Comparing rhythm in speech and music: the case of English and Polish

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Language and music

- appear in every society, even if other aspects of culture are absent (Nettl 2000)
Language and music

- prosodic and musical processing share resources at certain neural levels (Patel 2008)
  - forming learned sound categories
  - extracting regularities from rhythmic sequences
  - integrating incoming elements into syntactic structures
Language and music

● an evolutionary perspective (Mithen 2007)
  ○ human minds have been shaped by natural selection for music
  ○ co-evolution of music and language
  ○ the existence among Neanderthals of a peculiar proto-music/language
Language and music

- Linguists have borrowed musicological concepts in building prosodic theories (Liberman 1975)
- Musicologists have used tools from linguistic theory to describe musical structure (Lerdahl & Jackendoff 1983)
Language rhythm

- no universally accepted definition of rhythm
  - the systematic organisation of prominent and less prominent speech units in time (Dellwo 2006)
    - speech units: e.g. syllables, vocalic intervals
    - prominence: higher duration, intensity, frequency
- all languages are rhythmically organised
Rhythmic classification

- isochrony (Pike 1945; Abercrombie 1967)
  - syllable-timed languages
    - syllables of equal duration
      - e.g. French, Italian, Spanish
  - stress-timed languages
    - patterns of equal duration between stressed syllables
      - e.g. English, German, Dutch
Rhythmic classification

**syllable timing:** (syllable isochrony = here: 11 equally timed syllables)

**stress timing:** (foot or interstress isochrony = here: 3 equally timed feet)

- Red = prominent syllable
- Blue = non-prominent syllable
Rhythmic classification

- Dauer (1983)
  - gradient feature, not an absolute one
  - all languages are more or less stress-based
  - rhythmic diversity results from combinations of phonological, phonetic, lexical and syntactic facts associated with different languages
    - syllable structure
    - vowel reduction
    - word stress
Rhythmic classification

- **Nespor (1990)**
  - rhythmically intermediate languages exhibit some properties associated with stress-timing and some associated with syllable-timing
  - neither a dichotomous view nor a continuous classification system can adequately account for the rhythmic properties of such languages
    - Polish classified as stress-timed but doesn’t have vowel reduction
    - Catalan classified as syllable-timed but has vowel reduction
Rhythm measurements

- finding acoustic correlates of language rhythm in the speech signal
  - Roach (1982)
    - stress-timed languages allow complex consonant clusters
      - higher variation or content of complex consonant clusters
    - stress-timed languages allow vowel reduction
      - higher variation or content of vocalic intervals
**Rhythm measurements**

- **Grabe & Low (2002)**
  - nPVI: normalized pairwise variability index for vocalic intervals
    - measures the degree of durational contrast between successive elements in a sequence
    - developed to explore rhythmic differences between stress-timed and syllable-timed languages

\[
nPVI = \frac{100}{m - 1} \times \sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{2} \right|
\]
Rhythm measurements

High nPVI
Large contrast between neighboring durations

Low nPVI
Small contrast between neighboring durations
Rhythm measurements

Ramus (2002)
Comparing rhythm in speech and music

- Patel & Daniele (2003)
  - the prosody of a composer’s native language can influence the structure of his or her instrumental music (Abraham 1974; Wenk 1987)
  - little empirical work comparing rhythm across domains
    - Kirkpatrick (20th c. harpsichordist) claimed that French music sounded like the French language
    - Hall (1953) suggested a resemblance between Elgar’s music and British speech
Comparing rhythm in speech and music

- method (Patel & Daniele 2003)
  - speech nPVI values
    - obtained from recordings of 20 news-like utterances in English and French
    - vocalic durations
  - musical nPVI values
    - obtained directly from music notation
    - 137 English and 181 French musical themes
      - 19th-20th c. classical music (musical nationalism)
      - instrumental music only
Comparing rhythm in speech and music

- music reflects patterns of durational contrast between successive vowels in spoken sentences

Pilot study

● English vs. Polish
  ○ English: high nPVI
  ○ Polish: low nPVI

● classical music vs. folk music
  ○ Polish classical music nPVI lower than English?
  ○ folk music nPVI more similar to speech?
<table>
<thead>
<tr>
<th>English</th>
<th>Polish</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ complex syllable structure</td>
<td>○ complex syllable structure</td>
</tr>
<tr>
<td>○ trochaic rhythm type</td>
<td>○ trochaic rhythm type</td>
</tr>
<tr>
<td>○ no fixed stress</td>
<td>○ penultimate</td>
</tr>
<tr>
<td>○ stress-timed language</td>
<td>○ syllable-timed language/mixed</td>
</tr>
<tr>
<td>○ complex consonant clusters</td>
<td>○ complex consonant clusters</td>
</tr>
<tr>
<td>○ complex vowel system</td>
<td>○ simple vowel system</td>
</tr>
</tbody>
</table>
20 news-like utterances

- *This supermarket had to close due to economic problems.*
- *A hurricane was announced this afternoon on the TV.*
- *No welcome speech will be delivered without the press offices’ agreement.*

