Testing Different Models of Melodic Contour

Daniel Müllensiefen, Melanie Bonometti, Lauren Stewart, Geraint Wiggins
Goldsmiths, University of London
This paper is about …

a comparison between different models of melodic contour and their cognitive usefulness.

We present

• some background and motivation,
• the four contour theories compared,
• the setup of the experiment, and
• results
Melodic Contour is important for …

- composing and structuring melodies (Toch, 1923; Jeppesen, 1935; Hindemith, 1940; Perricone, 2000; Kachulis, 2003; Bradford, 2005)
- analysing and classifying melodies (Meyer, 1956; Rosen, 1971; de la Motte, 1993)
Melodic Contour has been defined formally ...

- as contour classes (Huron, 1996)
- as Fourier coefficients (Schmuckler, 1999)
- as polynomial coefficients (Müllensiefen & Wiggins, submitted)
- as interpolation lines (Steinbeck, 1982; Zhou & Kankanhalli, 2003)
- as symbol sequences (Parson, 1975; Kim et al., 2000; Pauws, 2000; Müllensiefen & Frieler, 2004)
- as step curves (Juhasz, 2000; Eerola & Toiviainen, 2004)
- as matrix of interval relationships (Friedmann, 1985; Marvin & Laprade, 1987; Quinn, 1999)
Our motivation:

Compare different contour representations and find one that:

- can be implemented in a computer program
- has a level of abstraction comparable to what human listeners extract
- is useful for modelling human melody processing
- allows for a compact representation as a feature to characterise melodies and be part of the FANTASTIC* analysis toolbox

*http://www.doc.gold.ac.uk/isms/mmm/?page=Software%20and%20Documentation
The compared models

- **Huron’s Contour** (Huron, 1996)
- **Interpolation Contour** (Steinbeck, 1982; Müllensiefen & Frieler, 2004)
- **Polynomial Contour** (Müllensiefen & Wiggins, submitted)
- **Step Contour** (Eerola & Toiviainen, 2004)
• 1 parameter (categorical, 9 classes)
• Depends on: ordinal relation between $p_1$, mean($p_2,\ldots,p_{n-1}$), $p_n$
Contour Categories

Melody 1
Interpolation Contour

- A variable number of parameter pairs (line gradient, length), usually 1 to 5.
- Depends on: Number of reversals of pitch direction and exclusion of change notes.
Polynomial Contour

- 8 numerical parameters (polynomial coefficients)
- Depends on: Capacity of pitch and onset data to be approximated by polynomial shapes
Step Curve Contour

- $n$ numerical parameter pairs (pitch, IOI) for $n$ notes
- Depends on: pitch values and IOIs of all notes
Experiment

• Paradigm:
  - Audio–visual shape assignment task
  - Assumption: Visual recoding of note sequence is inherent in cognitive contour processing (e.g. Balch & Muscatelli, 1986; Prince et al., 2009)
  - 4x10 practice trials
  - 4x20 trials, including 5 repetition trials
  - Complete randomisation, individual testing

• Participants:
  - 85 adults (mean age: 21.2, normal vision, hearing)
  - no selection for musical background (‘college population’)

• Dependent variables:
  - Response Times
  - Intra–subject consistency
  - Inter–subject consistency
  - Subject–Model consistency (i.e. accuracy)

• Independent Variable: Contour Representation (4–level factor)
Working definition of melodic contour in instructions:

“An image that represents the melody just heard”
Example Trial

1

2

3

4
Results
Results: Reaction Times

Reaction Times by Contour Model

Mean Response Times in Milliseconds, incl. 95% confidence intervals
Results: Subject–Model Accuracy

Response Accuracies by Contour Model

<table>
<thead>
<tr>
<th></th>
<th>Step</th>
<th>Huron</th>
<th>Curve</th>
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Percentage of Correct Responses, incl. 95% confidence intervals
Results: Inter-Subject Agreement

Values of Fleiss' kappa by contour representation

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<tr>
<th>Contour</th>
<th>Kappa</th>
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<tr>
<td>Step</td>
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</tbody>
</table>
Results: Intra-Subject Agreement

*Intra-Subject Agreement by Contour Model*

Correct Identical Answers as Proportions of Identical and Correct Answers

Proportions of Identical Answers for Repeated Items, incl. 95% confidence intervals
Summary

- Step Contour takes longest to process
- Step Contour significantly better in terms of
  - Model–Subject Agreement
  - Inter–Subject Agreement
  - Proportion of correct ∧ identical responses

⇒ supports assumption of contour as a representation for conscious processing (Dowling et al., 1995)
Next steps

• Look at individual differences
• Implement features characterising step contour curves (*FANTASTIC*):
  - Global Variation
  - Global Direction
  - Local Variation
• Create Contour Space
• Test: Distance in feature space ~ distance in cognitive space?
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