FANTASTIC: A Feature Analysis Toolbox for corpus-based cognitive research on the perception of popular music

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Summary of a Research Project

M4S: *Modelling Music Memory and the Perception of Melodic Similarity (2006-2009)*

Question: How do Western listeners perceive melody?

Domain: Western commercial pop music

Method: Computational modelling

Outline

1. Results
   - Music Cognition
   - Popular Music Research
2. Methods
   - Computing Features with FANTASTIC
   - Modelling Music Knowledge from a Corpus
3. Background
   - Similar Approaches/Systems
   - Questions to be addressed

Results: Music Cognition I

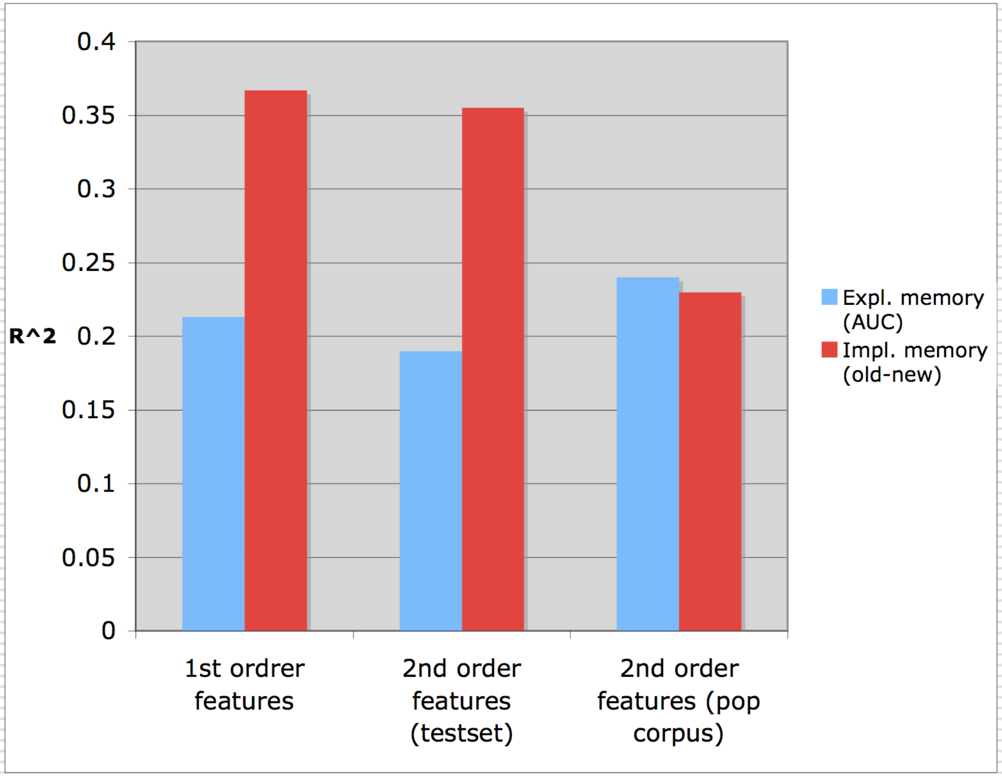
Memory for Melodies:

Are there structural features that make melodies more memorable?

How are listeners using musical knowledge to perform implicit and explicit memory tasks?

Results: Music Cognition I

Modelling explicit and implicit memory performance in a recognition paradigm (Müllensiefen, Halpern & Wiggins, in prep.)



Results:

- Memory performance is partially explained by musical features
- Implicit memory is better explained by raw features or local context
- Explicit memory draws on domain knowledge and features that are distinctive wrt corpus

