

Uses of Humdrum

Overview

Traditional categories of music analysis

□ Traditional means of analysis

- Harmony

- Counterpoint

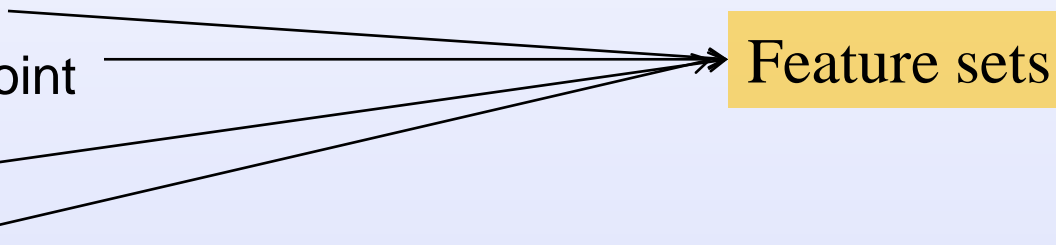
- Melody

- Rhythm

Feature sets

Traditional categories of music analysis

□ Traditional means of analysis

- Harmony
 - Counterpoint
 - Melody
 - Rhythm
- 
- Feature sets

Humdrum = Toolset

****kern** = encoding format

>> Manual processes in music analysis

Riemann analysis

Handwritten musical score with Riemannian harmonic analysis. The score is in G major and 4/4 time. The first system has a treble clef and a bass clef. The treble clef part has notes G4, A4, B4, C5, B4, A4, G4. The bass clef part has notes G3, A3, B3, C4, B3, A3, G3. Handwritten Roman numerals below the first system are (I) vi I₄ (k?) IV I₆. The second system has notes G4, A4, B4, C5, B4, A4, G4 in the treble and G3, A3, B3, C4, B3, A3, G3 in the bass. Handwritten Roman numerals below the second system are V₅ I₆ 5 I₆ 11^b I V⁷ I.

Schenkarian analysis

Agmon, Conventional Harmonic Wisdom

Ex. 6

Musical score for Ex. 6, showing a piano accompaniment with chords and a bass line. The chords are G major, A major, B major, and C major. The bass line consists of eighth notes G, A, B, C, G, A, B, C.

LEVEL 1: T — S — D — T

LEVEL 2: T D T T D T T D T

Root analysis

Blair Johnson, MTO (2012)

Musical score for Blair Johnson, MTO (2012). The score is in G major and 4/4 time. The treble clef part has notes G4, A4, B4, C5, B4, A4, G4. The bass clef part has notes G3, A3, B3, C4, B3, A3, G3. Handwritten Roman numerals below the first system are i and "v".

first, last, highest, lowest: (014)

Musical score for Blair Johnson, MTO (2012), showing a single note G4 on a treble clef staff.

Perspectives on music analysis: 1-2

- **Traditional** (*theoretical, historical*) means of analysis

- Harmony

- Counterpoint

- Melody

- Rhythm

Feature sets:
Results related to score

- **Statistical** (*systematic*) approaches

Feature sets: results reported in tables, charts, graphs

Disembodied information about music

- **Audio-based** analysis

More approaches to analysis

- Procedures imported from other disciplines
 - Often *procedural* or *structural*
 - Borrowed from
 - Linguistics
 - Mathematics
 - Computer science
 - Engineering
- Cognitive and perceptual studies
- Performance-based analysis
- Data visualization

Generation of new works

- Flip side of analysis (work of David Cope)
- Emphasis on form/genre
- Emphasis on style/authorship
- Idiomatic writing for specific instrument

Other legitimate projects

- **Data translation**, enrichment
- **Linking symbolic data** with MIDI, audio, structured data
- **Style evaluation**
 - generation as proof of general concept
 - **Attribution** studies (e.g. Josquin Research Project)
- **Deep-learning/convolutional-network** (AI) analysis
- Generative approaches to new music

Algorithmic generation: 12-bar blues

Exercise: Simple 12-bar Blues in F

phrase 1

phrase 2

phrase 3

Improvise over the 12 bars using notes from this blues scale

Francesco Giomi, c. 1988

Is repertory highly
patterned?

