De- and recomposition of expression in music performance

Michiel Borkent

November 25, 2005

Outline

Final thesis - where, when, what?

- Music Mind Machine group, NICI, Raboud University, Nijmegen

Final thesis - where, when, what?

- Music Mind Machine group, NICI, Raboud University, Nijmegen
- Combination of music and computer science

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Expression in music

- tension, emotions, moods

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Expression in music

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- composer writes and gives directions in score
- musician interprets and **performs**
- tools: dynamics, harmonies, ornaments, **timing**
- similar to someone reading aloud a poem

Expression and structure

- poems, literature: written words, sentences with structure, meter, questions, answers

Expression and structure

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- music scores: phrase structures (melody), bars, ritards

Aims of research

- Analyze expressive timing in terms of structure

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- Draw quantitative conclusions

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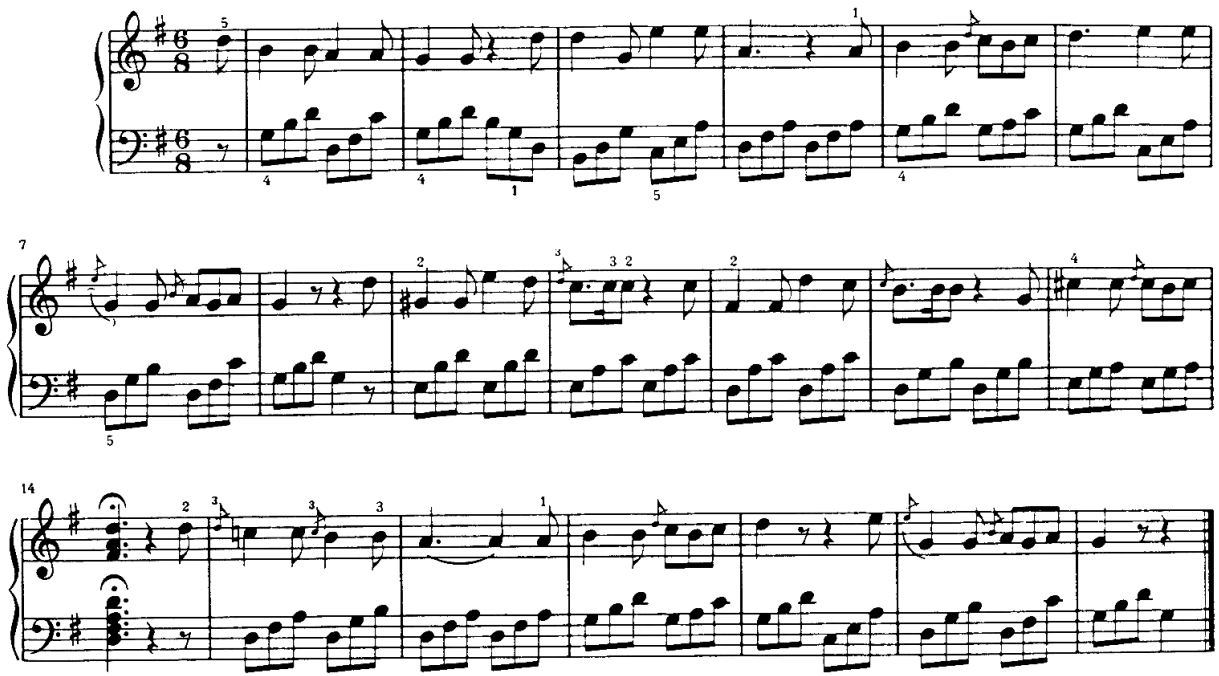
- Draw quantitative conclusions
- Edit expressive timing