Results: Music Cognition II

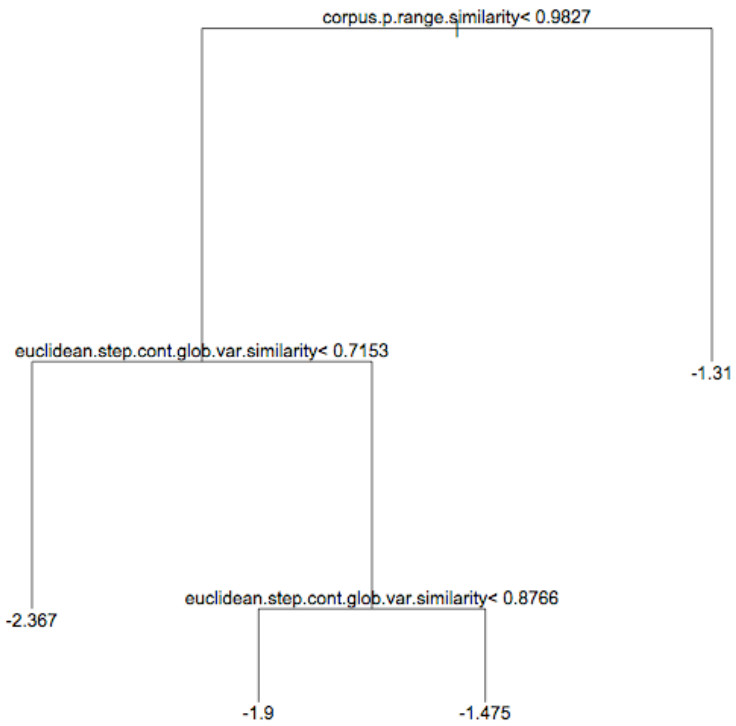
Montreal Battery of Amusia, MBEA, (Peretz et al., 2003):

What makes some test items more difficult than others?

What information do subjects actually use to process tasks?

Results: Music Cognition II

Modelling item difficulty in MBEA (Stewart, Müllensiefen & Cooper, in prep)



Results:

- 70-80% of item difficulty can be explained with as few as three musical features
- Relation between item difficulty and features is often non-linear
- Some subtests don't measure what they are believed to measure (e.g. scale)

Results: Pop Music Research I

Court cases of music plagiarism:

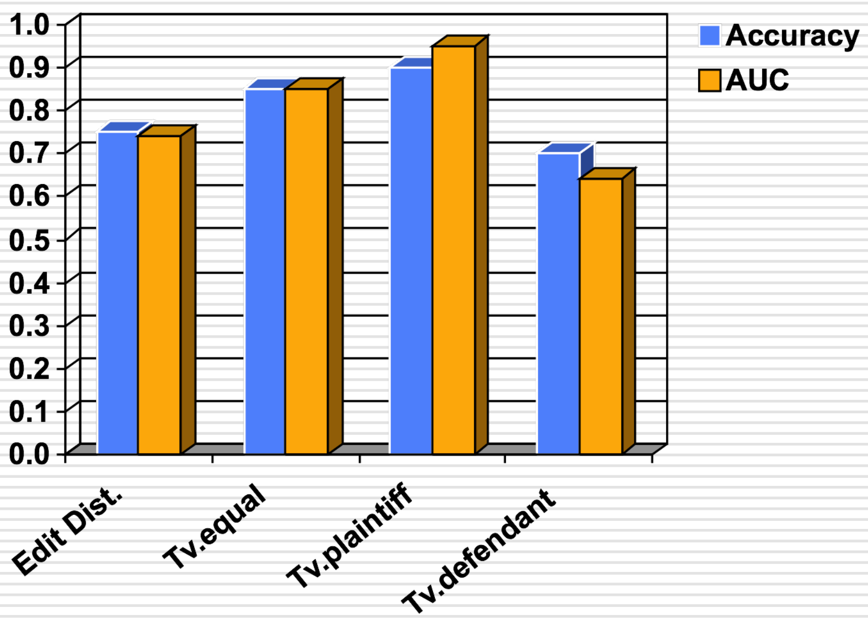
Are court decisions predictable from melodic structures?

What musical information is used in court decisions?

Results: Pop Music Research I

Model court decisions on melody plagiarism

(Müllensiefen & Pendzich, 2009)



Results:

- Court decisions can be closely related to melodic similarity
- Plaintiff's song is often frame of reference
- Statistical information about commonness of melodic elements is important

Results: Pop Music Research II

Melodic structure and popularity:

Does popularity correlate with certain structural features of a tune?

Results: Pop Music Research II

Identify features of commercially successful songs on *Revolver*
(Kopiez & Müllensiefen, 2008)

Criterion for commercial success: Entered charts as cover version (yes/no)

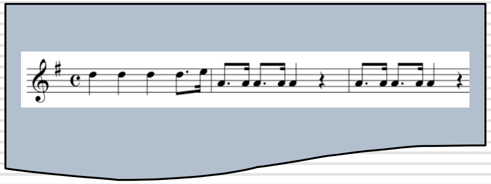
$$p\ (\text{chart\_entry} = 1) = \frac{1}{1 + e^{-(772.4\ +141.2\ \cdot\ \text{pitch\_range}\ -\ 4731.3\ \cdot \text{pitch\_entropy})}}$$

