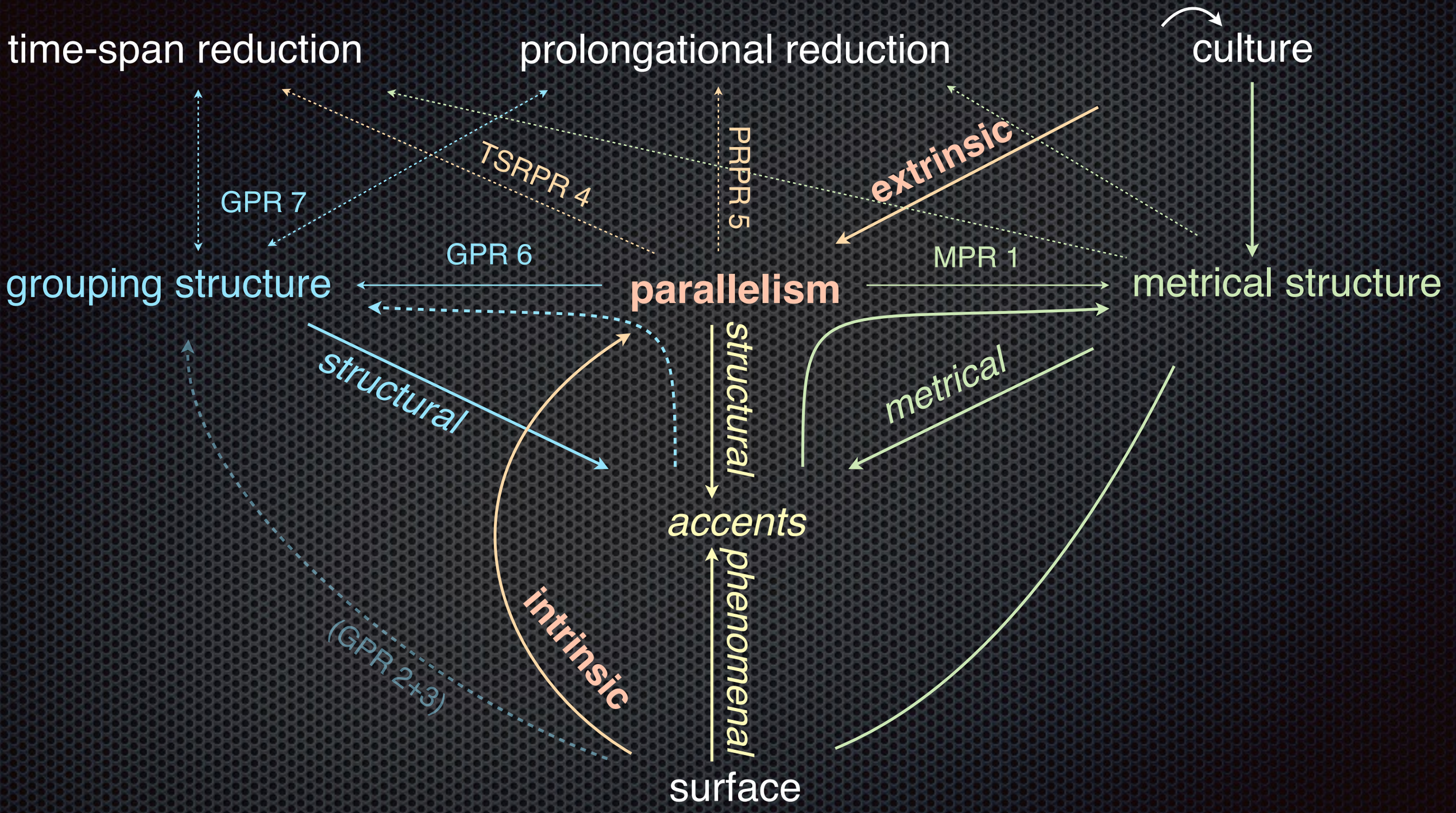
Ornamentation reduction

- Schenkerian analysis, Lerdahl & Jackendoff's GTTM
  - Reduction based on completely hierarchical structural analysis



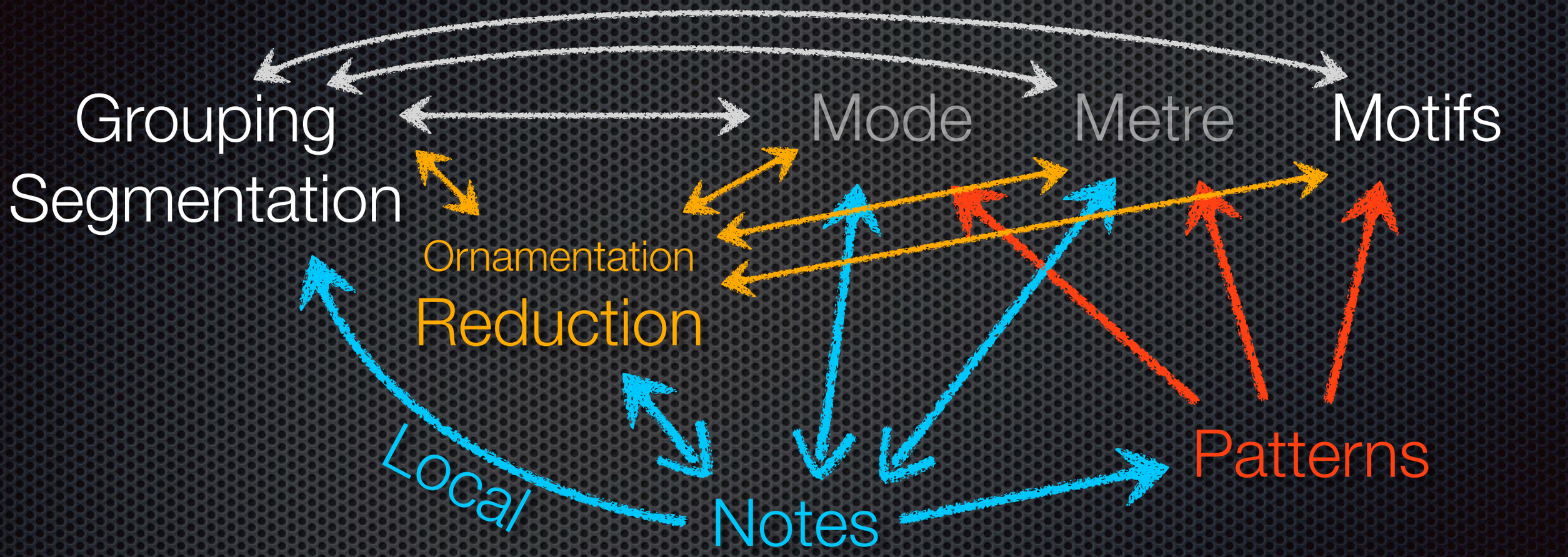
- Attempts of computational modelling (Marsden; Hirata, Hamanaka et al.)