Structure in music

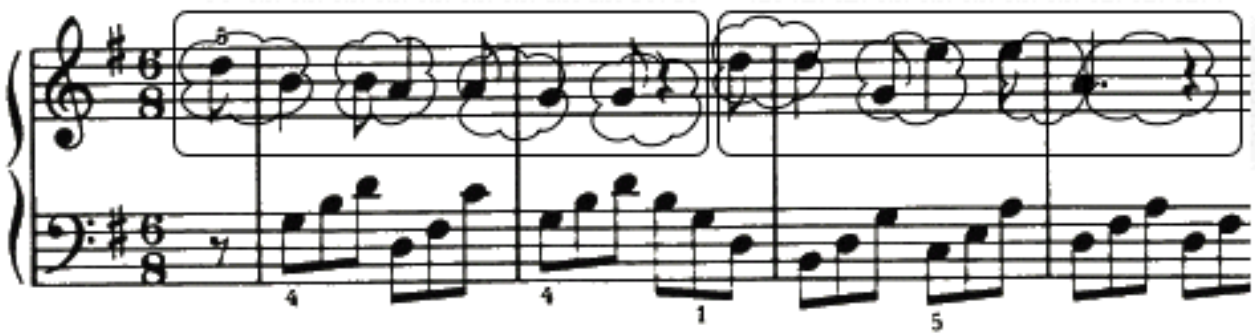
Beethoven's Paisiello theme

Figure 1



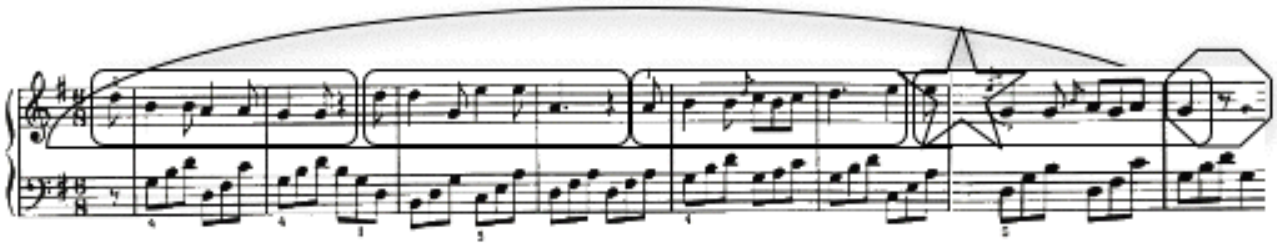
Structure in music

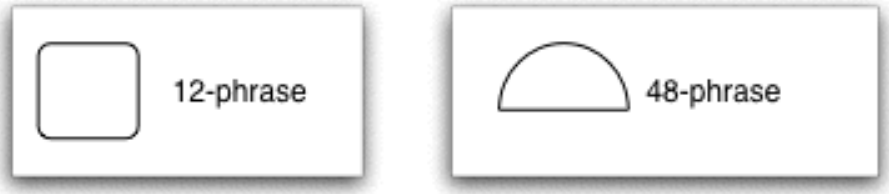
compare phrases with singing a melody in one breath