Results:

- 2 features (pitch range and entropy) are sufficient for fully accurate classification into successful / unsuccessful songs
- Plausible interpretation as compositional exercise: *Invent a chorus melody such that it has a large range and uses only few pitches much more frequently than the majority of its pitches*

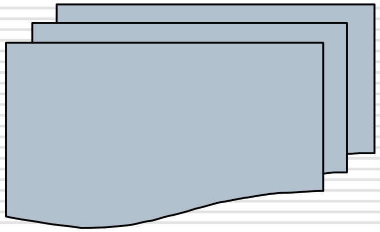
Method

Two Components



$$i.abs.std = \sqrt{\frac{\sum_i \left(|\Delta p_i| - \overline{|\Delta p|}\right)^2}{N-1}} = 2.83$$

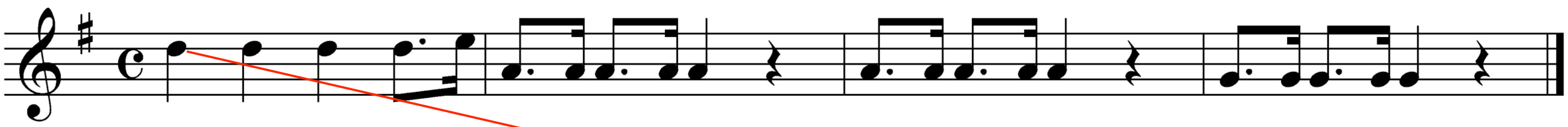
Feature Computation



Knowledge from a large corpus of music

Method: Feature Computation

Pre-requisite: Transformation from notes to numbers



L	Typ	Anfang	Ende	Länge	Wert 1	Wert 2
	Note	1. 1. 1. 5	1. 1. 4.102	0. 3. 97	D4	69
	Note	1. 2. 1. 14	1. 2. 4. 98	0. 3. 84	D4	65
	Note	1. 3. 1. 10	1. 3. 4. 94	0. 3. 84	D4	67
	Note	1. 4. 1. 6	1. 4. 3. 87	0. 2. 81	D4	65
	Note	1. 4. 3.119	1. 4. 4. 93	0. 0. 94	E4	64
	Note	2. 1. 1. 2	2. 1. 3.101	0. 2. 99	A3	69
	Note	2. 1. 4. 13	2. 1. 4.107	0. 0. 94	A3	64
	Note	2. 2. 1. 14	2. 2. 3. 95	0. 2. 81	A3	65
	Note	2. 2. 4. 7	2. 2. 4.103	0. 0. 96	A3	64
	Note	2. 3. 1. 10	2. 3. 4. 94	0. 3. 84	A3	67
	Note	3. 1. 1. 2	3. 1. 3.101	0. 2. 99	A3	69
	Note	3. 1. 4. 13	3. 1. 4.107	0. 0. 94	A3	64
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	Note	4. 1. 1. 2	4. 1. 3.101	0. 2. 99	G3	69
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	Note	4. 3. 1. 10	4. 3. 4. 94	0. 3. 84	G3	67

Method: Summary Features

Cognitive Hypothesis: Listeners abstract summary representation of short melodies during listening

Format: Value that represents particular aspect of melody

Ex. 1: Pitch range (p.range):

