

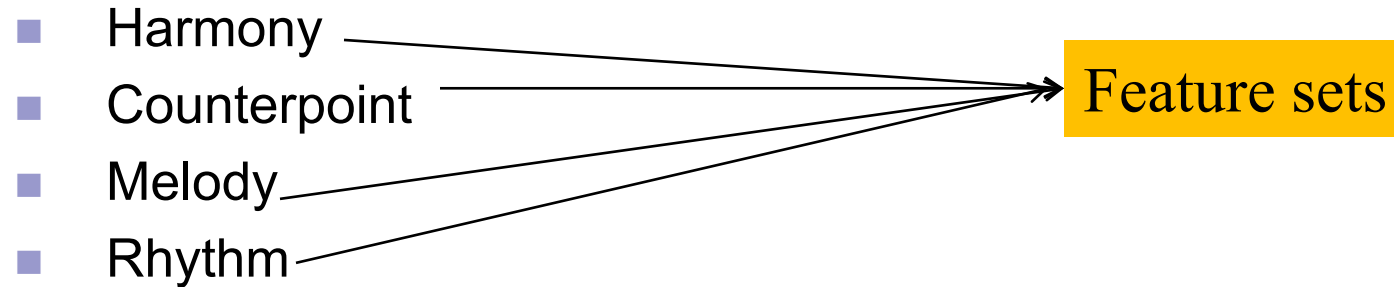
Analytical uses of Humdrum Tools

Music 253/CS 275A

Stanford University

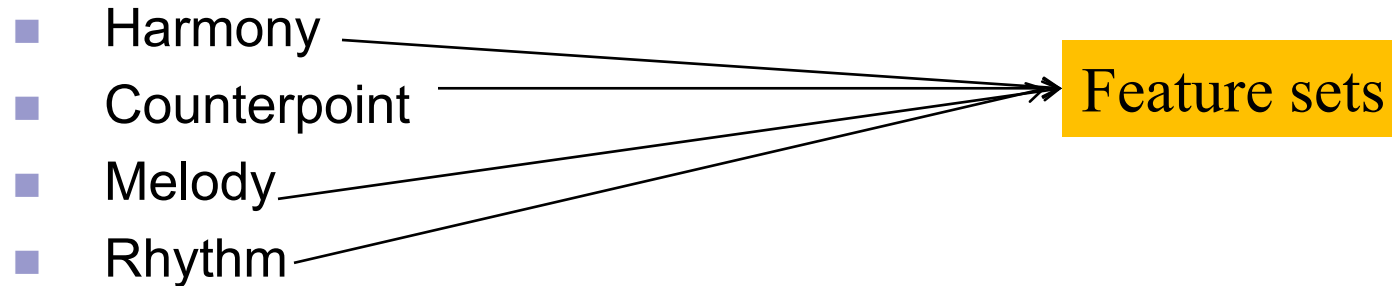
Traditional categories of music analysis

□ Traditional means of analysis



Traditional categories of music analysis

□ Traditional means of analysis



Humdrum = Toolset

****kern** = encoding format

>>Manual processes in music analysis

Riemann analysis

Handwritten Riemann analysis of a musical score. The score is in two systems, each with a treble and bass staff. The first system is labeled "unlabeled period" and the second "IAC". The analysis shows a sequence of chords: (I) vi I₄(7) IV I₆ vi I₄(9) IV I₆ V_{4/3}. The second system is labeled "DAC" and shows: V₅ I₅ I_{1b} I V₇ I.

Schenkarian analysis

Agmon, Conventional Harmonic Wisdom

Ex. 6

Musical score for Ex. 6, showing a sequence of chords in a piano setting. The chords are T, S, D, and T, each represented by a block of notes in the treble and bass staves.

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 shows a sequence of chords in a piano setting. The chords are labeled "i" and "V". The analysis shows a sequence of chords: i V.

first, last, highest, lowest: (014)

Musical score for first, last, highest, lowest: (014). The score shows a sequence of chords in a piano setting. The chords are labeled "i" and "V".