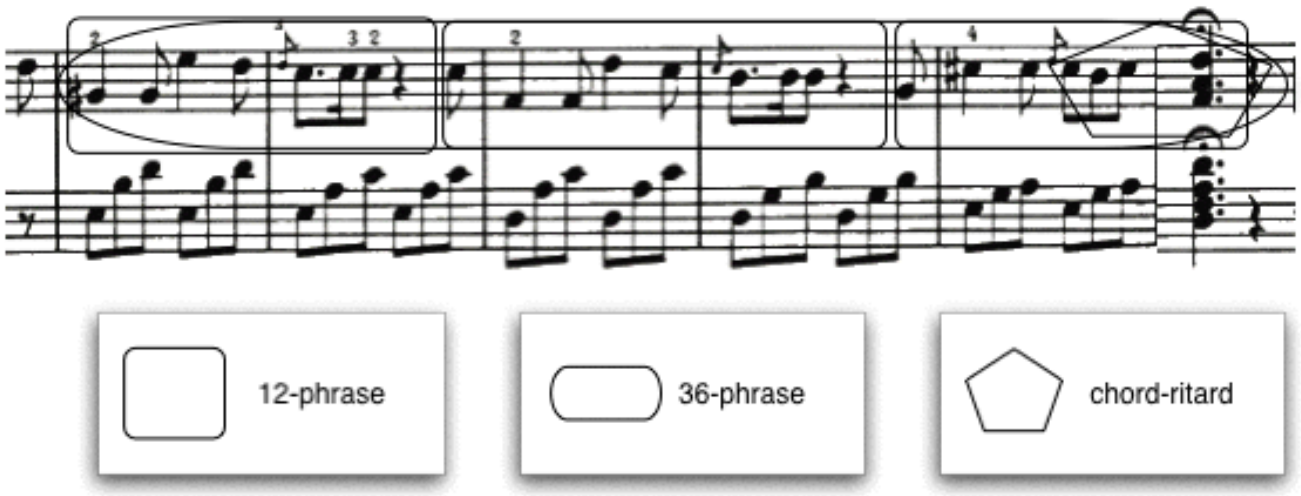
Structure in music

some structural units are very piece specific



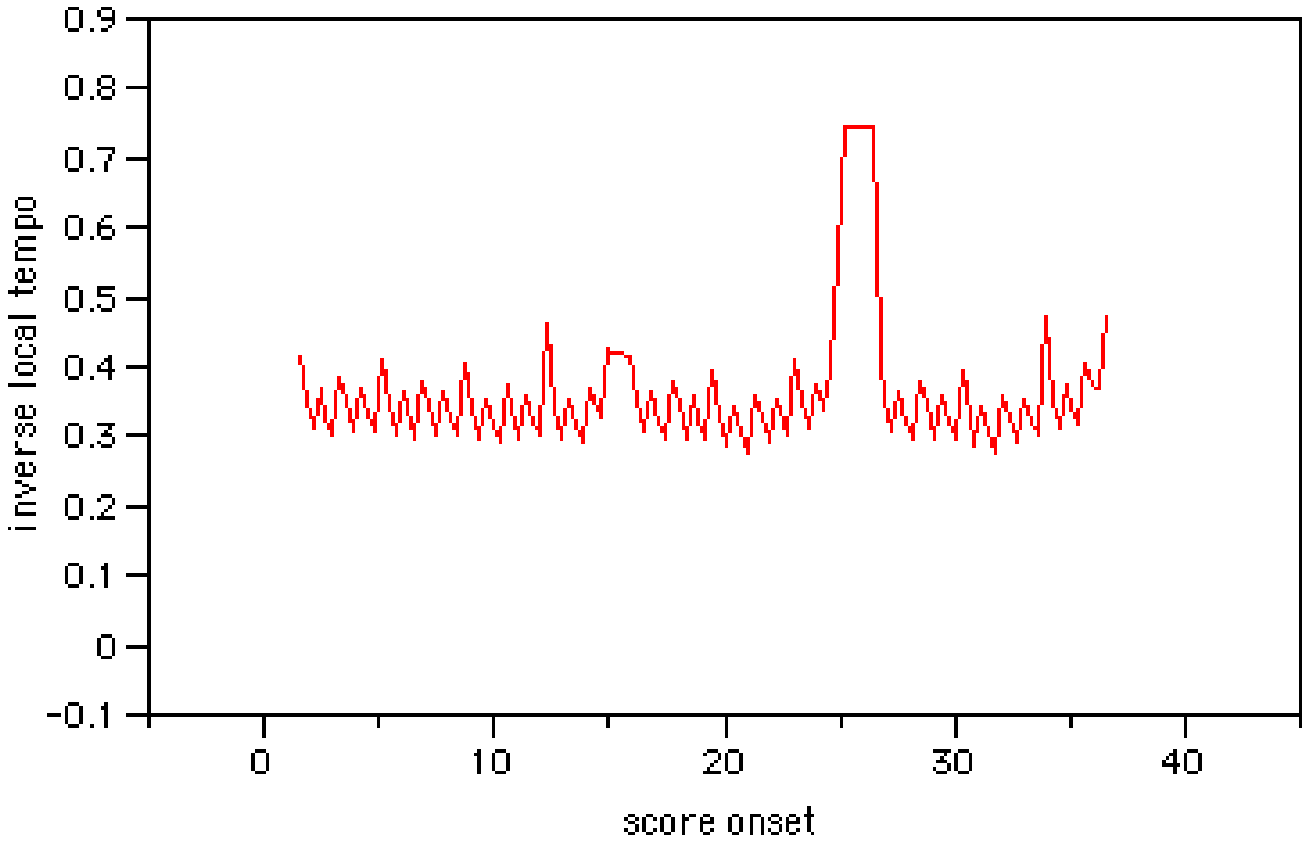


Structure in music



Expressive timing diagram

Note that performer does not play at constant tempo

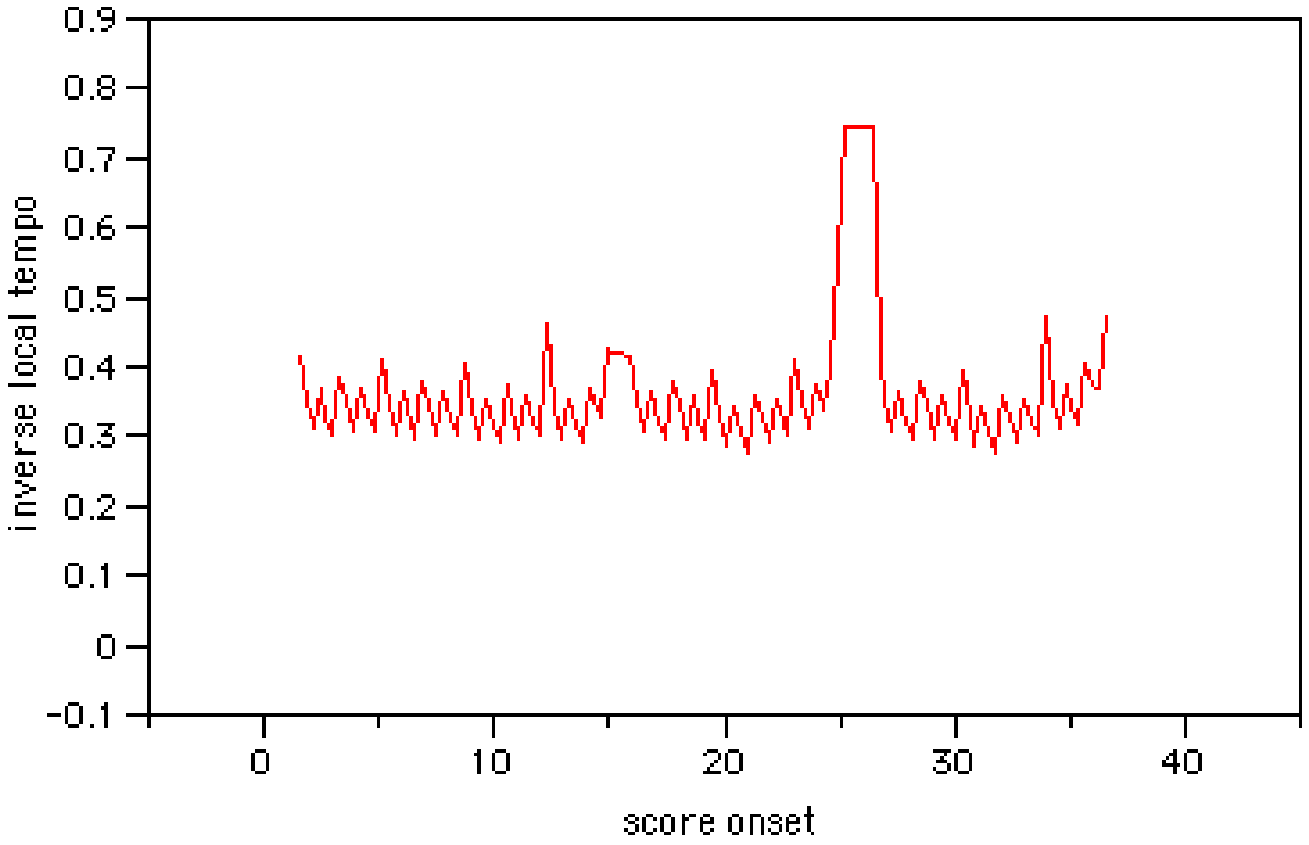


Expressive timing diagram

- Basic time unit: eighth note duration
- Score time vs Performance tempo
- Subtle deviations from global tempo
- Expressed as seconds per time unit