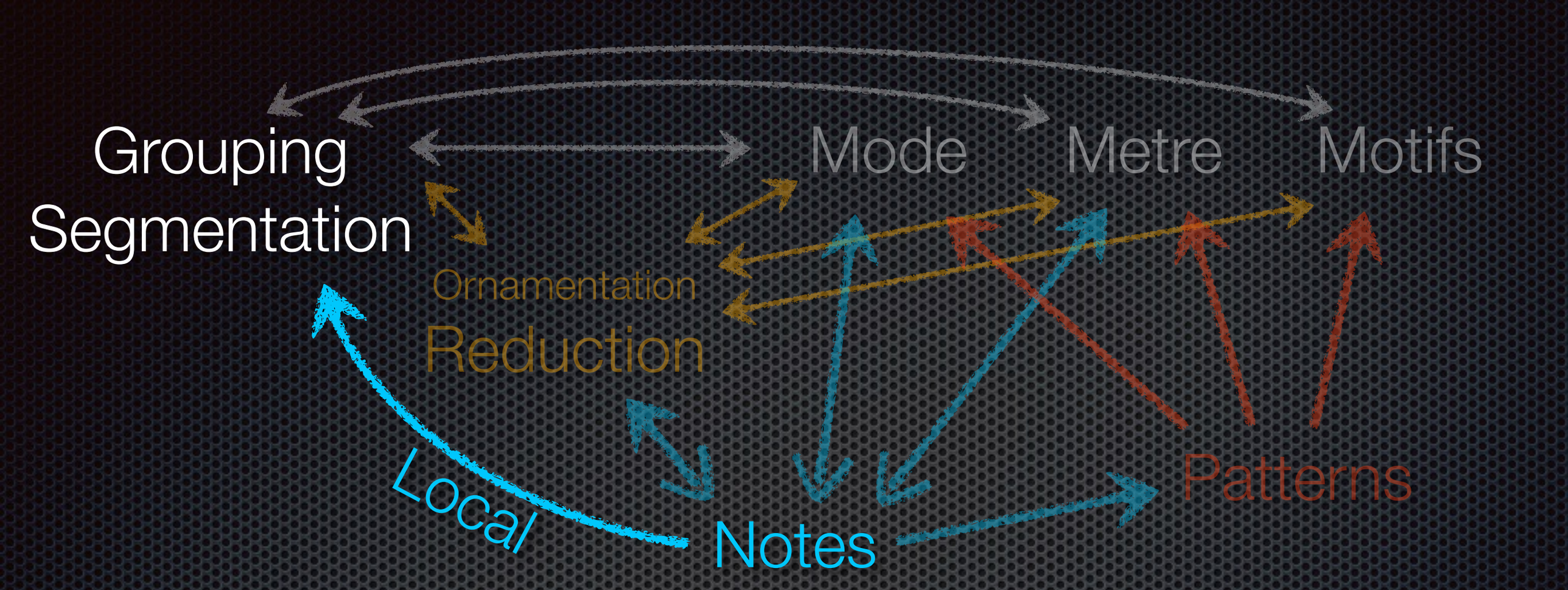
F. Lerdahl, R. Jackendoff, *A generative theory of tonal music*, MIT Press, 1983.



O. Lartillot, “Reflexions towards a generative theory of musical parallelism”, *Musicae Scientiae*, DF 5, 2010.

Music is a complex system





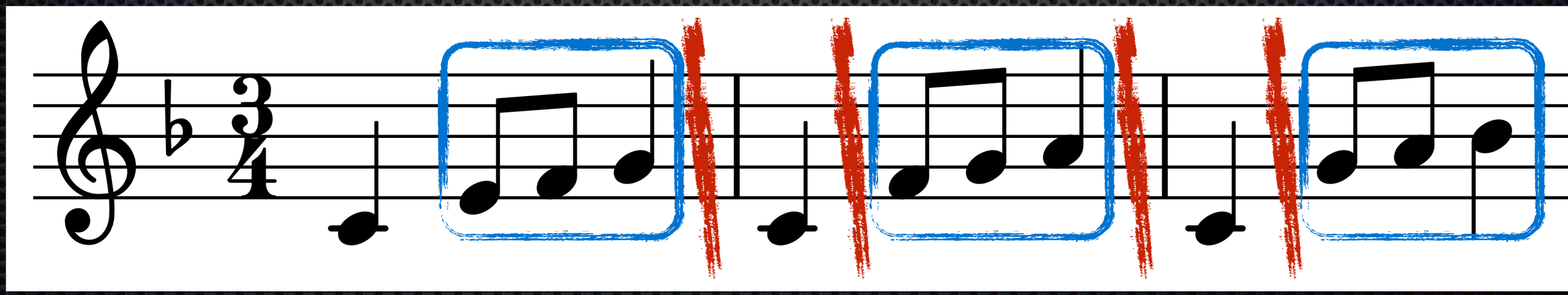
- Lerdahl & Jackendoff ***G****rouping* ***P****reference* ***R****ules* 2 & 3
  - **GPR2: based on temporal proximity**
  - GPR3: based on similarity/contrast

Local segmentation
GPR2: temporal proximity

Tenney & Polansky (1980) Cambouropoulos (2006)

Local ~~segmentation~~ grouping

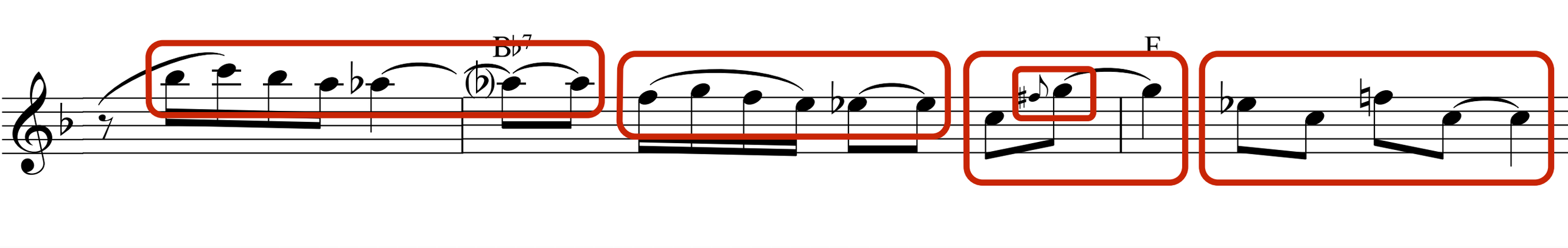
GPR2: temporal proximity



Tenney & Polansky (1980) Cambouropoulos (2006)

