

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)

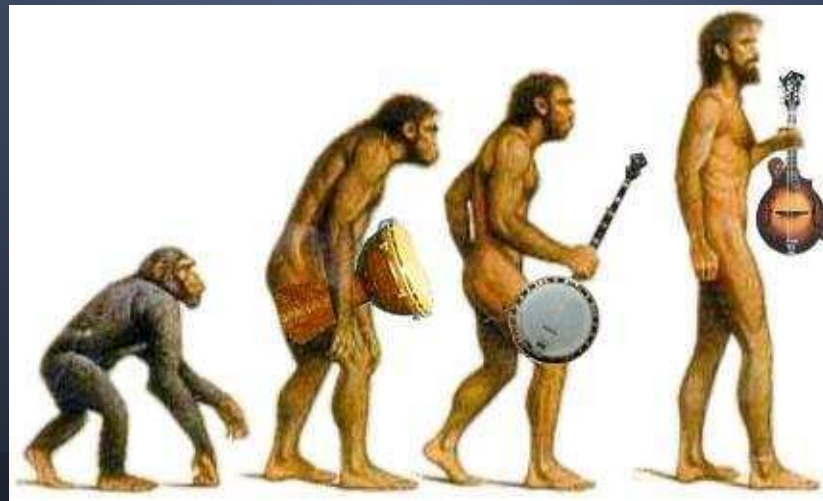


Language and music

- 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 (Lieberman 1975)
- musicologists have used tools from linguistic theory to describe musical structure (Lerdahl & Jackendoff 1983)

timbre

interval

accent

meter

tone

rhythm

melody

harmony

pitch

Language rhythm

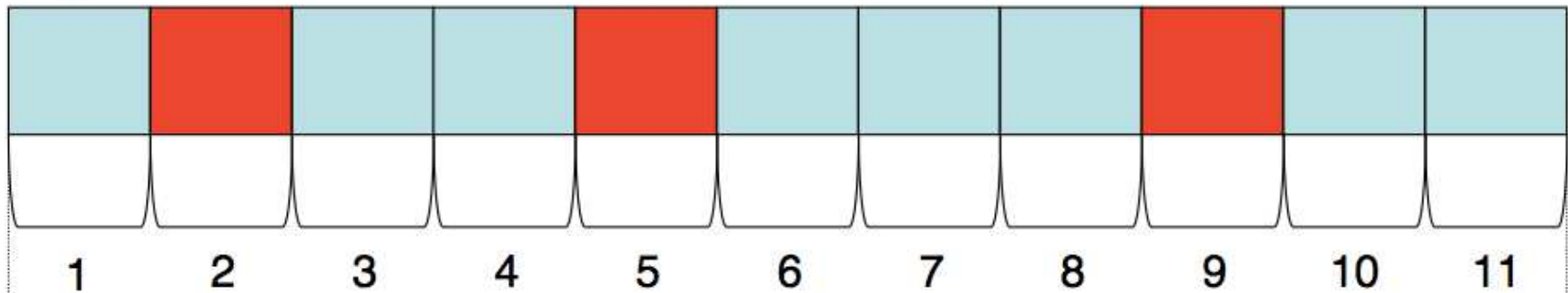
- no universally accepted definition of rhythm
 - the systematic organisation of prominent and less prominent speech units in time (Dellwo 2006)
 - speech units: e.g. syllables, vocalic intervals
 - prominence: higher duration, intensity, frequency
- all languages are rhythmically organised