- **Inverse** local tempo: line going up means slower

Expressive timing diagram

Note that performer does not play at constant tempo



Switch to demo

Let's have a listen...

Outline

Approach

- Specific piece of music as starting point

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- Piece specific model based on musical structure and expectations/intuition

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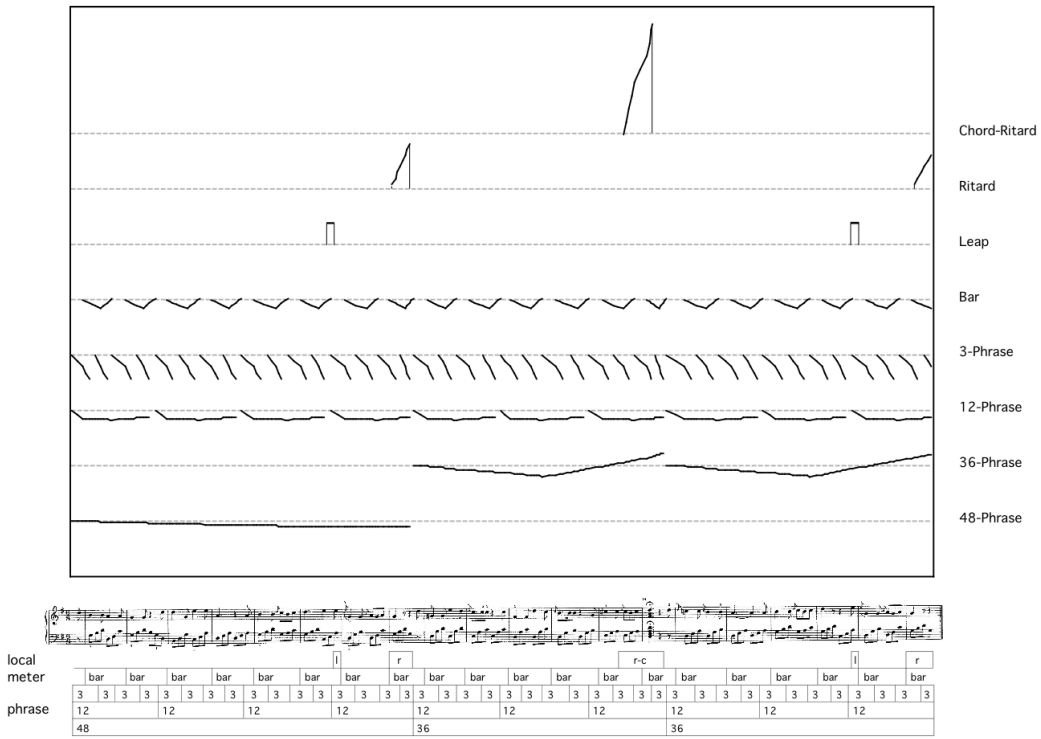
Approach