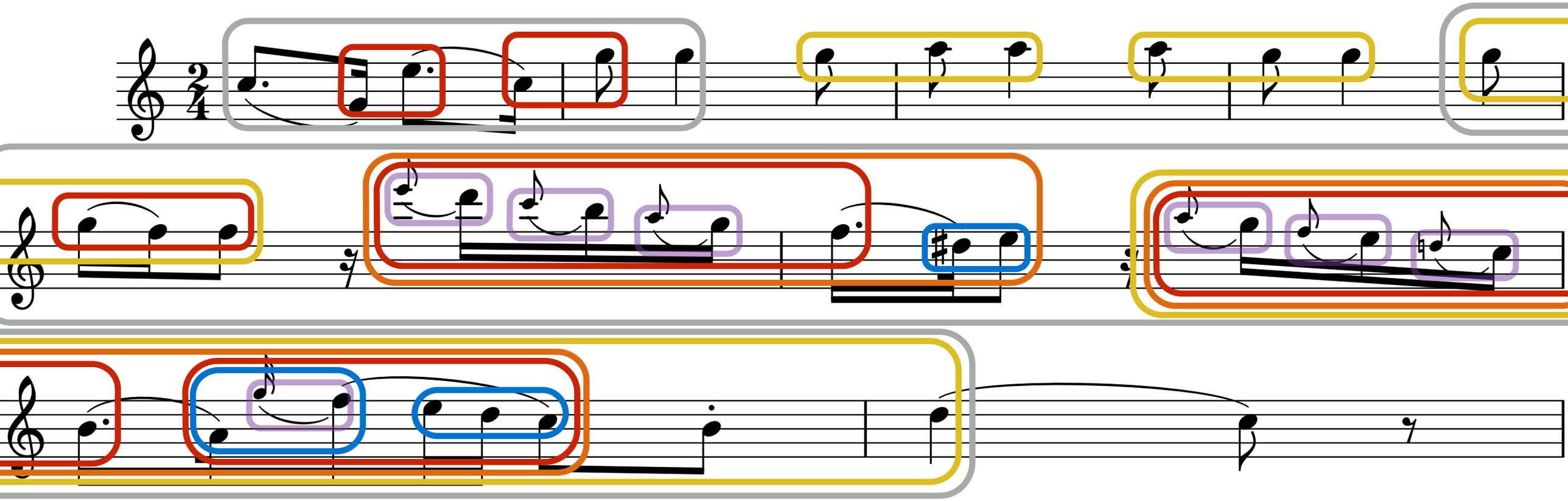
Lartillot (ICMPC 2014)

Local grouping
GPR2: temporal proximity

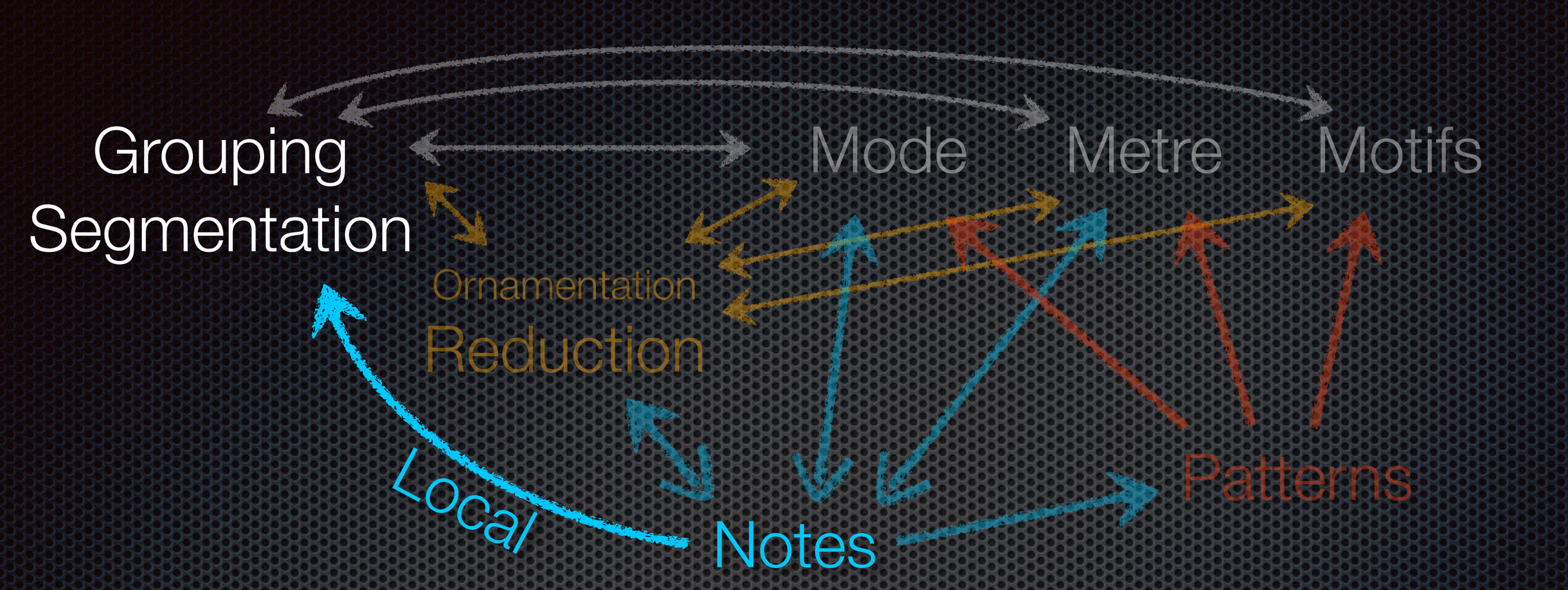


Charlie Parker, *Billie's Bounce*

Local grouping
GPR2: temporal proximity



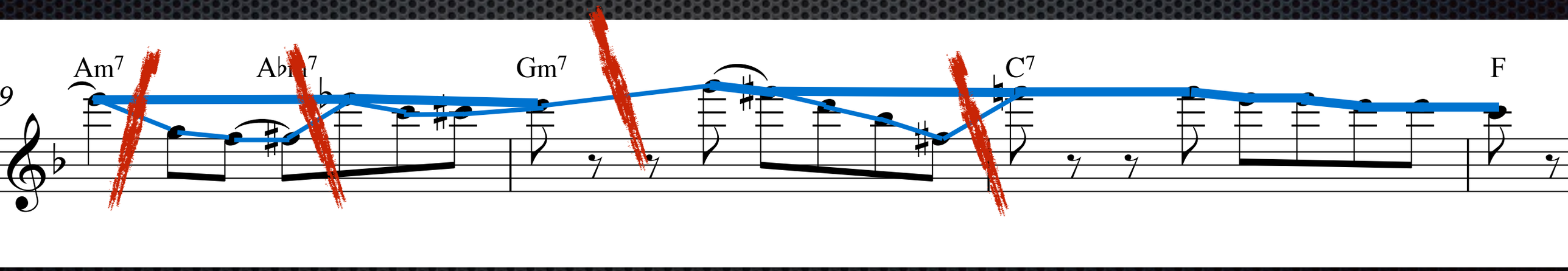
Mozart, Variation XI on "*Ah, vous dirai-je maman*", K.265/300e