Rhythmic classification

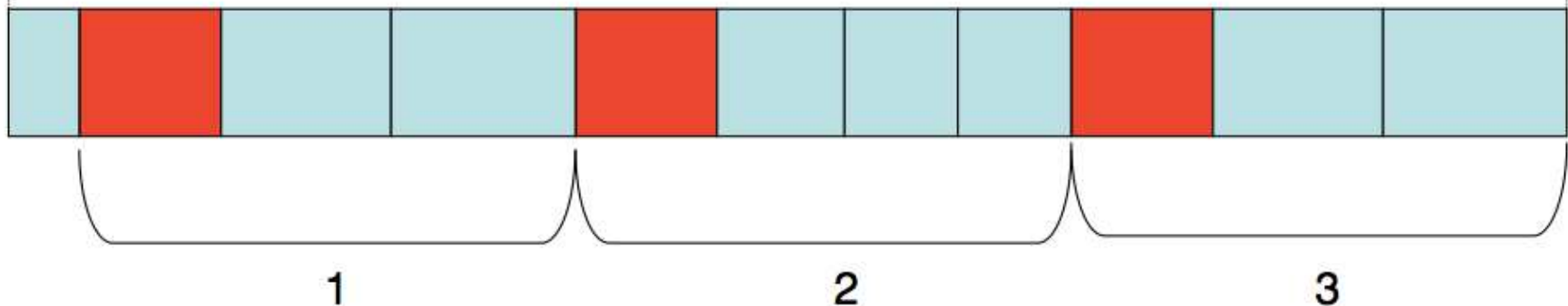
- isochrony (Pike 1945; Abercrombie 1967)
 - syllable-timed languages
 - syllables of equal duration
 - e.g. French, Italian, Spanish
 - stress-timed languages
 - patterns of equal duration between stressed syllables
 - e.g. English, German, Dutch

Rhythmic classification

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



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



 = prominent syllable  = 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

- Nespov (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

$$\text{nPVI} = \frac{100}{m-1} \times \sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{\frac{d_k + d_{k+1}}{2}} \right|$$

Rhythm measurements



High nPVI

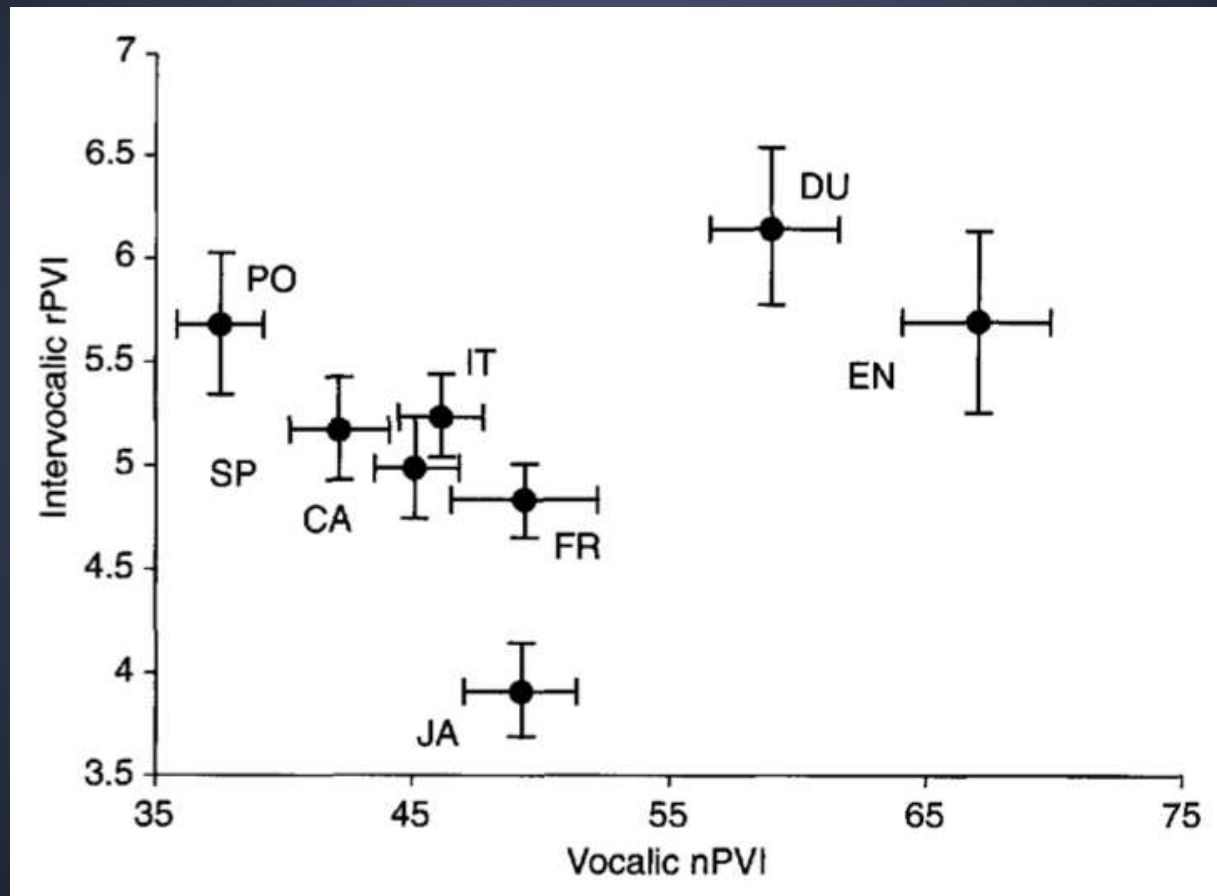
Large contrast
between
neighboring
durations