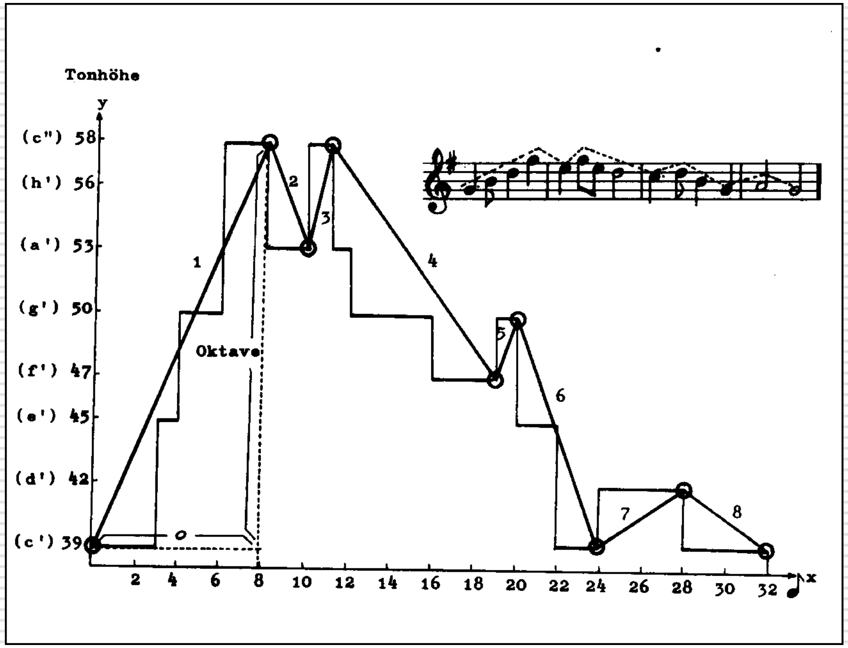
$$p.range = \max(p) - \min(p)$$

Ex. 2: Standard deviation of absolute intervals (i.abs.std):

$$i.abs.std = \sqrt{\frac{\sum_i \left(|\Delta p_i| - \overline{|\Delta p|} \right)^2}{N-1}}$$

Method: Summary Features

Ex. 3: Relative number of direction changes in interpolated contour representation (int.cont.dir.changes)

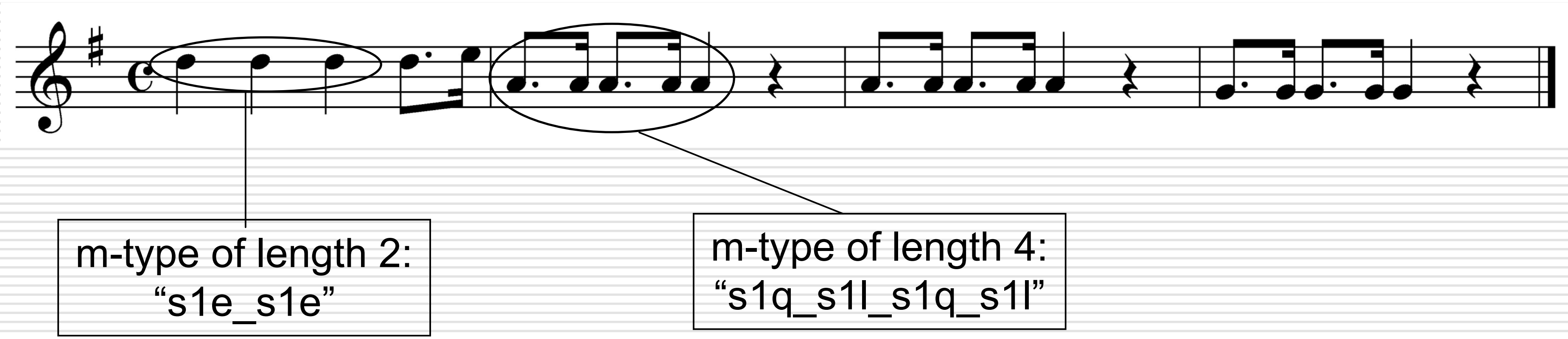


$$int.cont.dir.changes = \frac{\sum_{sgn(x_i)\neq sgn(x_{i+1})} 1}{\sum_{x_i \neq x_{i+1}} 1}$$

Method: m-type Features

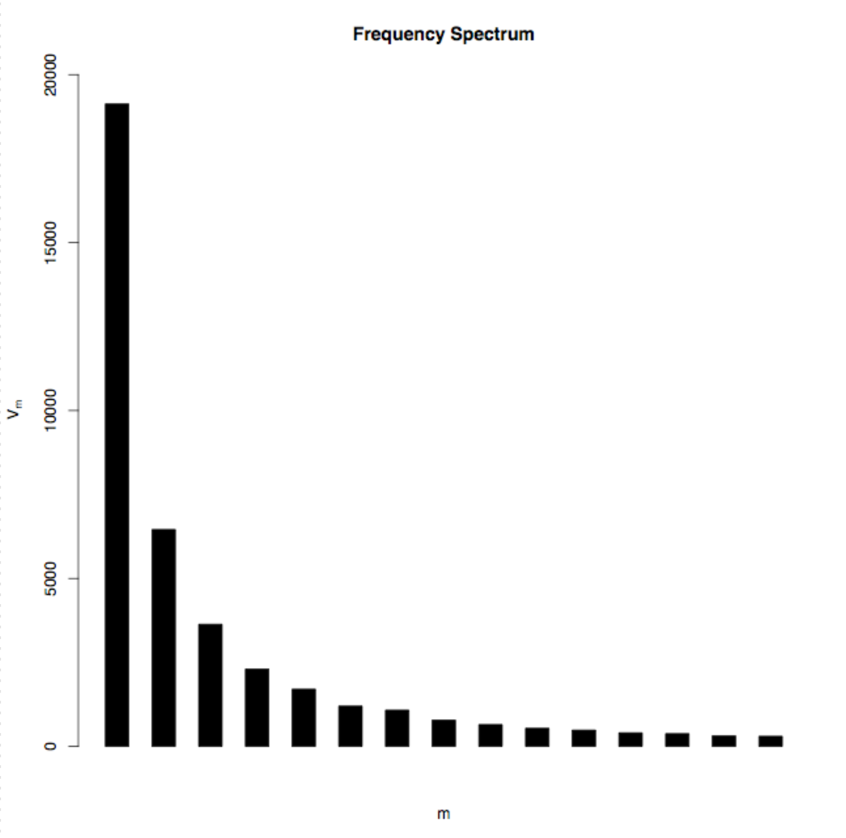
Cognitive Hypothesis: Listeners use literal representation of short subsequences of melody for processing