- Lerdahl & Jackendoff ***G****rouping* ***P****reference* ***R****ules* 2 & 3
  - GPR2: based on temporal proximity
  - **GPR3: based on similarity/contrast**

Local grouping
GPR3: contrast / similarity

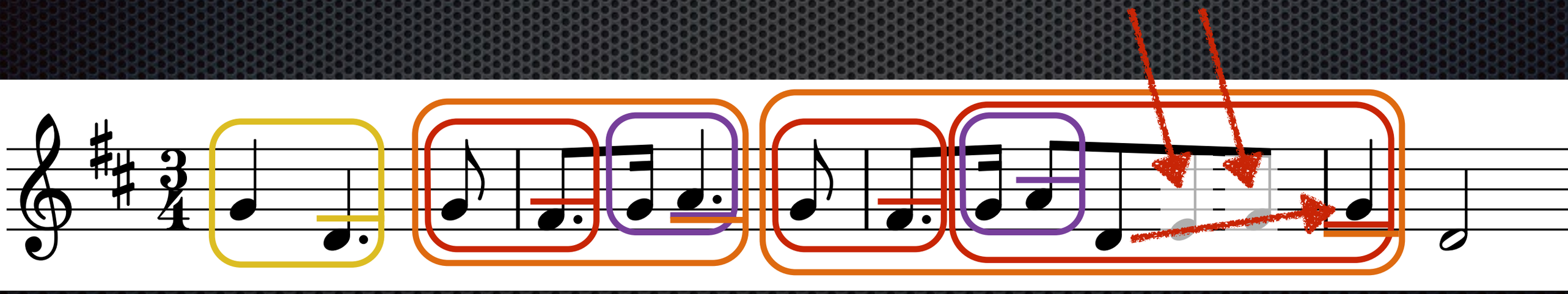
- syntagmatic chain
- syntagmatic network, voice streaming