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

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



Sample Projects, Random Order

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, consisting of 8 staves. Each staff contains a line of music with Greek lyrics underneath. Brackets above the staff mark the family's opening and closing formulas. The lyrics are as follows:

1. Του λιθου σφραγισθεν τος υ πο των Ι ου δαιων

2. Του Γαβριηλ φθην ξα με νου σοι Παρ θε νε το χαρ τε

3. Εν τω θλιβε σθαι με εισαι κου σον μου των ο δου νων

4. Α γι ω Πνευ ματι πα σαι η ου σης και νουρ χει ται

5. δε ξι αι σου χει ρι λα βων συ λο γε

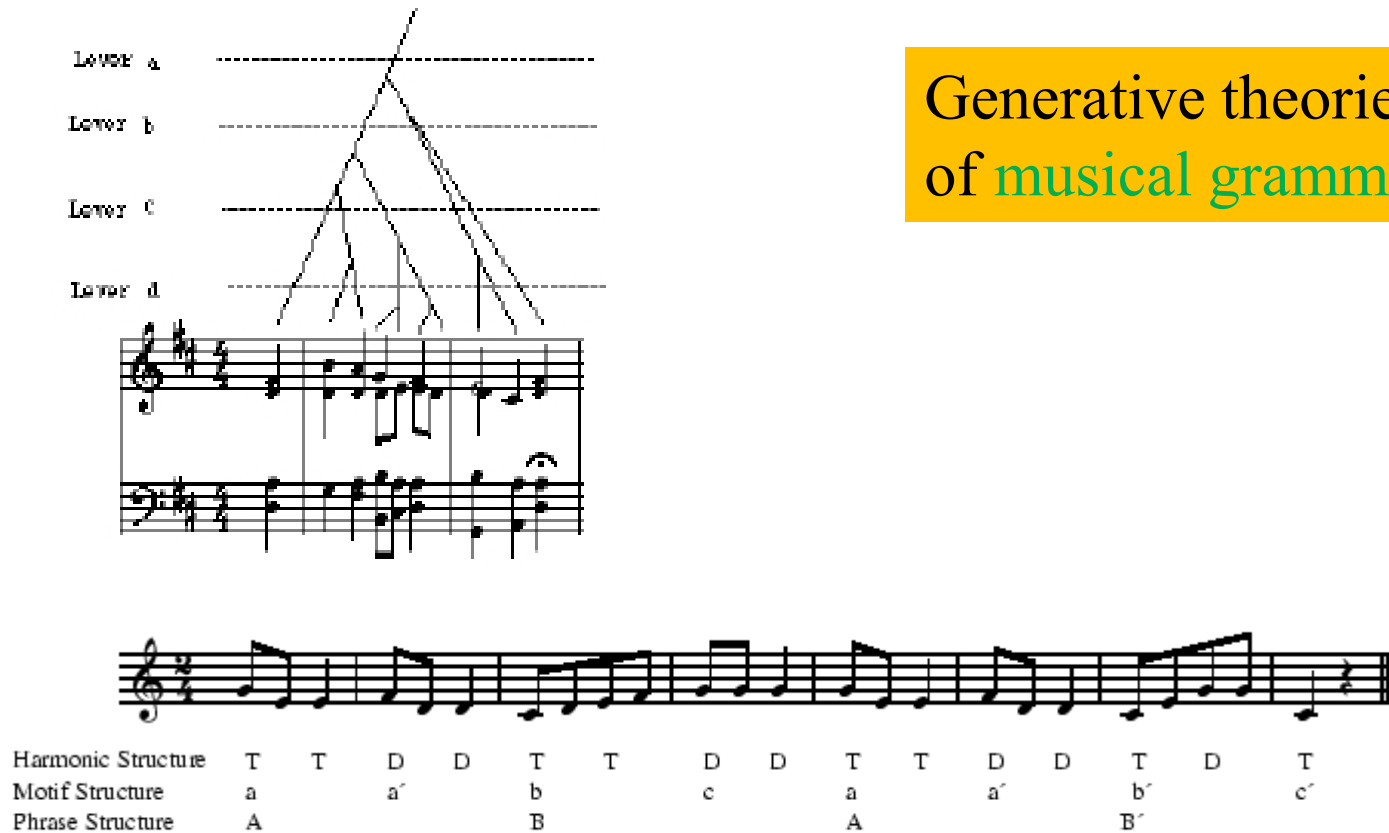
6. Τους ε ρη μι κοις αι παυ στας ο θει ος πο θος εγ γι νε ται

7. Α γι ω Πνευ ματι τι μη και δο ξαι ως περ Πατρι

8. Εις ται ο ρη των σων υ ψω σας με νο μων

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

Generative theories of musical grammar (1984)



Linear systems (species counterpoint)

Two-Voice Analysis

Vincentino: *L'artico musica* Vol. 4

A two-voice musical score in G major, 3/4 time. The treble staff contains a melody with figured bass notation below it: 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. The bass staff contains a simple harmonic accompaniment.