- *Straż pożarna dostała zgłoszenie o pożarze pociągu.*
- *Biuro podróży zobowiązało się do pokrycia kosztów transportu.*
- *W pełnym słońcu odczuwalna temperatura wynosi ponad czterdzieści stopni.*
Vowel measurements
Classical music

- English
  - Edward Elgar (1857-1934)
  - Frederick Delius (1862-1934)
  - Ralph Williams (1872-1958)
  - Gustav Holst (1874-1934)
  - John Ireland (1879-1962)
  - Arnold Bax (1883-1953)
Classical music

- Polish
  - Fryderyk Chopin (1810-1849)
  - Henryk Wieniawski (1835-1880)
  - Władysław Żeleński (1837-1921)
  - Juliusz Żarębski (1854-1885)
  - Ignacy Jan Paderewski (1860-1941)
  - Karol Szymanowski (1882-1937)
Classical music

- **20 English and Polish classical music themes**
  - Symphony No. 1 in A Flat Op. 55 by Edward Elgar
  - Sonata For Violin And Piano by Frederick Delius
  - A London Symphony by Ralph Williams
  - The Planets by Gustav Holst
  - Violin Sonata No.1 in D minor by John Ireland
  - Sonata For Viola And Piano by Arnold Bax
  - Piano Sonata No. 1 Op. 4 by Fryderyk Chopin
  - Violin Concerto Op. 14 by Henryk Wieniawski
  - Mazurka Op. 31 by Władysław Żeleński
  - Polonaise Op. 10 by Juliusz Zarębski
  - Piano Sonata Op. 21 by Ignacy Jan Paderewski
  - Violin Concerto Op. 35 by Karol Szymanowski
Folk music

Francis James Child (1825 - 1896)
*The English and Scottish Popular Ballads* (1882)
305 ballads from England and Scotland

Oskar Kolberg (1814 - 1890)
*Pieśni Ludu Polskiego* (1857)
41 ballads with regional variants
Folk music

- 20 English and Polish folk songs
  - *Barbara Allen*
  - *Edward*
  - *Robin Hood and the Tanner*
  - *The Elfin Knight*
  - *The Friar in the Well*
  - *The Three Ravens*
  - *Gdybym to Ja miała*
  - *Jasio Konie poił*
  - *Na Podolu Biały Kamień*
  - *Stała nam się Nowina miła*
  - *Tam za Warszawą na Błoniu*
  - *Wezmę Ja Kontusz*
Elgar’s Symphony No. 1, in A Flat, Opus 55, 4th movement, 2nd theme

- the first note is assigned a duration of 1, the durations of the remaining notes are expressed as multiples or fractions of this value
## Data

<table>
<thead>
<tr>
<th>Category</th>
<th>English</th>
<th>Polish</th>
</tr>
</thead>
<tbody>
<tr>
<td>total vowels</td>
<td>310</td>
<td>386</td>
</tr>
<tr>
<td>no. vowels/sentence mean</td>
<td>15.5</td>
<td>19.3</td>
</tr>
<tr>
<td>classical, total notes</td>
<td>364</td>
<td>362</td>
</tr>
<tr>
<td>classical, no. notes/theme mean</td>
<td>18.2</td>
<td>18.1</td>
</tr>
<tr>
<td>folk, total notes</td>
<td>327</td>
<td>353</td>
</tr>
<tr>
<td>folk, no. notes/theme mean</td>
<td>16.4</td>
<td>17.7</td>
</tr>
</tbody>
</table>
Results

![Results Graph](image)

- English speech
- English classical music
- English folk music
- Polish speech
- Polish classical music
- Polish folk music

The graph shows the results for different types of speech and music, measured in NPVI. The y-axis represents NPVI, ranging from 0 to 80.
Discussion

○ more speakers
○ more languages/accents/varieties
○ spontaneous speech (Thomas & Carter 2006)
○ more music themes
  ■ classical
  ■ folk / regional variants (McGowan & Levitt 2011)
  ■ music notation vs. live performances (Raju, Asu & Ross, 2010)
  ■ metrical hierarchies & musical rhythm (London & Jones 2010)
○ other units
  ■ syllables (Deterding 2001)
  ■ feet (Asu & Nolan 2006)
○ one unit for all languages?
○ different units for different languages?
Thank you for listening!
Notes on vowel measurements

- Vocalic intervals: stretch of signal between vowel onset and vowel offset, characterised by vowel formants, regardless of the number of vowels included in the section (Grabe & Low 2002)
- Vowels identified using generally accepted criteria (Peterson and Lehiste, 1960, Fischer-Jørgensen and Hutters, 1981)
  - in fricative-vowel sequences, the onset of the vowel was taken to be the onset of the second formant
  - in vowel-voiceless fricative sequences, the vowel was considered terminated where the noise pattern began
  - in vowel-voiced fricative sequences, the vowel was considered terminated at the onset of high frequency energy
  - nasal-vowel sequences were segmented by observing the fault transitions between nasal and vowel
  - the duration of a vowel was measured only if there was evidence of a voiced vowel in the acoustic signal