Charlie Parker, *Billie's Bounce*

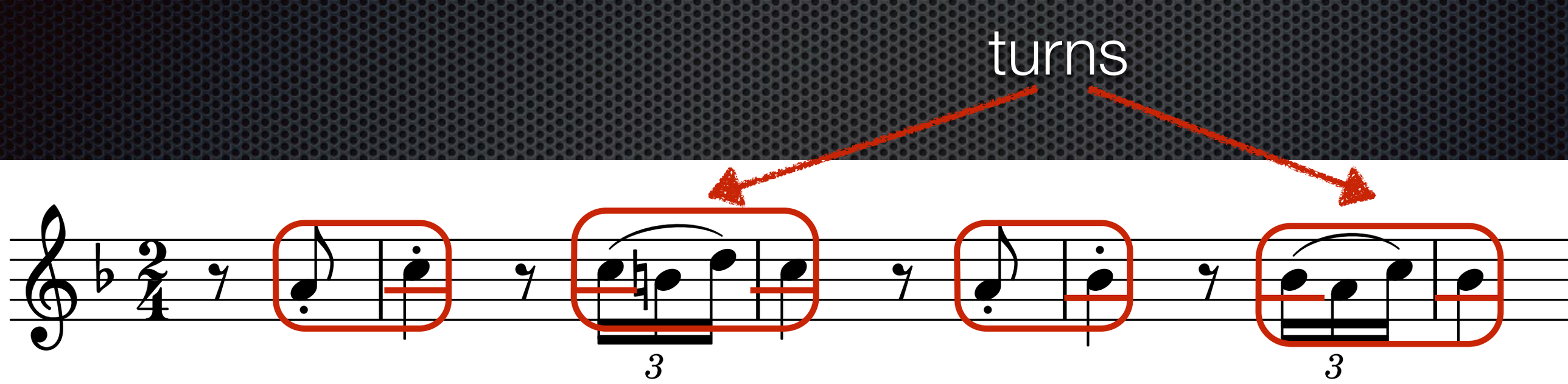
Ornamentation reduction

passing notes



Schubert, Symphony in B minor, *Allegro moderato*, theme

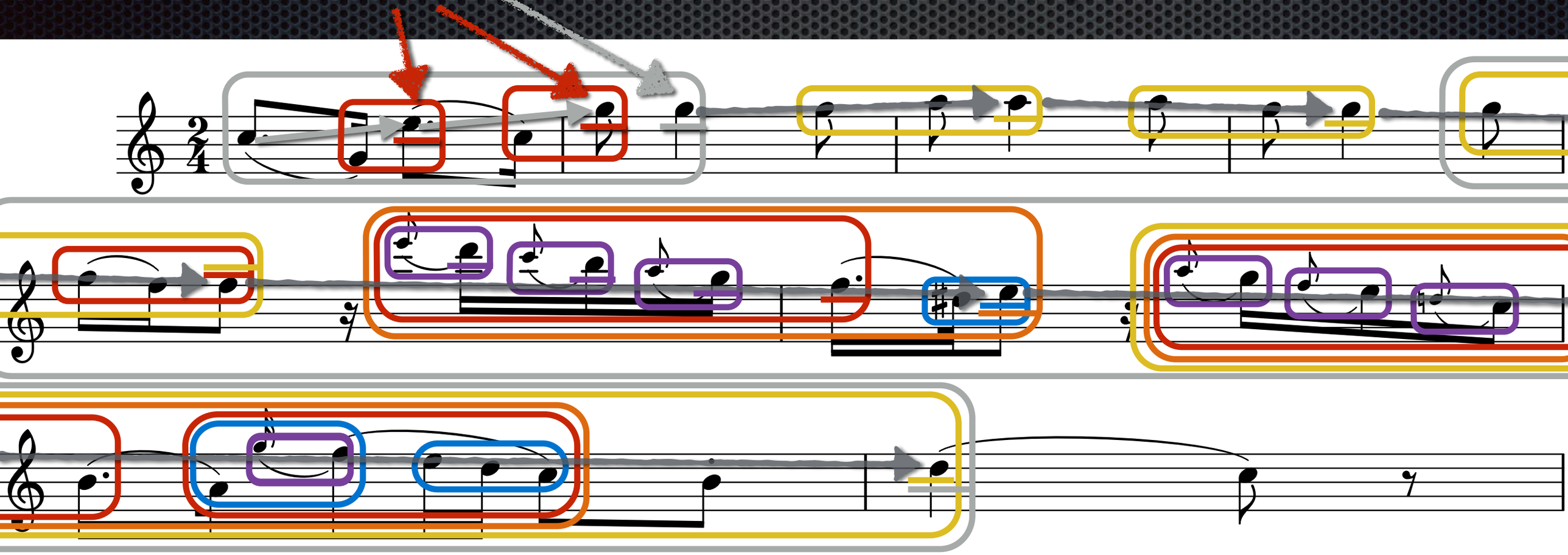
Ornamentation reduction



Beethoven, Piano Sonata No. 6, Op. 10 No.2, *Allegro*, theme

Ornamentation reduction

head (cf. GTTM's *Time-Span Reduction*)



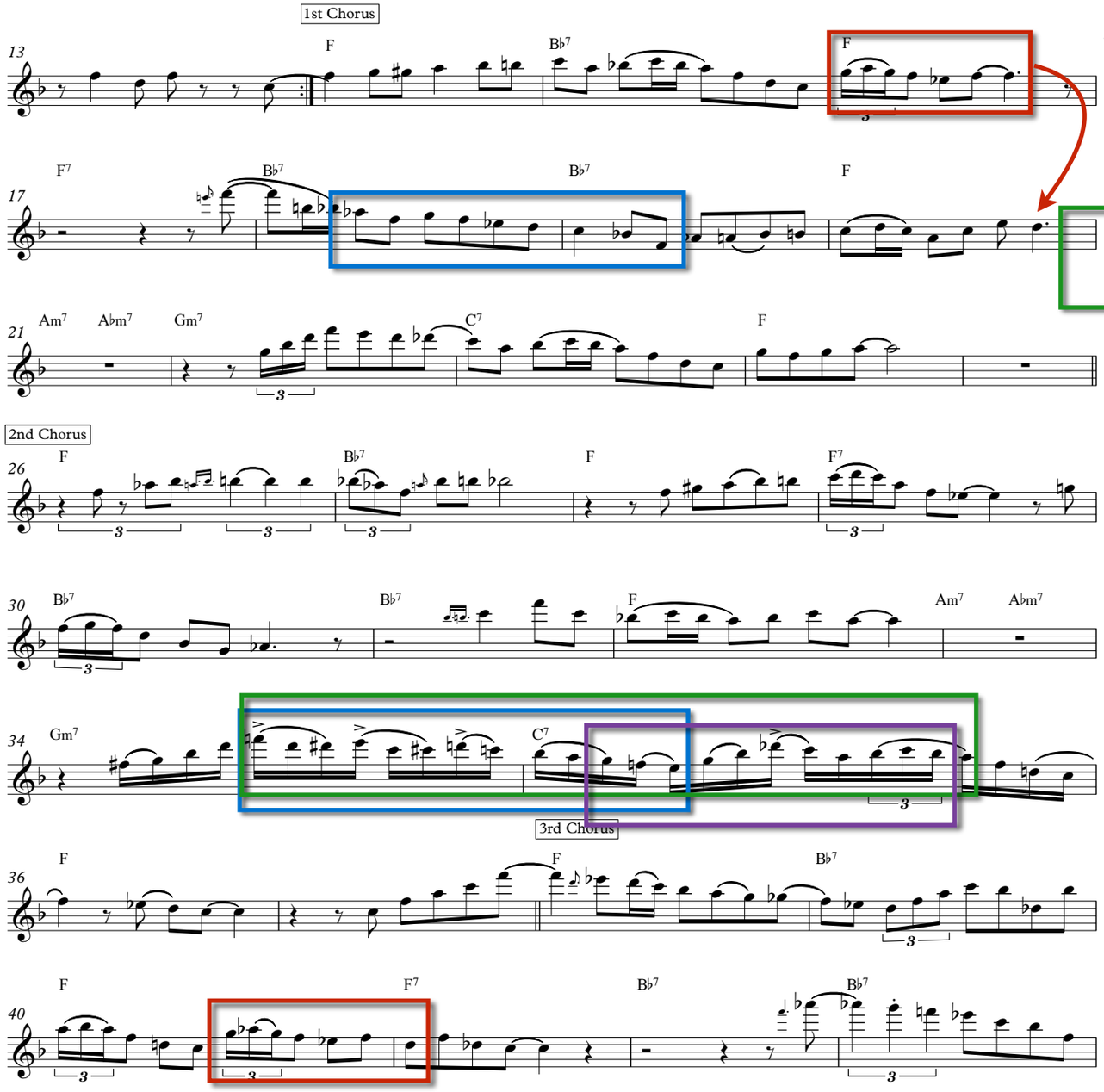
Mozart, Variation XI on "*Ah, vous dirai-je maman*", K.265/300e