Format of m-type: String of digits (similar to “word type” in linguistics)



Method: m-type Features

Format of m-type feature: Number that represents distribution of m-types in melody



$$mean.Honores.H = \frac{1}{|n|} \cdot 100 \cdot \frac{\log N}{1.01 - \frac{V(1,N)}{V(N)}}$$

Method: M4S publications on features

- Melodic Contour (Müllensiefen, Bonometti, Stewart & Wiggins, 2009; Frieler, Müllensiefen & Riedemann, in press; Müllensiefen & Wiggins, under review)
- Phrase segmentation (Pearce, Müllensiefen & Wiggins, 2008; accepted)
- Harmonic content (Mauch, Müllensiefen, Dixon & Wiggins, 2008; Rhodes, Lewis & Müllensiefen, 2007)
- Melodic accent structure (Pfleiderer & Müllensiefen, 2006; Müllensiefen, Pfleiderer & Frieler, 2009)

Method: Using a music corpus

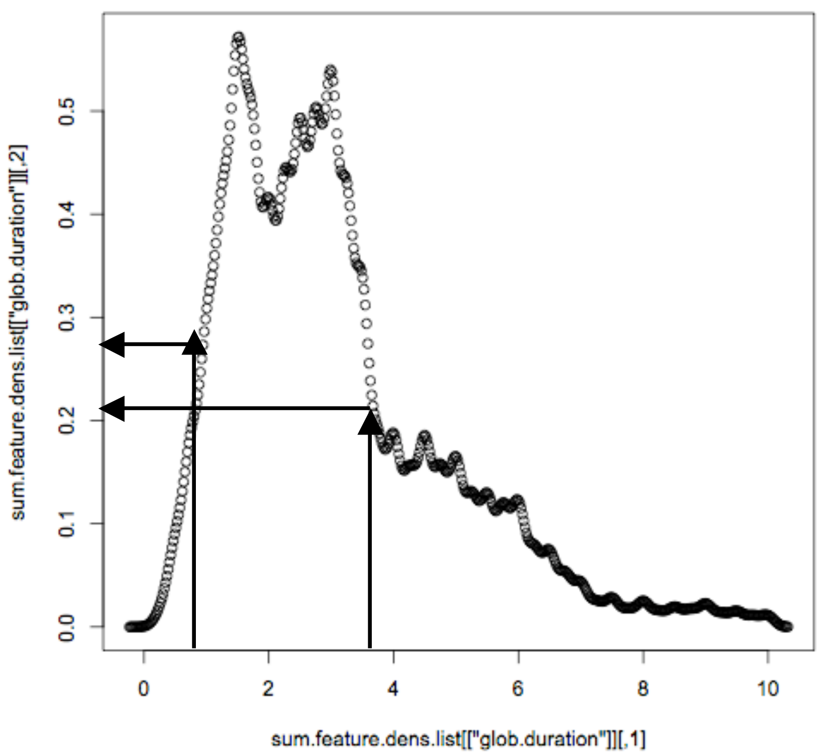
The M4S Corpus of Popular Music (Müllensiefen, Wiggins & Lewis, 2008):