- Specific piece of music as starting point
- Piece specific model based on musical structure and expectations/intuition
- Assumption: expressive signal can be decomposed into separate timing profiles
- One timing profile per structural category
- Timing profile motive repeats where structural units repeat
- Simple model: linear shapes for going up and down in tempo

Expressive timing signal decomposed into profiles

Figure 5



Data

- Annotated score

Data

- Annotated score
- Performances

Data

- Annotated score
- Performances
- Description of profiles: expected positions of breakpoints

Description of profiles

- Intuition, trial and error

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- Found plausible in previous research

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- Linear profiles with breakpoints for going up and down in tempo

Description of profiles

- Intuition, trial and error
- Found plausible in previous research
- Linear profiles with breakpoints for going up and down in tempo
- Vertical position of breakpoints decided by observation from performance

Profile descriptions

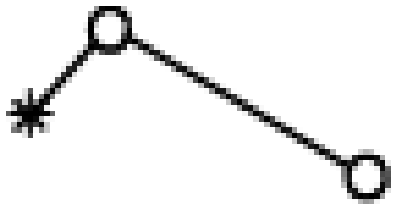
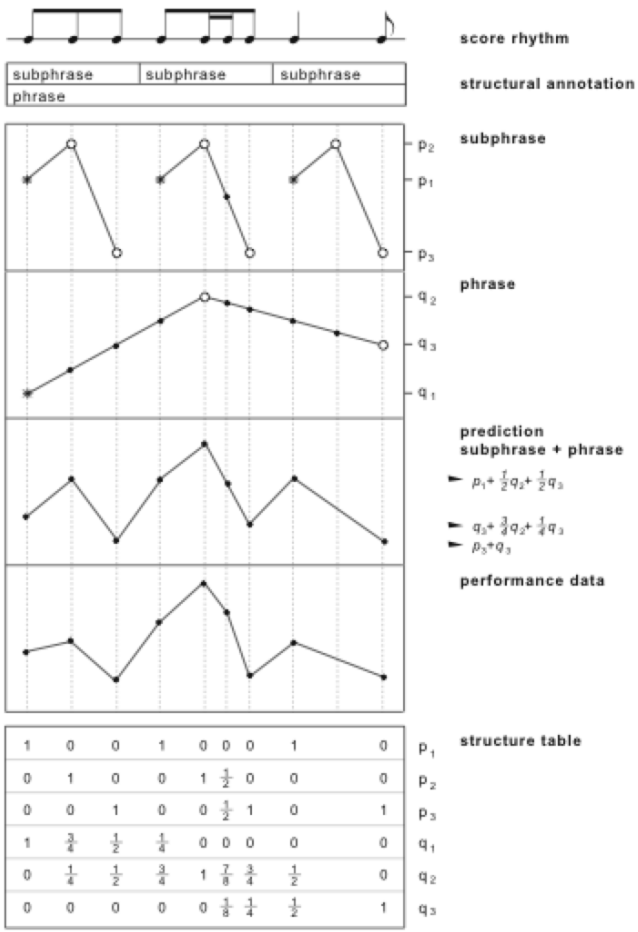
Structural unit	profile shape
36-phrase	
3-phrase	
chord ritard (8 notes)	

Table: Structural units and their profile descriptions

Procedure


score rhythm
subphrase
subphrase
subphrase
phrase
structural annotation
subphrase
phrase
prediction
subphrase + phrase
performance data
structure table

Procedure

Modelled as multiple linear regression problem:

$$\begin{pmatrix} 1 & 1 \\ 2 & 0 \\ 3 & 0 \end{pmatrix} \begin{pmatrix} ?_1 \\ ?_2 \end{pmatrix} = \begin{pmatrix} 1.5 \\ 2.5 \\ 3 \end{pmatrix}$$

Find optimal $?_1$ and $?_1$, such that error between optimal solution and observed data is minimized.