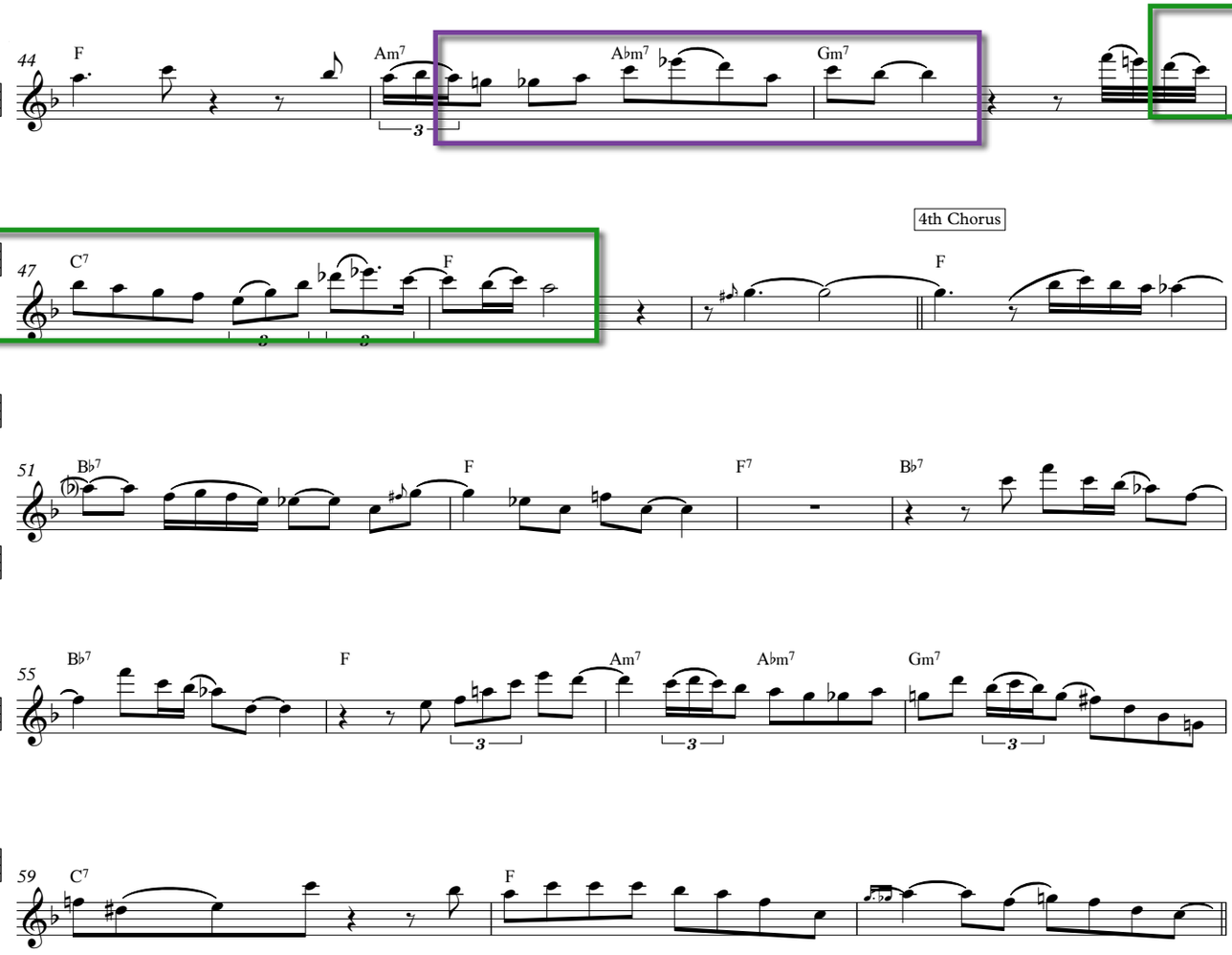
- syntagmatic network

Incremental approach for pattern mining

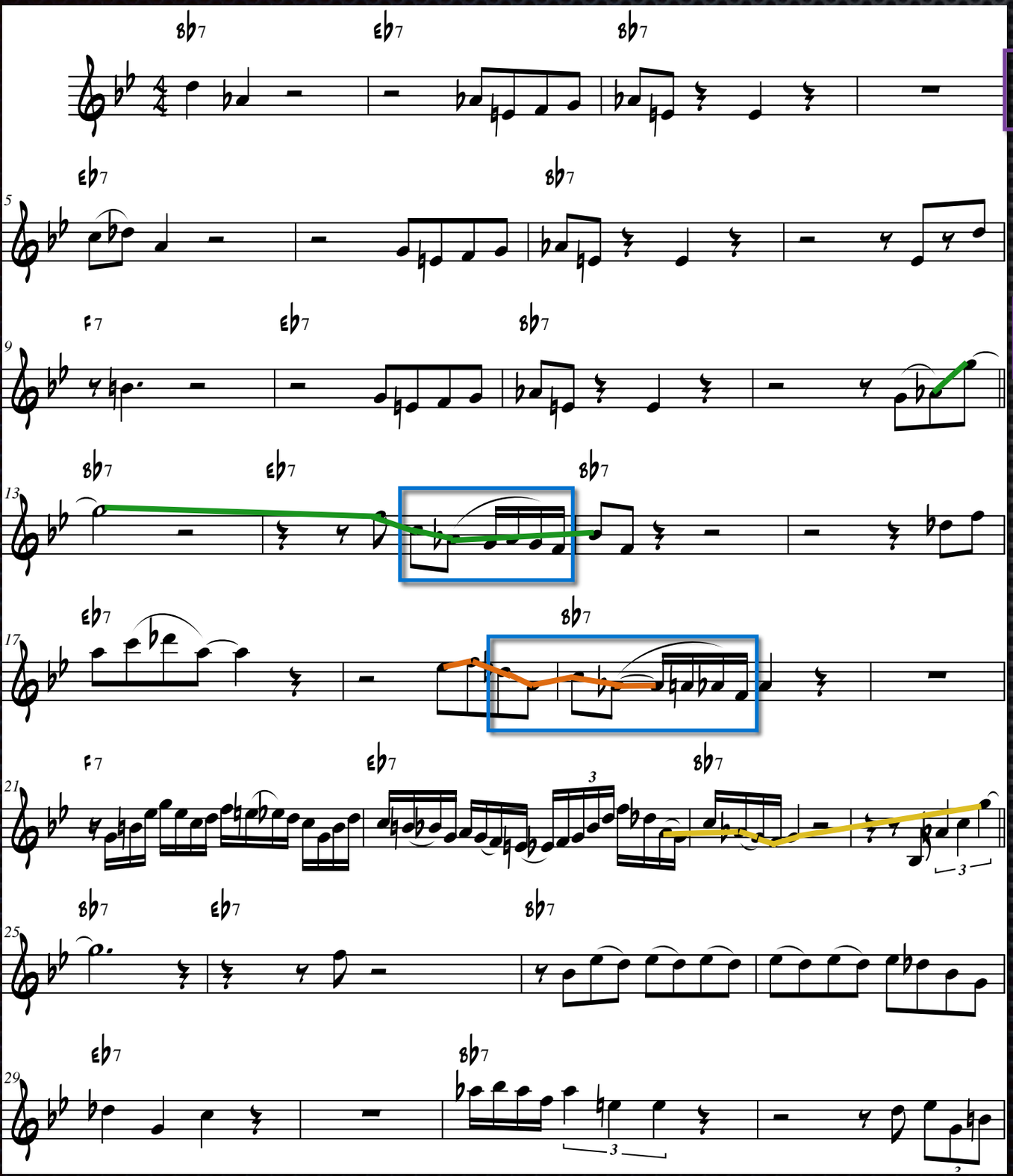
- Progressively analysing music through one single pass
- Controls structural complexity in a way similar to the way listeners perceive music.
- Future works: application to polyphony (syntagmatic network), metrical analysis, form analysis, etc.