Low nPVI

Small contrast
between
neighboring
durations

Rhythm measurements



Ramus (2002)

Comparing rhythm in speech and music

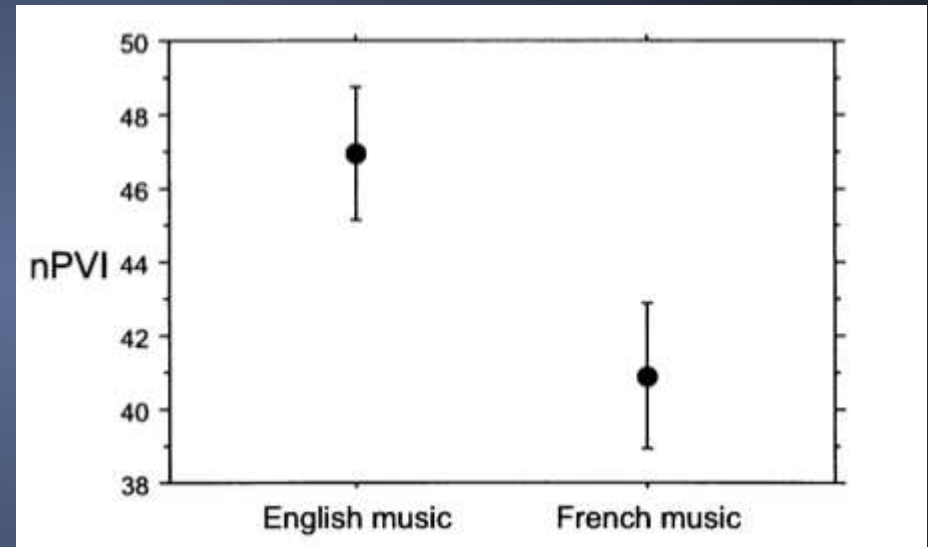
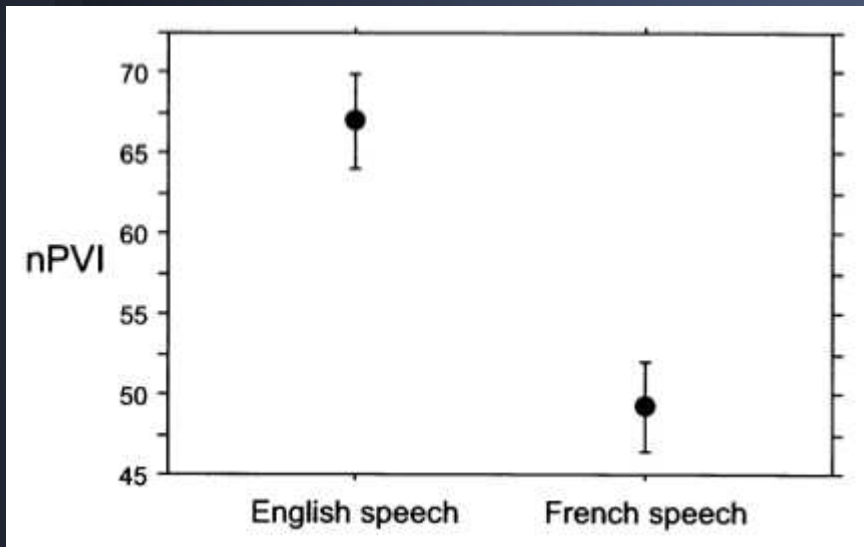
- Patel & Daniele (2003)

- 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



Patel & Daniele (2003)

- 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?