Several systems

Pedagogical orientation

Answer (Contrapunctus III)

A musical score for the Answer (Contrapunctus III) in G major, 3/4 time. The treble staff contains a melody. The bass staff contains a simple harmonic accompaniment. A red box highlights the first countersubject of the AOF, which is a descending eighth-note scale: G4, F#4, E4, D4, C4, B3, A3, G3.

First Countersubject of the AOF

Three-Voice Analysis

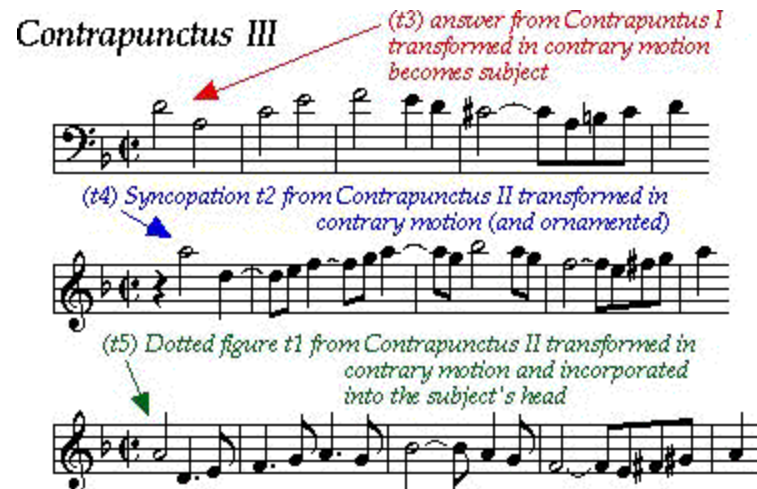
Robert Kelley

A three-voice musical score in G major, 3/4 time, by Robert Kelley. The staves are labeled A (Alto), T (Tenor), and B (Bass). The lyrics are: Ec - ce Do - mi - num nos - ter cum vir - tu - te ve - ni - et. The figured bass notation is: 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. The bass staff contains a simple harmonic accompaniment.

Imitative systems (18th-century counterpoint)



Timothy Smith, NAU



Music-theory applications

Generative chorale variations

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

The image displays a musical score for a chorale variation. The top staff is a vocal line in G major (one sharp) and 4/4 time, with the lyrics: "Al - le Men - schen m s - sen ster - ben, al - les Fleisch ver - was - da le - bet, muß ver - der - ben, soll es an - ders". The bottom two staves show a keyboard elaboration, featuring a complex, flowing melody in the right hand and a simpler, harmonic accompaniment in the left hand, both in G major and 4/4 time.

Chorale elaboration

Rhythm, Meter, Tempo (performance)

Simon Dixon, Gerhard Widmer, Walter Göbl (2004)

Comparative performance analysis

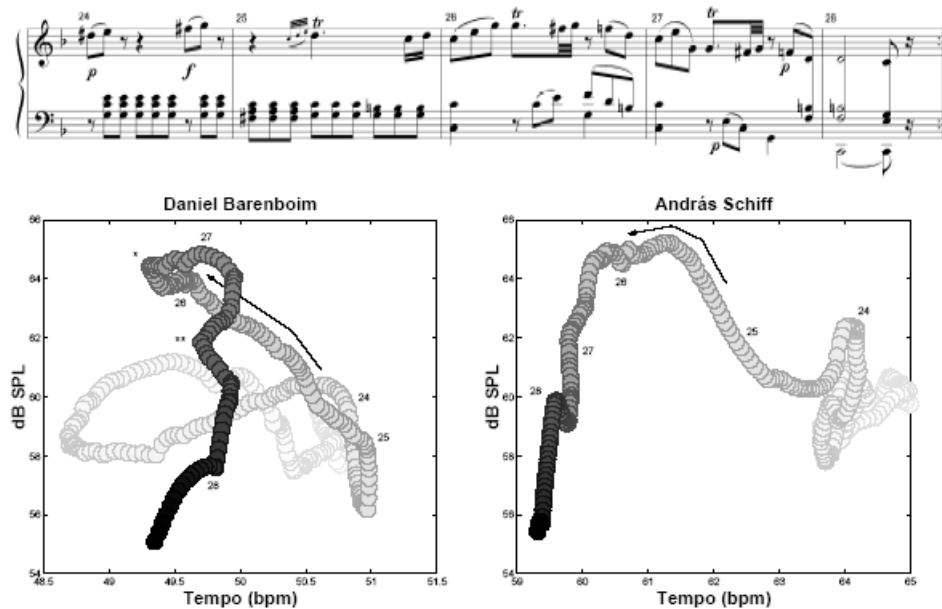


Figure 4. Expression trajectories over the last bars (mm.24–28) of the Mozart piano sonata K.279, second movement, first section, as played by Daniel Barenboim (left) and András Schiff (right). *x* axis: tempo in beats per minute; *y* axis: dynamics ('loudness') in decibel. The darkest point represents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