Phrase families (centonization)

- Panos Mavromatis (2006)
 - N.B. Lerdahl-Jackendoff touch

Linguistic orientation

The image shows a musical score for Echos 1, illustrating formulaic variation. The score consists of eight staves (1-8) with Greek lyrics. Brackets above the staff mark the opening and closing formulas of a phrase family. The lyrics are:

1 Του λιθου σφραγισθεντος υπο των Ιουδαϊων
2 Του Γαβριηλ εθελξα με νουσαι Παρθε νε το χαριρε
3 Εν τω θλιβεσθαι με εισαι κουσον μου των οδων
4 Αγιω Πνευματι πασαι ησυσ και νουρ γε τα
5 δεξιαι σου χειρι λαβων σου λογε
6 Τους ερημικους αι πουστος ο θεος ποθος εγχι νε τα
7 Αγιω Πνευματι τιμη και δοξασ περ Πατρι
8 Εις τα ορη των σων υψωσας με νομην

Figure 3. A Phrase family in Echos 1, illustrating formulaic variation. Brackets above the staff mark the family's opening and closing formulas.

Hierarchical systems: Lerdahl-Jackendoff

Generative theories
of musical grammar (1984)

The diagram illustrates a hierarchical tree structure for a musical phrase. The tree is divided into four levels, labeled 'Level a' through 'Level d'. Level a is the root, which branches into two nodes at Level b. Each of these nodes branches into two nodes at Level c. Finally, each of these four nodes branches into two nodes at Level d. Below the tree is a musical score in treble and bass clefs, showing the notes and rests corresponding to the structure above.

The musical score is a single line in treble clef, 2/4 time, with a key signature of one sharp (F#). The notes are: G4, A4, B4, C5, B4, A4, G4, F#4, E4, D4, C4, B3, A3, G3, F#3, E3, D3, C3. Below the score is a table with three rows: Harmonic Structure, Motif Structure, and Phrase Structure. The columns correspond to the notes above.

Harmonic Structure	T	T	D	D	T	T	D	D	T	T	D	D	T	D	T
Motif Structure	a		a'		b		c		a		a'		b'		c'
Phrase Structure	A				B				A				B'		

Linear systems (species counterpoint)

Two-Voice Analysis

Vincentino: *L'artico musica* Vol. 4

5 6 8 2 3 | 3 5 3 5 | 3 2 8 7 5 4 3 | 5 4 3 3 3 | 3 8 6 5

Several systems

Pedagogical orientation

Answer (Contrapunctus III)

First Countersubject of the AOF

Three-Voice Analysis

Robert Kelley

A Ec - ce Do - mi - rum nos - ter cum vir - tu - te ve - ri - et

T Ec - ce Do - mi - rum nos - ter cum vir - tu - te ve - ri - et

B Ec - ce Do - mi - rum nos - ter cum vir - tu - te ve - ri - et

5 6 3 5 | 6 3 8 5 | 3 2 3 8 | 2 3 3 | 6 6 3 2 3 3 | 5 4 8 6 7 3 | 3 6 5 | 3 3

8 7 3 8 | 7 6 5 3 3 | 5 6

Imitative systems (18th-century counterpoint)

A musical score in G major, 3/4 time, showing a piano arrangement. The right hand (treble clef) contains a melodic line starting at measure 5. A bracket labeled "motive" spans measures 5 and 6. A bracket labeled "sequence" spans measures 5 through 8, indicating a descending chromatic sequence of the motive. The left hand (bass clef) provides a simple accompaniment.

Timothy Smith, NAU

A musical score for "Subj. 2" in G major, 3/4 time. It shows a two-staff piano arrangement. The right hand (treble clef) has a melodic line with a fermata over the final note. The left hand (bass clef) has a simple accompaniment.

Contrapunctus III

(t3) answer from Contrapunctus I transformed in contrary motion becomes subject

(t4) Syncopation t2 from Contrapunctus II transformed in contrary motion (and ornamented)

(t5) Dotted figure t1 from Contrapunctus II transformed in contrary motion and incorporated into the subject's head

A musical score for "Contrapunctus III" in G major, 3/4 time. The score is in a single staff (bass clef). It features three annotations with arrows pointing to specific notes: a red arrow points to a note in measure 1, a blue arrow points to a note in measure 2, and a green arrow points to a note in measure 3. The annotations describe transformations of motifs from other contrapunctus.

Music-theory applications



Sample Projects, Random Order

Generative chorale variations

- Dominik Hörnel (2005): Pachelbel
 - Keyboard elaboration generated from chorale melody

The image displays a musical score for a chorale variation. It features three staves. The top staff is a vocal line in G major, 4/4 time, with the lyrics: "Al - le Men - schen müs - sen ster - ben, al - les Fleisch ver - was da le - bet, muß ver - der - ben, soll es an - ders". The middle staff is a keyboard elaboration, showing a complex, flowing melodic line in the right hand. The bottom staff is a bass line, providing harmonic support with chords and single notes. The key signature is one sharp (F#) and the time signature is 4/4.