English and Polish

- English

- complex syllable structure
- trochaic rhythm type
- no fixed stress
- stress-timed language
- complex consonant clusters
- complex vowel system

- Polish

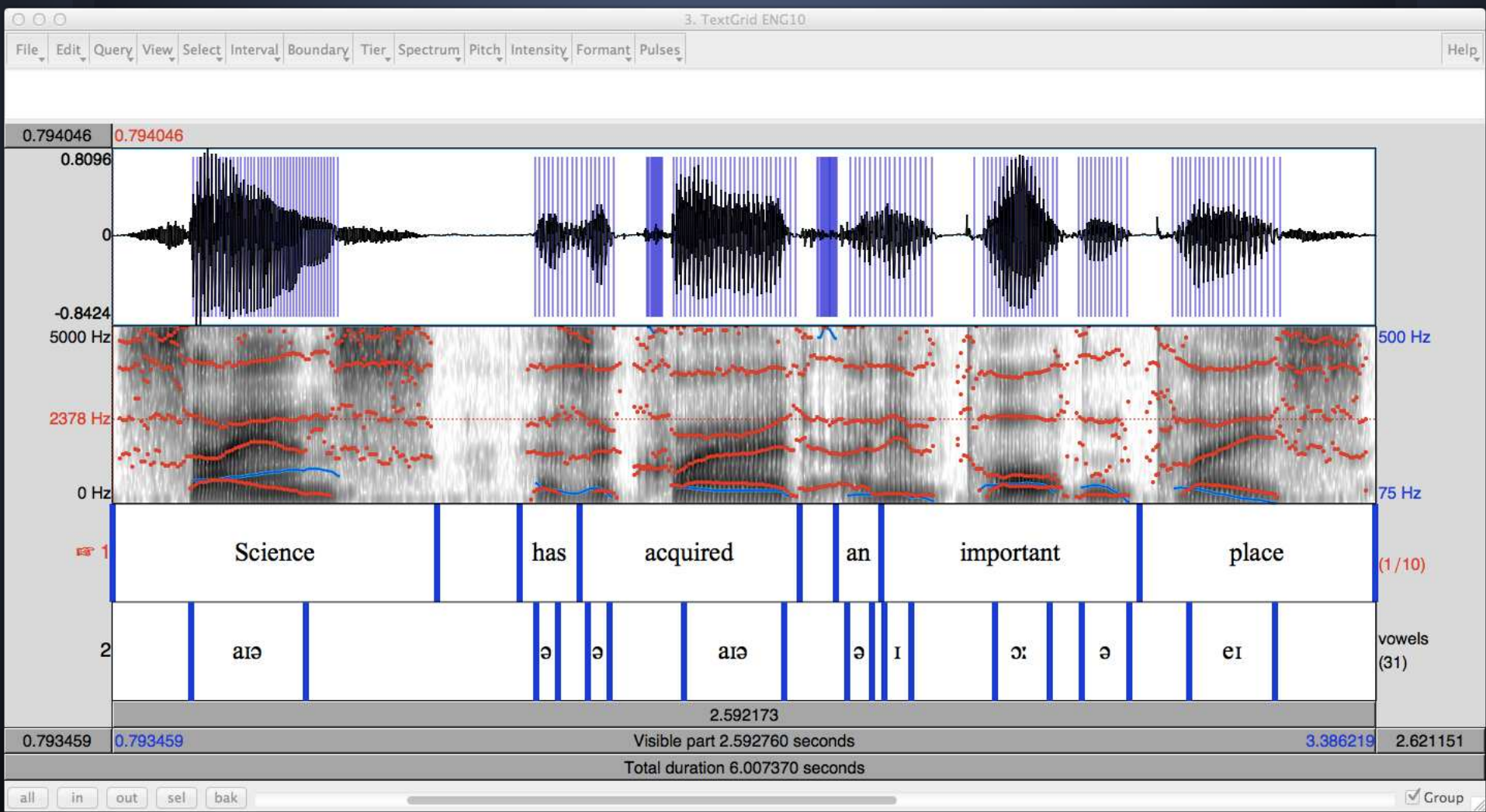
- complex syllable structure
- trochaic rhythm type
- penultimate
- syllable-timed language/mixed
- complex consonant clusters
- simple vowel system