Computation perception

Gerhard Widmer, *Motherboard* (2016)

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

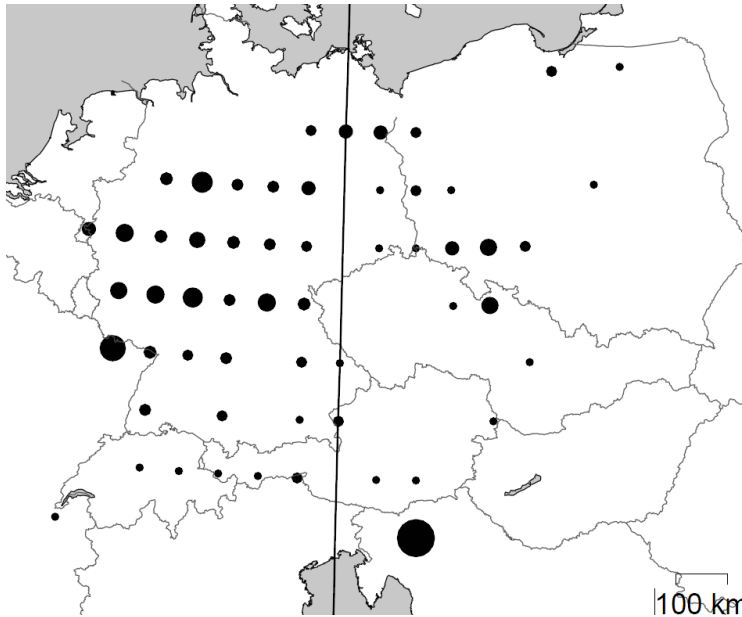
Computer Scientist Publishes Manifesto for Expressive Algorithmic Music

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

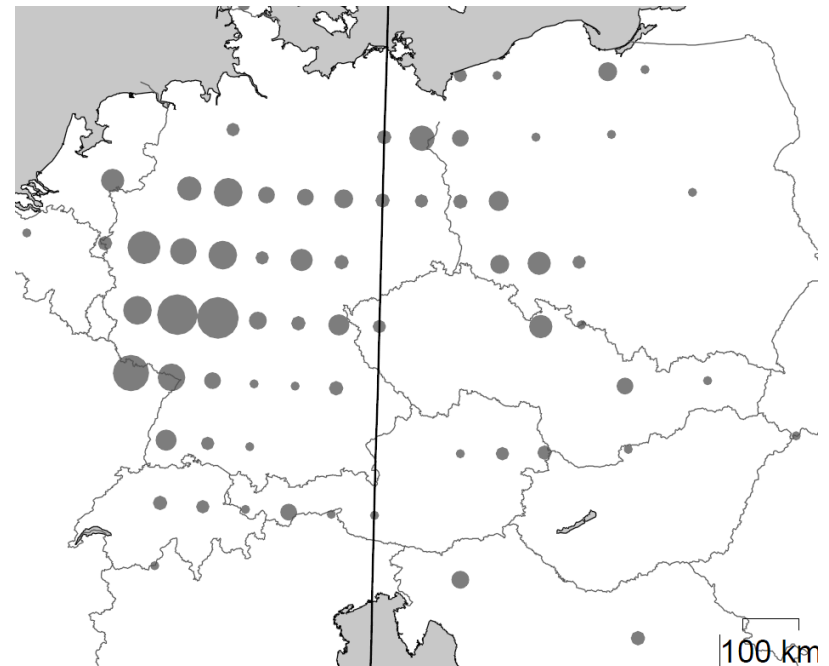


Geospatial mapping of musical features

- 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 dha ne 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 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.](#)

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

<http://ismir2004.ismir.net/proceedings/p051-page-266-paper135.pdf>

- Uses 100,000 musical incipits

- Also: Sapp, Shanahan: Rhythmic search in 1m+ incipits

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

Neuromusicology

- Carol Krumhansl: Tonal, harmonic understanding
 - Their physiological correlated
- Petr Janata: specific-key perception
 - Neural correlates
- Petri Toiviainen
 - Spatial-temporal music cognition