Procedure

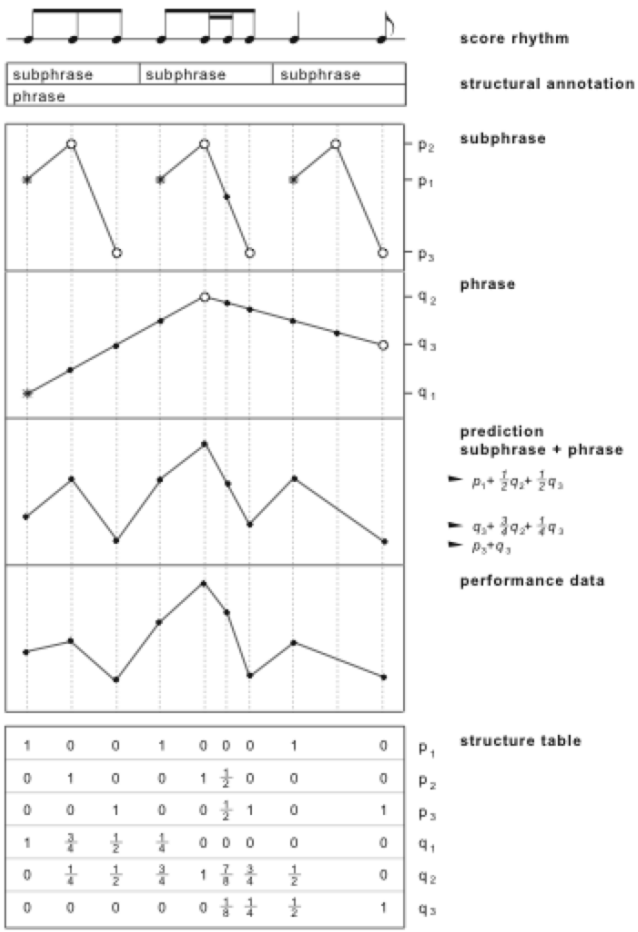
Modelled as multiple linear regression problem:

$$\begin{pmatrix} 1 & 1 \\ 2 & 0 \\ 3 & 0 \end{pmatrix} \begin{pmatrix} 1.08 \\ 0.42 \end{pmatrix} = \begin{pmatrix} 1.5 \\ 2.15 \\ 3.23 \end{pmatrix}$$

Error (sum squared differences) here is

$$(1.5 - 1.5)^2 + (2.5 - 2.15)^2 + (3 - 3.23)^2 = 0.175$$

Procedure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subphrase
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phrase
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subphrase + phrase
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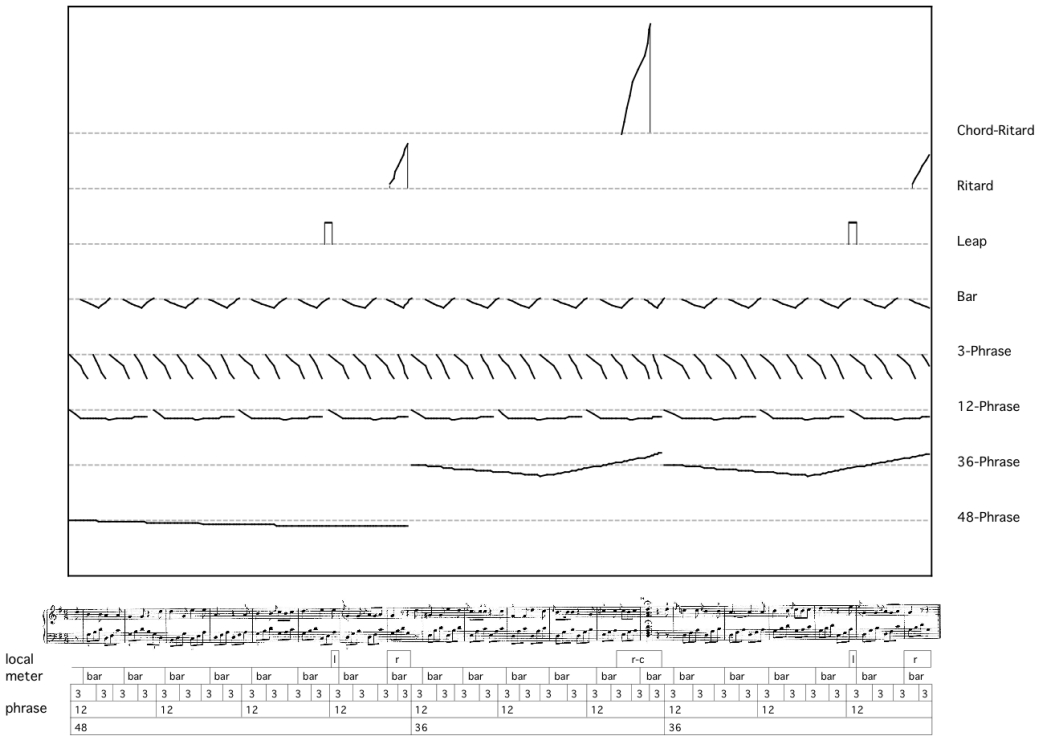
Voici