English and Polish

- 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.*

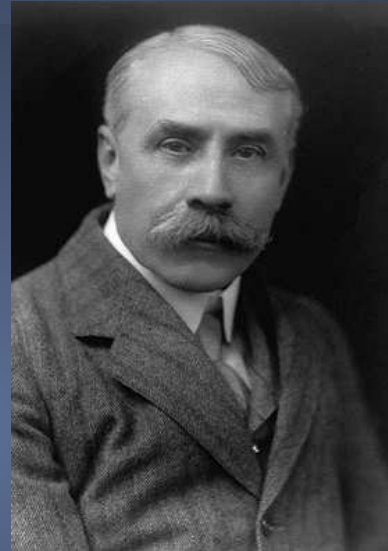
Vowel measurements



Classical music

- English

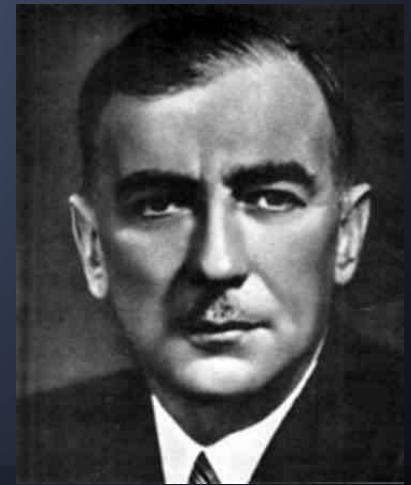
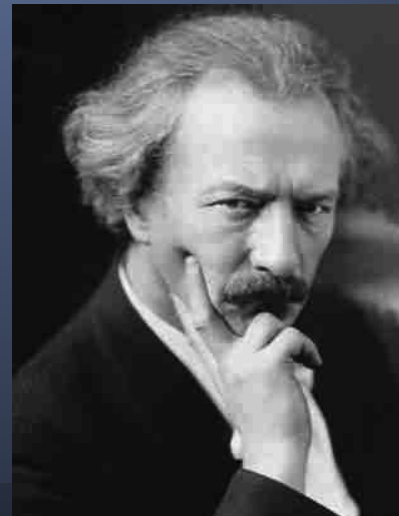
- Edward Elgar (1857-1934)
- Frederick Delius (1862-1934)
- Ralph Williams (1872-1958)
- Gustav Holst (1874-1934)
- John Ireland (1879-1962)
- Arnold Bax (1883-1953)



