Statistical analysis of a music database to investigate historical changes in consonance and dissonance

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15 March 2016

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Statistical analysis of a music database to investigate historical changes in consonance and dissonance

As music changed historically, so too did concepts and percepts of consonance and dissonance (C/D). Assuming that consonant tone combinations generally occur more often than dissonant, we evaluated C/D by analyzing a representative database of unaccompanied vocal polyphony from seven centuries (13th to 19th). Method: We found electronic scores in the internet, assigned all pitches to the 12-tone chromatic scale, and used the Humdrum Toolkit (Huron) to count pitch patterns, labeling them as pitch-class sets (Forte).

For simultaneous tones, we considered chords of three pitch classes (triads). The most consonant triads in the 14th-16th centuries corresponded to today's major (in semitones: 047), minor (037), suspended (027) and diminished (036) in that order, plus 025/035 (e.g. CDF, DFG). With time, major and minor became relatively more common. We used this data to test psychological models of C/D based on roughness (fast beating), harmonicity (similarity to harmonic series), diatonicness (scale belongingness) and evenness (spacing around chroma cycle). Simultaneous C/D depended mainly on roughness, harmonicity and familiarity.

For successive tones, we considered tones that immediately precede and follow triads. Profiles were remarkably independent of preceding versus following as well as century, suggesting they were determined primarily by stimulus properties. We compared profiles with psychoacoustic predictions and results of listening tests, and tested whether profile peaks corresponded to chord roots, missing fundamentals, completion tones (to complete a familiar tetrad), fifth-related tones, or diatonic tones.

“Music” ≈ MmT?

Major-minor tonality (MmT):

- Most “Western music”
- Most “world music”
- Increasingly: most “music”

Choose a radio station at random, anywhere!

Why?

- Global politics (e.g. V. Kofi Agawu)
- European history
- Psychology

Malungeni, South Africa, 2009
tfstravels.blogspot.co.at

What is major-minor tonality (MmT)?

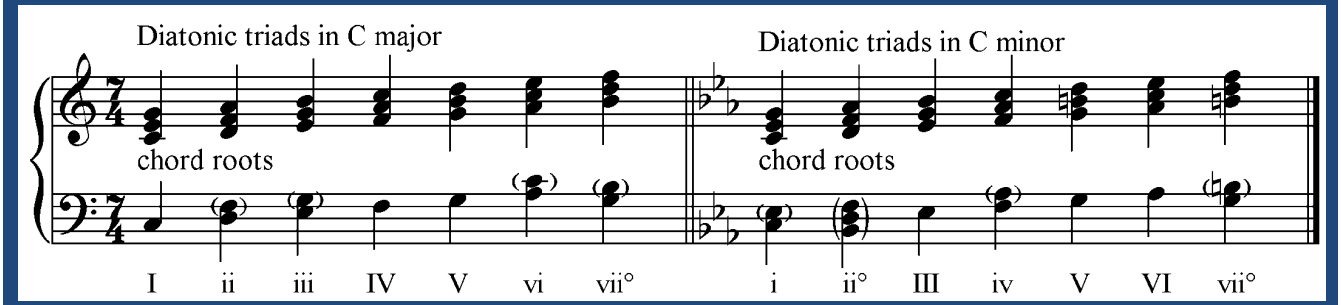
Tonality:

All pitches relative to a reference pitch or structure
(e.g. Fétis *melodic tonality*)

MmT:

- Polyphonic
  (Dahlhaus: *harmonic tonality*)
- Reference is a major or minor triad
  (or its root or corresponding scale)

Diatonic triads



MmT

- Reduces to chord progressions
- Often based on diatonic triads

Simple questions - simple answers?

Why is MmT like it is and not very different?

Where does MmT come from?

How does MmT work?

Eberlein, R. (1994).
Die Entstehung der tonalen Klangsyntax.
Frankfurt: Peter Lang.