Chorale elaboration

Rhythm, Meter, Tempo (performance)

Simon Dixon, Gerhard Widmer, Walter Göbl (2004)

Comparative performance analysis

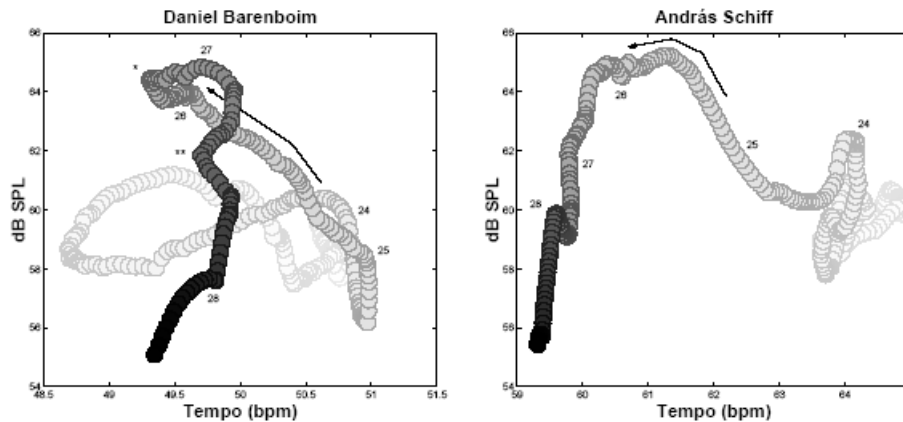


Figure 4. Expression trajectories over the last bars (mm.24–28) of the Mozart piano sonata K.279, second movement, first section, as played by Daniel Barenboim (left) and András Schiff (right). *x* axis: tempo in beats per minute; *y* axis: dynamics ('loudness') in decibel. The darkest point represents the current instant (third beat of m.28), while instants further in the past appear fainter.

Computational perception

MACHINES | By Michael Byrne | Oct 9 2016, 11:00am

Computer Scientist Publishes Manifesto for Expressive Algorithmic Music

A new five-year research project aims to understand how humans compute music.



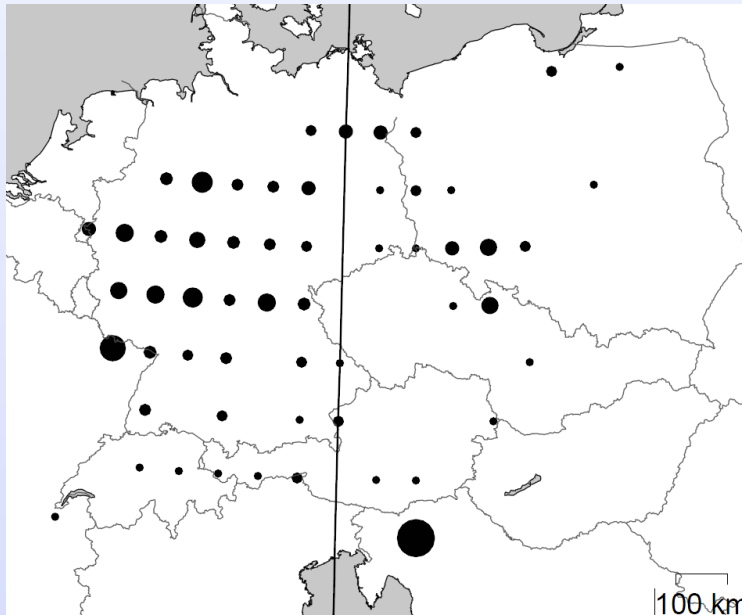
Gerhard Widmer, *Motherboard* (2016)