Classical music

- Polish

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



Classical music

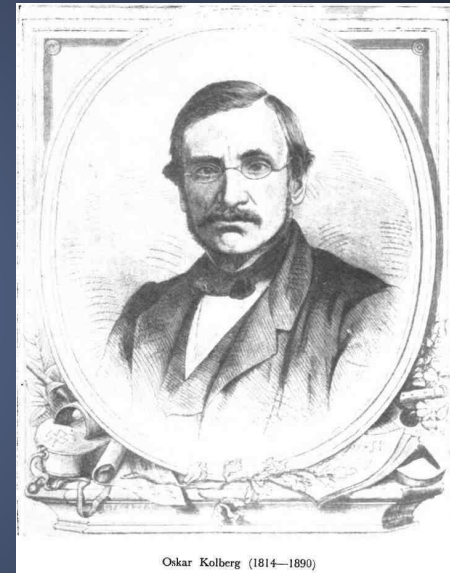
- 20 English and Polish classical music themes
 - *Symphony No. 1 in A Flat Op. 55* by Edward Elgar
 - *Sonata For Violin And Piano* by Frederick Delius
 - *A London Symphony* by Ralph Williams
 - *The Planets* by Gustav Holst
 - *Violin Sonata No.1 in D minor* by John Ireland
 - *Sonata For Viola And 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 poit*
 - *Na Podolu Biały Kamień*
 - *Stała nam się Nowina miła*
 - *Tam za Warszawą na Błoniu*
 - *Wezmę Ja Kontusz*

Note measurements

E72 nPVI = 57.1

1 $\frac{3}{2}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{3}{2}$ $\frac{1}{2}$ $\frac{3}{2}$ $\frac{1}{2}$ $\frac{3}{2}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{3}{2}$ $\frac{1}{2}$ $\frac{3}{2}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{2}{3}$ $\frac{3}{2}$

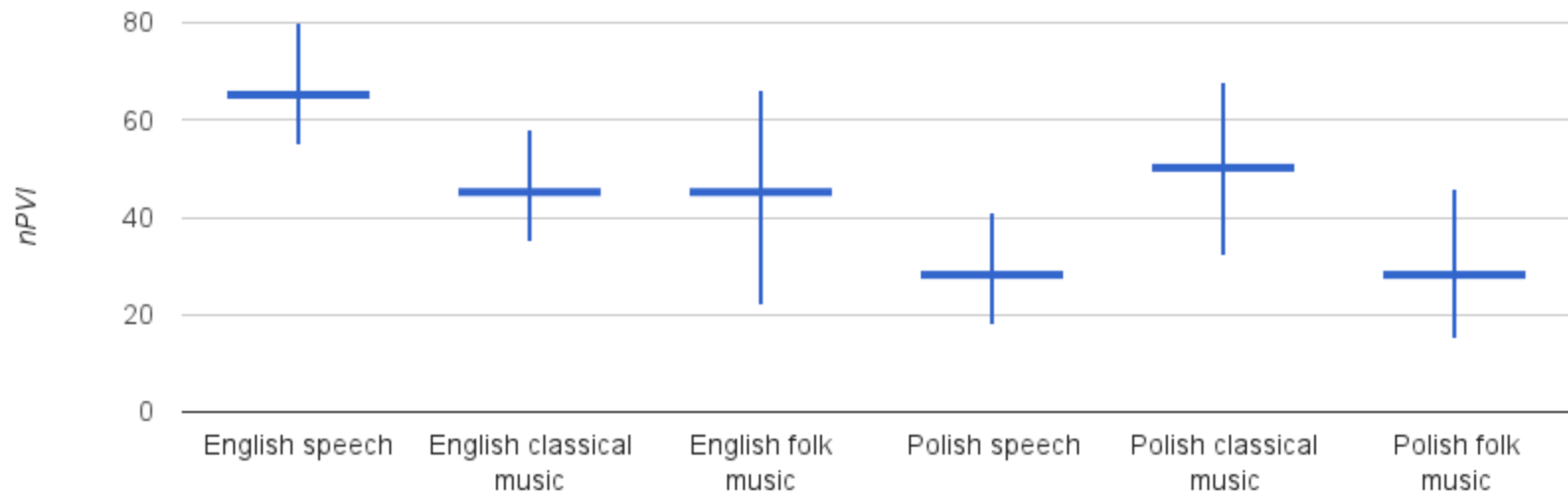
Elgar's *Symphony No. 1, in A Flat, Opus 55, 4th movement, 2nd theme*

- 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

	English	Polish
total vowels	310	386
no. vowels/sentence mean	15.5	19.3
classical, total notes	364	362
classical, no. notes/theme mean	18.2	18.1
folk, total notes	327	353
folk, no. notes/theme mean	16.4	17.7

Results



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!



Selected references

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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