Figure 5



Use of results

- Statistical, quantitive analyses
- Edit expression

Example of quantitative analysis

Structural unit	Stepwise r^2
chord ritard	0.786
3-phrase	0.456
12 phrase	0.181
ritard	0.173
bar	0.153
36-phrase	0.166
leap	0.107
48-phrase	0.075
Full model	0.948

Table: Explained variance of individual timing profiles of performance at 57 BPM

Another example of quantitative analysis

Structural unit	Stepwise r^2
chord-ritard	0.687
3-phrase	0.238
36-phrase	0.147
bar	0.103
ritard	0.094
48-phrase	0.04
12-phrase	0.027
leap	0.012
Full model	0.837

Table: Explained variance of individual timing profiles of performance at 50 BPM

Outline

Why?

- Aim: edit expression in music performances
- Contrasts to brute force methods of music performance editing

Recomposition

Three steps:

- Recombine timing profiles with amplified with weights

Recomposition

Three steps:

- Recombine timing profiles with amplified with weights
- Build performance around it

Weights

- Control contribution of separate timing profiles

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- Some units can influence length: leap, ritard, chord ritard

Weights

- Control contribution of separate timing profiles
- Some units can influence length: leap, ritard, chord ritard
- Others are normalized to keep performance length same

Weights

- Weight $= 1$: copy performance expression

Weights

- Weight $= 1$: copy performance expression
- Weight $= 0$: mute performance expression

Weights

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- Negative weight: turn profile upside down

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- Absolute weight > 1: exaggeration

Weights

- Weight $= 1$: copy performance expression
- Weight $= 0$: mute performance expression
- Negative weight: turn profile upside down
- Absolute weight > 1: exaggeration
- Absolute weight < 1: understatement

Switch to demo

Let's have another listen...

Reconstruct performance

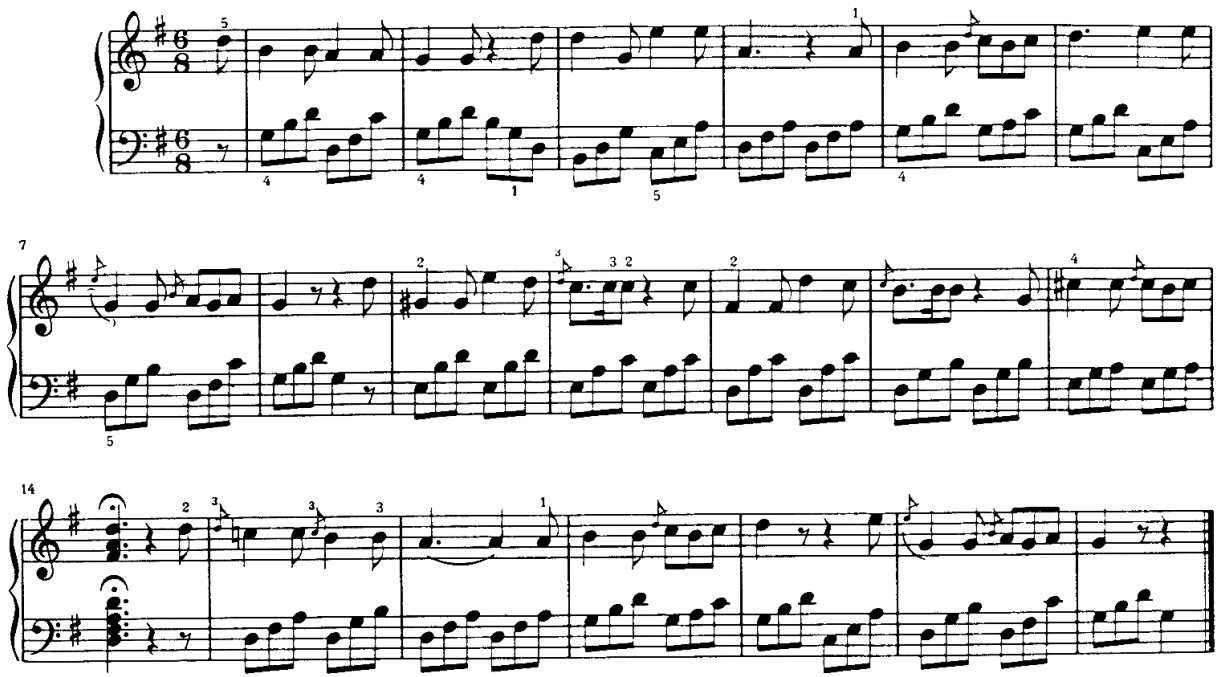
New expressive timing pattern...