https://www.youtube.com/watch?v=EJn_88Ru7w4

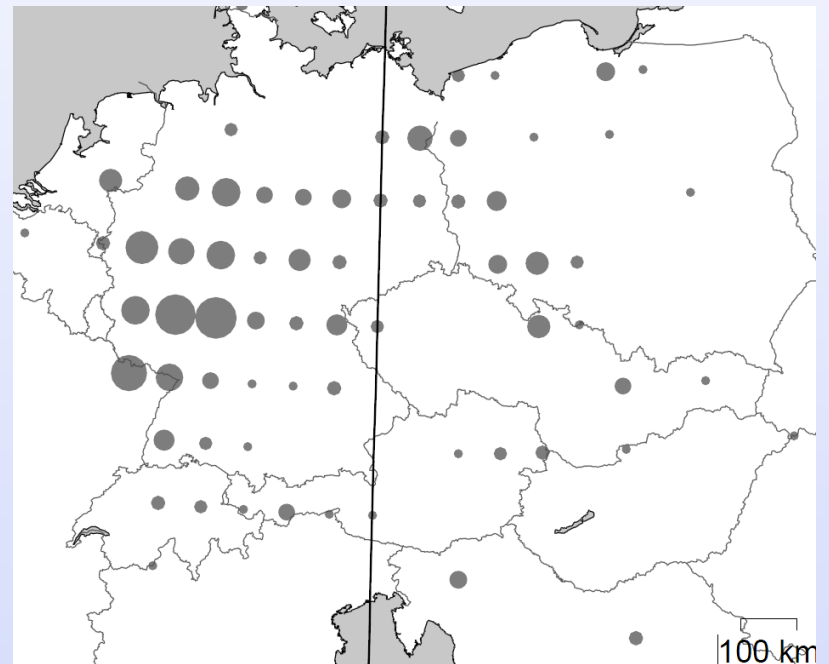


Geospatial mapping of musical features

- Bret Aarden (1998), from EsAC data



Minor mode



Triple meter

Tabla drumming

Parag Chordia: bol processor (2006)

Non-Western
repertoires



*Dhene ghene dheneghene nage tak dhane dha
na ge tak 'dha ne dha 'dha ketetake kitetak*

+ dhenegene dheneghene taketake dha ne
dha kite takedha kitetake dha

+ kr dhin o na kitetake dheneghene
na kite ta dhe te dha

+ gerenage na kite ta dhe te
kitetak gerenage na kite ta

+ dha

dha nagetake dha ne dha
dhet ta kitetake ta

natete^s dhet kitetak gerenage
ta gadigene dha kitetak

dha ta gadigene dha
dhe te dha ta gadigene

```
8.0 2.0 0.0 -36 0.0 0.0 -1.0
t 2 6 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04dha
t 2 21.582 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 28.26 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 36.058 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04kr
t 2 42.722 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04dhe
t 2 53.824 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 60.502 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04dhe
t 2 101.5 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 108.178 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 114.856 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04kre
t 2 124.474 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04dhe
t 2 136.696 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 143.374 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04dha
t 2 154.476 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
t 2 158.914 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04re
t 2 163.632 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04ki
t 2 167.468 0.0 1.0 1.03245 0.0 0.0 0.0 0.0 0.0
_04te
```

Haydn-Mozart Quartet Quiz

(machine learning/information theory)

The Haydn/Mozart String Quartet Quiz

Can you tell the difference between the musical styles of Haydn and Mozart?

This website tests how well you can distinguish between the string quartets of these two composers. You will listen to randomly selected movements composed by either [Mozart](#) or [Haydn](#). Then, you will choose the composer you think wrote the music you have just heard.

Digital scores for the quartet quiz have been provided by the [Center for Computer Assisted Research in the Humanities](#) at Stanford University. Click the start button below to answer some questions about your musical knowledge and then start the quiz...

start

- [View current identification statistics](#)

Brought to you by Craig Sapp and Yi-Wen Liu, Stanford University.



or ...



Yi-Wen Liu,
C. Sapp (2002-04)
-**entropy study (EE)**
[qq.themefinder.org]

Themefinder (melodic search)

- Huron, Kornstädt, Sapp, et al. (1996)


themefinder.org

Similarity studies

[Take the Quartet Quiz.](#)

<i>Repertory</i>	<input type="text" value="Classical"/>	? type of music to search
<i>Pitch</i>	<input type="text"/>	? A-G, sharp=#, flat=- e.g. C E- G F#
<i>Interval</i>	<input type="text"/>	? maj=M, min=m, aug=A, dim=d per=P, fifth=5, up=+, down=-. e.g. +m9 -P8 +M3 P1
<i>Scale Degree</i>	<input type="text"/>	? do=1, re=2, mi=3, fa=4, so=5, la=6, ti=7 (mode insensitive). e.g. 34554321
<i>Gross Contour</i>	<input type="text"/>	? up=/, down=\, unison=-. e.g. //\-/ or uudsu
<i>Refined Contour</i>	<input type="text"/>	? up step=u, up leap=U, down step=d, down leap=D, same=s. e.g. uUDsdu
<i>Location</i>	<input checked="" type="radio"/> beginning of theme only, or <input type="radio"/> anywhere in theme	?
<i>Key</i>	Any <input type="text"/> Mode: Any <input type="text"/>	?
<i>Meter</i>	<input type="text"/> / <input type="text"/>	?