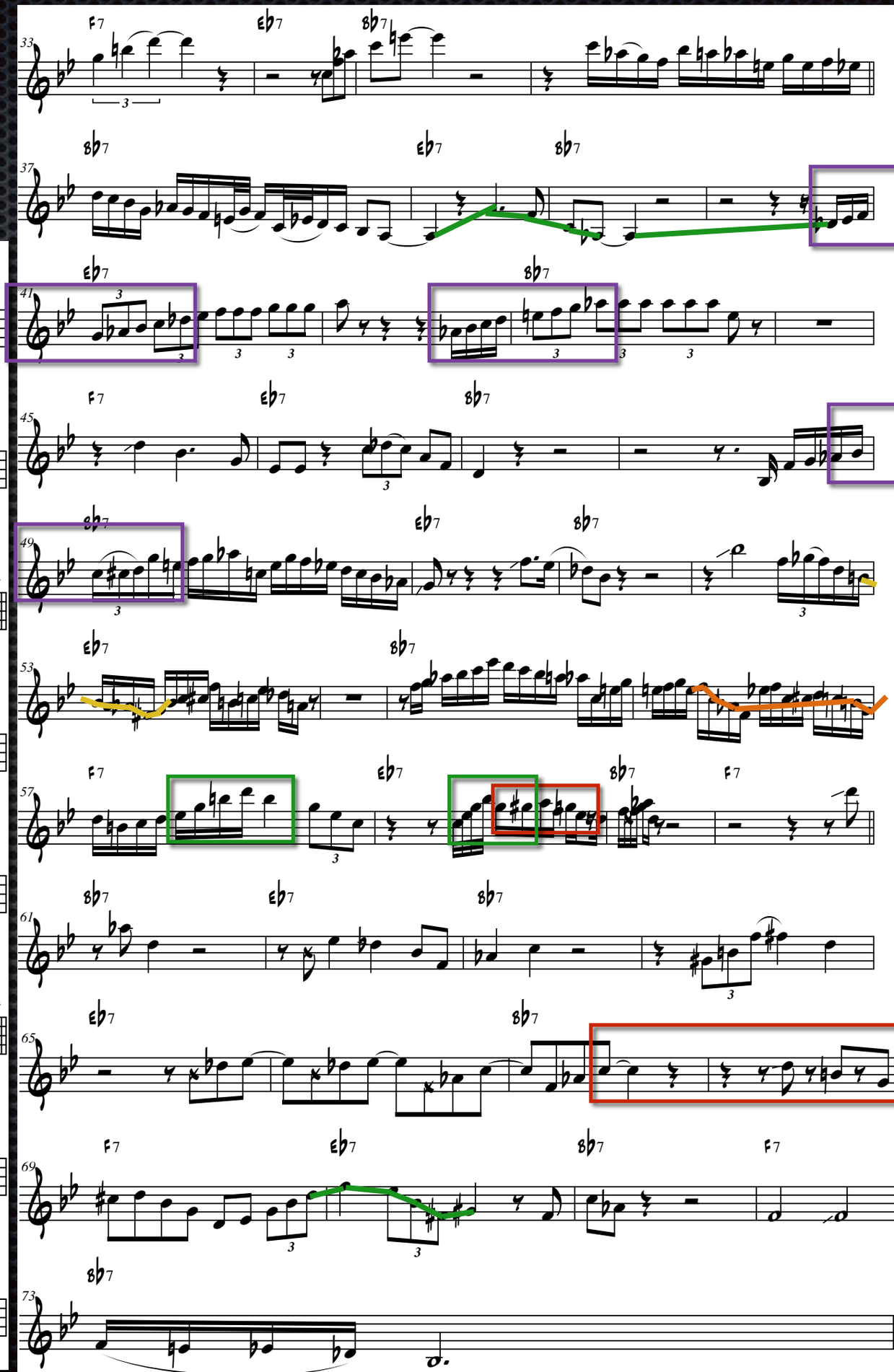
Charlie Parker, *Billie's Bounce*

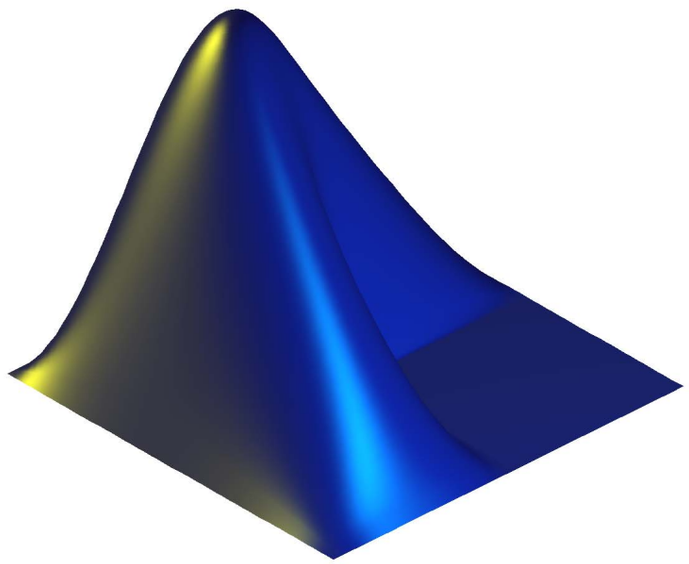




Sonny Rollins, *Blue 7*







MiningSuite

in Matlab

SigMinr
signal processing

AudMinr
auditory modelling

MusMinr
music analysis

PatMinr
pattern mining

Voc
voice analysis

"*MIRtoolbox* 2.0"