- Only onsets of one note per time unit!

Only 'main' notes in the analysis

Beethoven's Paisiello theme

Figure 1



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Reconstruct performance

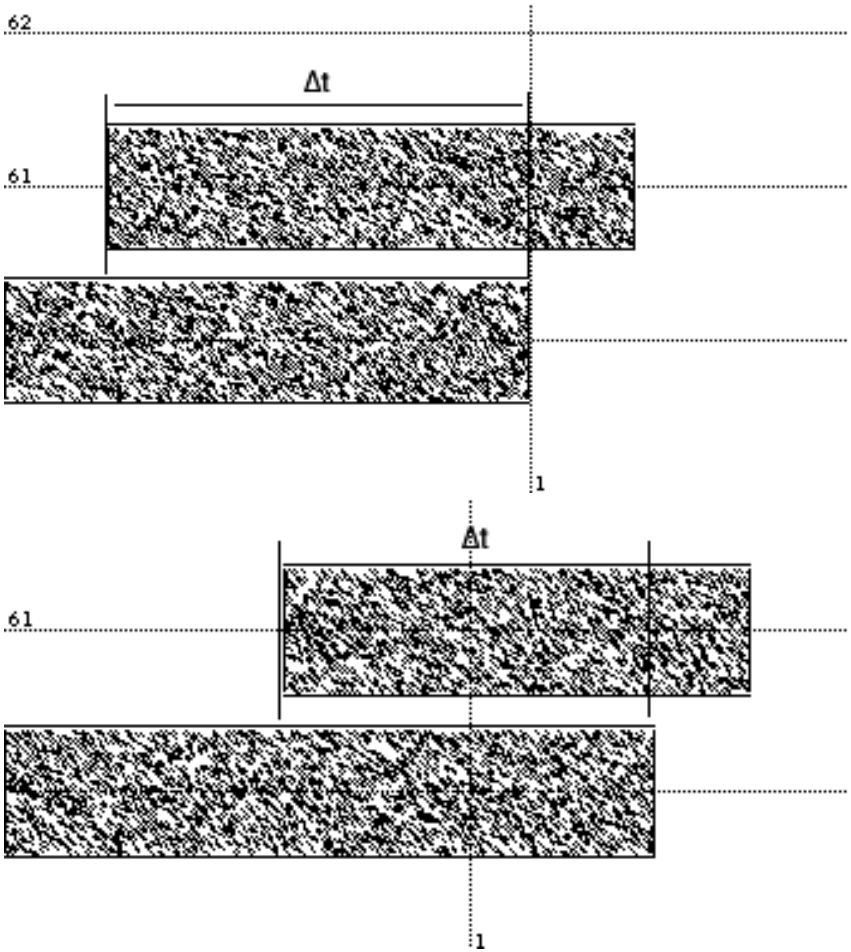
New expressive timing pattern...

- Only onsets of one note per time unit!
- other notes: asynchrony with 'main' notes
- intensity (volume): copy from original performance
- durations? articulation consistency!

Articulation

- Recipes for three different transitions
- Legato: keep overlapping duration the same

Articulation: legato



Outline

Conclusions

- Decomposition of expressive timing by linear profiles is very reasonable approach (correlation of 95% !)
- Quantitative analysis of music performance: comparison of structural units, performers, speeds
- Recomposition: provides evidence for plausibility of decomposition method
- Recomposition enables to edit expression in meaningful way
- Stimuli for perceptual experiments, studio editing

Further research

- Derivation of score from performance (quantization)
- Automatic recognition of structure and generation of profile description
- Integration of expressive timing (timing profiles) in composition software

Outline

Questions

You are invited for drinks after this talk in the Vestingbar!