Computer methodologies in music search

- Music geohash 
- Counterpoint/surfacing crawling
- Musical structure discovery via deep-learning algorithms (2016)
- Currently runs ETLep (data extraction, transformation, loading)



Melodic search in big data

- Sapp, Liu, Selfridge-Field (ISMIR, 2004)

Search effectiveness in large musical databases:

<http://ismir2004.ismir.net/proceedings/p051-page-266-paper135.pdf> (100,000 musical incipits)

- Sapp, Shanahan:

Rhythmic search in 1m+ incipits [RISM musical incipit database]

Studies comparing analytical tools

- Claire Arthur
MEI Proceedings (2015)
- Compares, Humdrum,
MEI
- Johanna Devaney, Hugh
Gauvin (Springer Verlag,
2016)
- Advocates extensions to
Humdrum and MEI

Stanford-related studies

LSJUMB (Stanford Band) repertory study

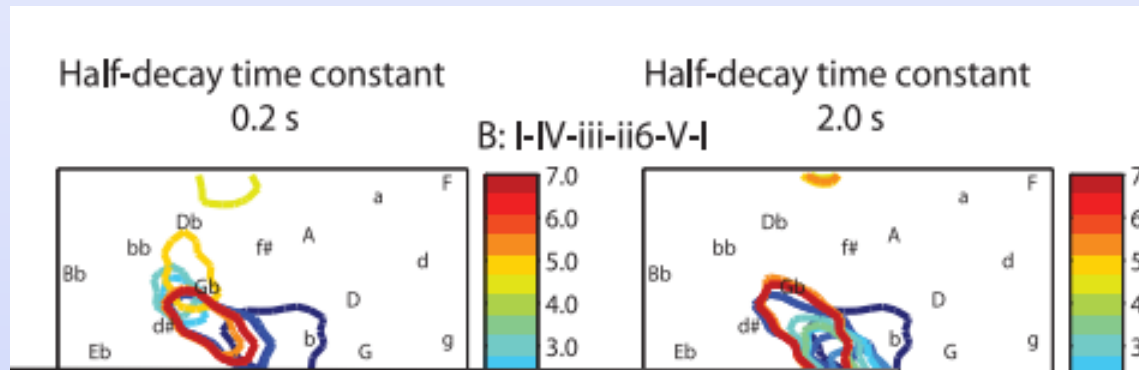
- <https://youtu.be/16Fvy3qXeaM?t=56>



Outside users: Neuromusicology



- Carol Krumhansl: Tonal, harmonic understanding
 - Their physiological correlates
- Petr Janata: specific-key perception
 - Neural correlates



Neuromusicology: movement/gesture

- Petri Toiviainen
 - Spatial-temporal music cognition
 - Perceived similarity and spontaneous dancing

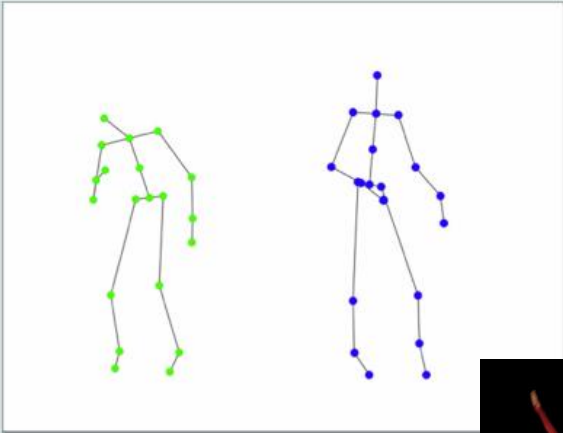


- Ari Patel
 - Avian perception of rhythm
 - [Snowball, the dancing cockatoo](#)



Please watch the video and then answer the questions on the right. When you are satisfied with your responses, click SAVE to save your answers.

SAVE ANSWERS



1) These dancers are interacting with each other
Strongly disagree Strongly agree

2) These dancers are dancing similarly to each other
Strongly disagree Strongly agree

3) Is one of the dancers leading and the other following?
 The green (left) dancer is leading The blue (right) dancer is leading Neither dancer is leading

4) How would you describe the way this dancers are moving and interacting? Further comments? (optional)