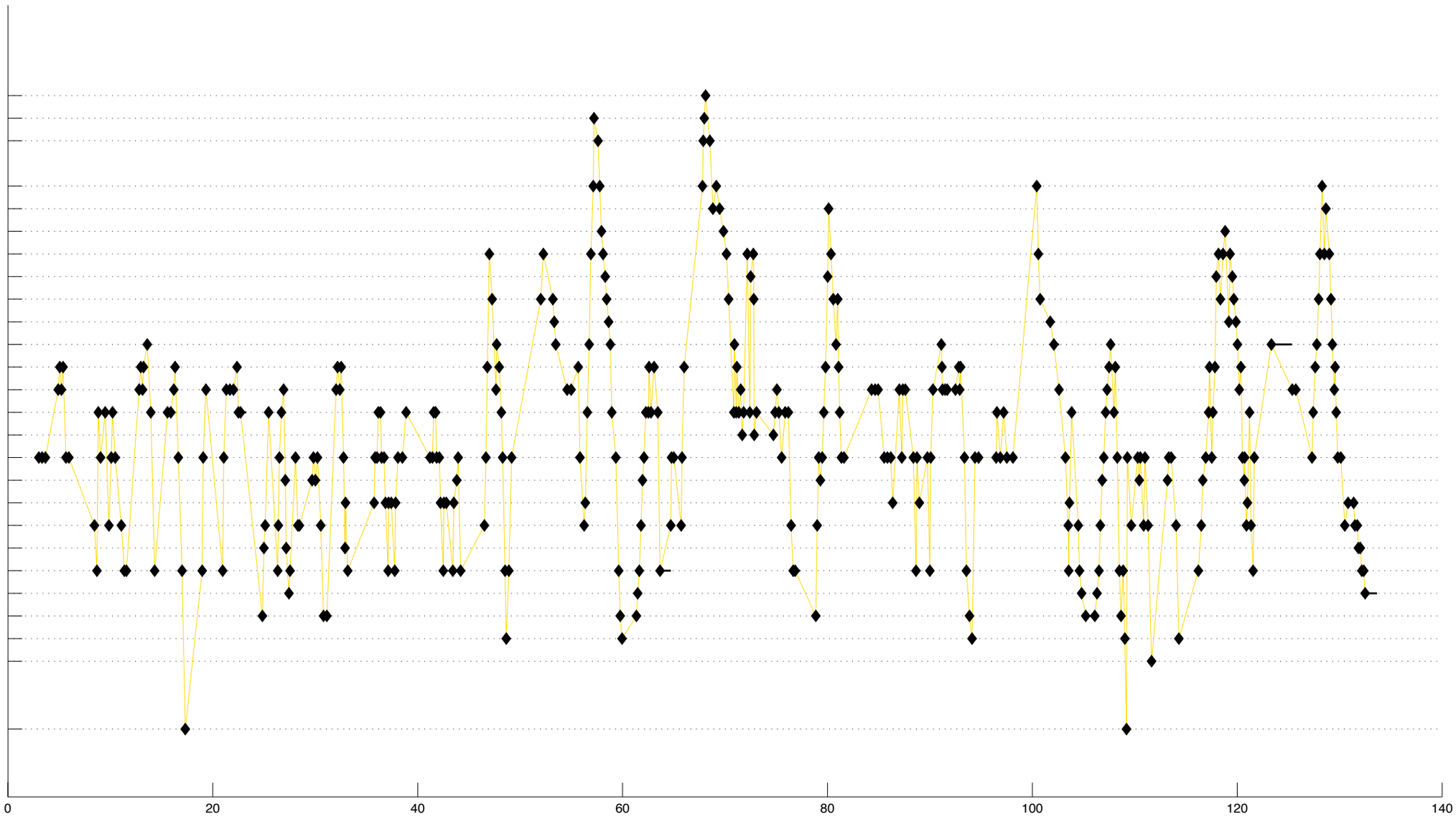
- user-friendly but powerful operators
- completely rewritten, optimised
- operators' code easy to read, open-source

"*MIDItoolbox* 2.0"

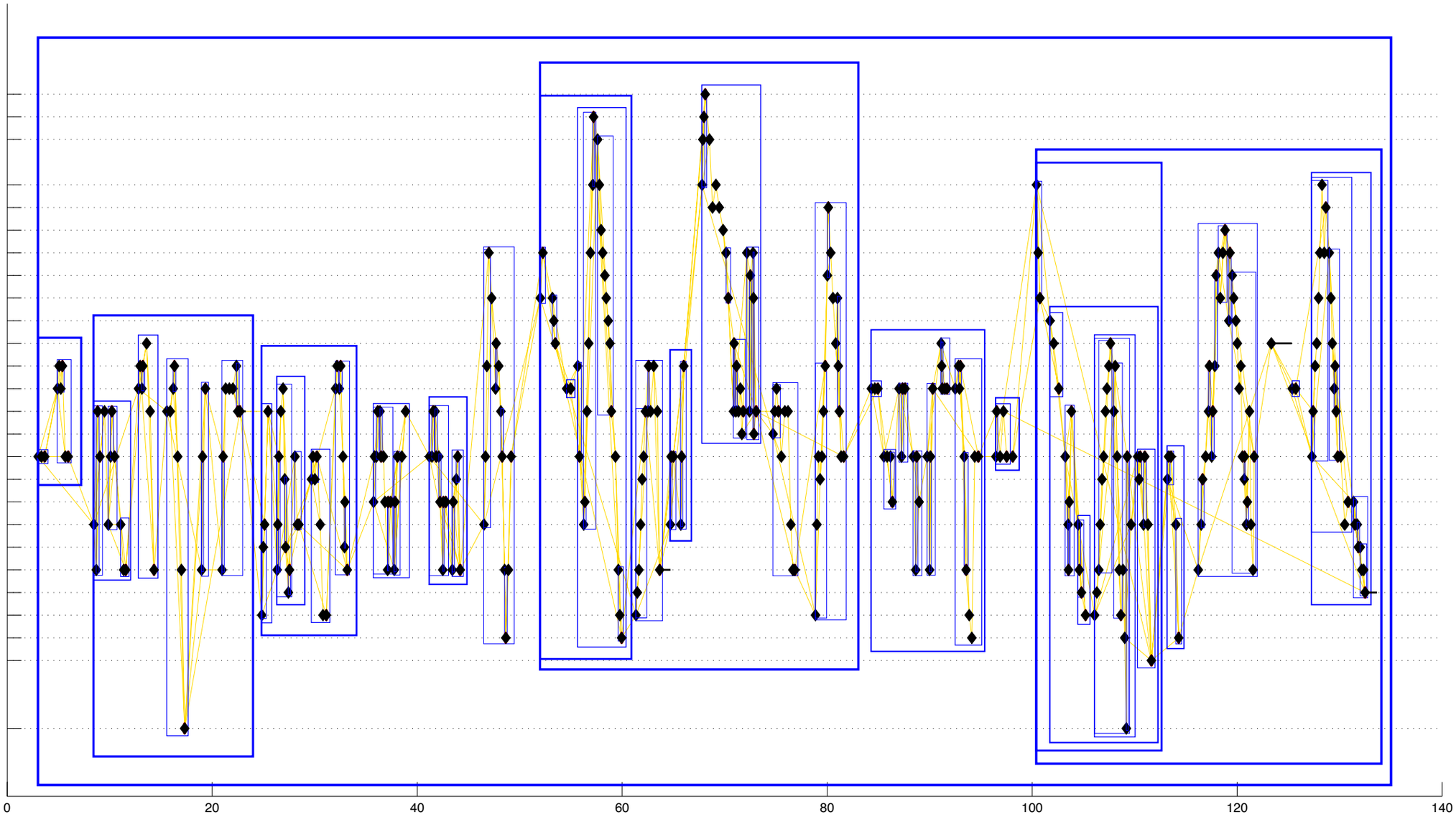
- processing of MIDI, transcription and score
- **advanced musicological analyses**

code.google.com/p/miningsuite

mus.minr('myfile')



mus.minr('myfile', 'Group')



mus.minr('myfile', 'Group', 'Motif')