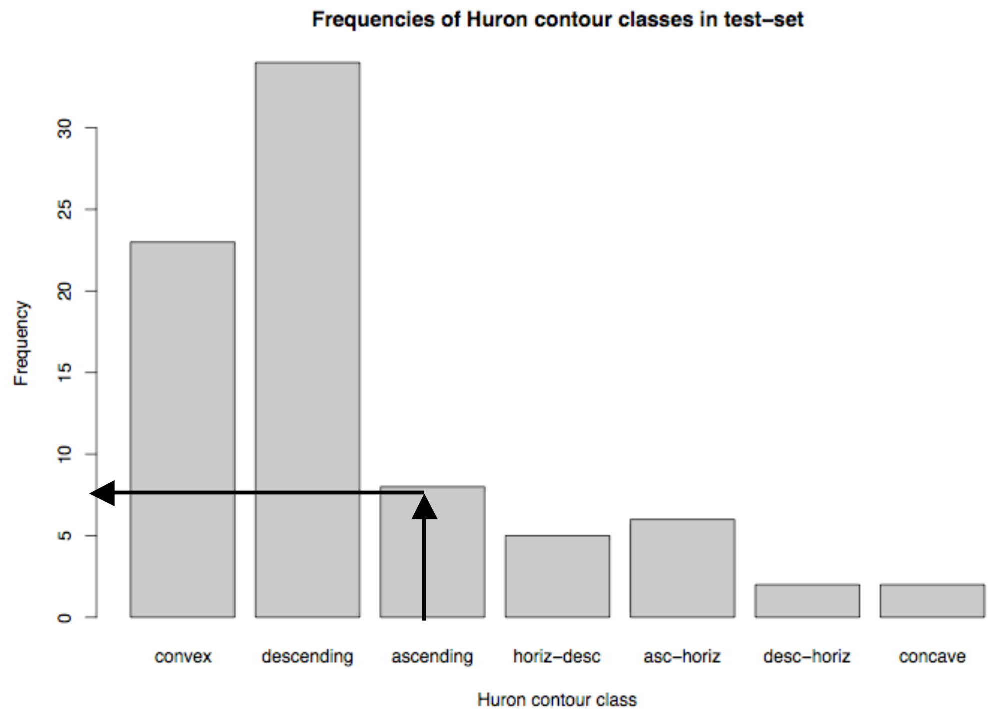
- 14,067 high-quality MIDI transcriptions
- Representative sample of commercial pop songs from 1950 - 2006
- Complete compositional structure (all melodies, harmonies, rhythms, instrumental parts, lyrics)
- Some performance information (MIDI patches, some expressive timing)

Using a music corpus:
2nd order summary features

Cognitive Hypothesis: Listeners encode commonness of feature value

Method: Replacing feature values by their relative frequencies





Using a music corpus: 2nd order m-type features

Cognitive Hypothesis: Listeners are sensitive to commonness of m-types

Method: Use frequency information on m-types from large corpus

Example: Normalised distance of m-type frequencies in melody and corpus *(mtcf.norm.log.dist)*

=> measures whether uncommon m-types are used rather frequently in melody

$$mtcf.norm.\log.dist = \frac{\sum_{\tau_i \in m} \left| TF'_{\tau_i} - DF'_{\tau_i} \right|}{\left| TF_{\tau \in m} \right|}$$

Method: Summary

Feature ANalysis Technology Accessing STatistics In a Corpus:

FANTASTIC

- Open source tool box for computational analysis of melodies*
- 58 features currently implemented
- Ideas from: Descriptive statistics, music theory, music cognition, computational linguistics, music information retrieval
- 2 feature categories: Summary features and m-type features
- Context modelling via integration of corpus: 2nd order features

* http://www.doc.gold.ac.uk/isms/m4s/?page=Software%20and%20Documentation

Background: Similar approaches

Folk Song Research / Ethnomusicology

- Bartók (1936), Bartók & Lord (1951)
- Lomax (1977)
- Steinbeck (1982)
- Jesser (1992)
- Sagrillo (1999)

Popular Music Research

- Moore (2006)
- Kramarz (2006)
- Furnes (2006)
- Riedemann (in prep.)

Computational / Cognitive Musicology

- Eerola et al. (2001, 2007)
- McCay (2005)
- Huron (2006)
- Frieler (2008)

Background: Questions to be addressed

Popular Music Research

Questions: How does melodic structure relate to

- Popularity and selection processes
- Style
- Transmission processes
- Specific types of behaviour (e.g. singalongability)
- Value attribution (originality, creativity)

Music Cognition Research

Questions: How does melodic structure relate to

- Memory performance and memory errors
- Similarity judgements
- Expectancy
- Preference / aesthetic judgements

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