Disciplinary perspectives

Humanities

- history
- theory/analysis
- philosophy

"subjective"
specific
relativist

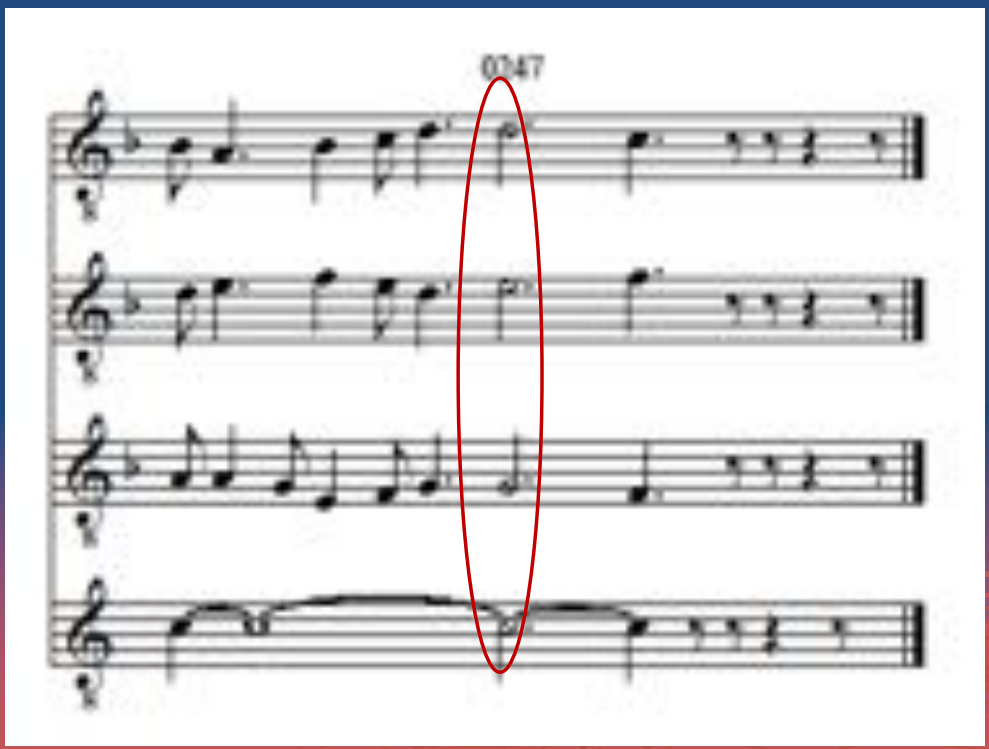
Sciences

- acoustics
- neurophysiology
- psychology

"objective"
general
positivist

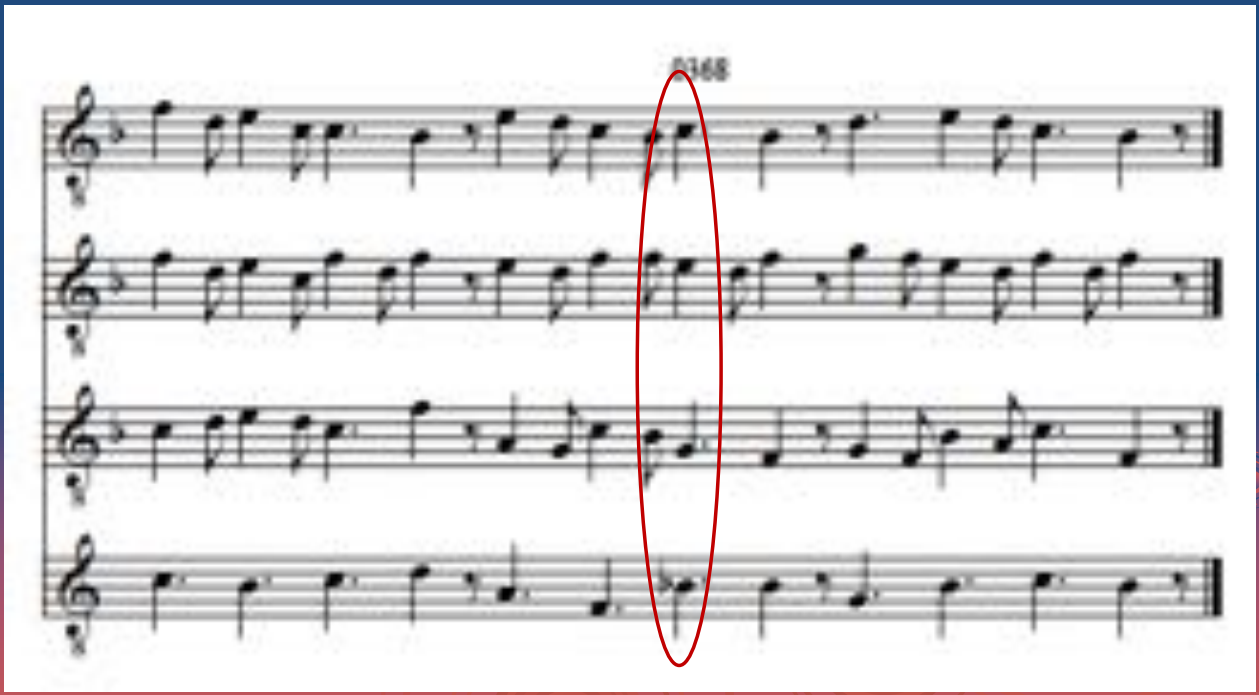
Pérotin: *Viderunt Omnes*

"Cadd9/G"



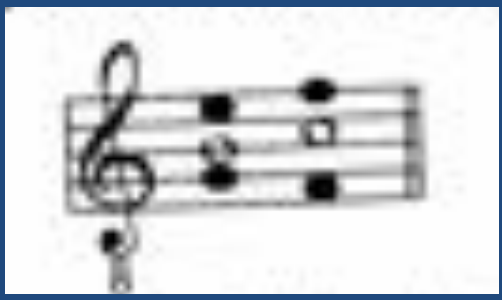
Perotin: *Viderunt Omnes*

"C7/G" – unprepared!



Double leading-tone cadence

14th Century



Origin: two-part cadences (12th Century)

- major sixth → octave; major third → fifth

Later: Falling-fifth cadence (16th Century)

- Avoid parallels in 4 voices?

Emergence of polyphony

Simple polyphony:

Singing in parallel fifths and octaves

More complex polyphony:

Not always parallel motion

E.g. phrase in parallel 5ths, cadence:
5^{th} → 3^{rd} → unison

Even more complex:

More than two voices

Regular 3rds and 6ths

Regular contrary motion

Why did this happen?

- To glorify God and the church
- cf. Gothic architecture

Reims cathedral

Working assumption

The prevalence
(frequency of occurrence)
of a musical element
(such as a chord)
in a given historical period
depends mainly on its consonance/dissonance (C/D).

Therefore:

Prevalence in musical scores is a measure of (historic) C/D

Focus on chords

Western "harmonic tonality" (Dahlhaus) is about **chords**.

- The tonic is a chord
- (Schenkerian) reduction:

surface → (chord) progression → tonic chord

Complementary methods

	Listening experiments → modern perception	Database analyses → historical perception
"Vertical" (simultaneous) C/D	How well do the chord tones sound together?	Prevalence of chord types
"Horizontal" (sequential) C/D	How well does tone follow the chord?	Prevalence profiles of tones following chords

"Composers" in our database of Western vocal polyphony

13th century

Perotin (1150/65-1200/25, French)
Alfonso el Sabio (1221-1284, Spanish)
Adam de la Halle (1250-1310, French)
Montpellier Codex (1250-1300, French)

14th century

Guillaume de Machaut (1300-1377, French)
Landini, Francesco (1325-1397, Italian)
Johannes Ciconia (c.1335 or c.1370, French)
Philippe de Vitry (1291-1361, French)
Jacopo da Bologna (1340-1386, Italian)
Egardus (*fl.* c. 1370 – after 1400, Flemish)

Composers in our database of Western vocal polyphony

15th century

Guillaume Dufay (1397-1474, Franco-Flemish)
John Dunstaple (1390-1453, English)
Johannes Ockeghem (1410/30-1497, Franco-Flemish)
Jacob Obrecht (1450-1505, Flemish)
Heinrich Isaac (1450-1517, Franco-Flemish)
Guillaume le Rouge (fl. 1450-1465, Netherlands)
Simon de Insula (fl. c.1450-60, English or French)

16th century

Orlando de Lassus (1532-1594)
Giovanni Pierluigi da Palestrina (1514/15-1594)
Josquin Desprez (1450/55-1521)
William Byrd (1540-1623)
Giovanni Gabrieli (1555-1612)
Andrea Gabrieli (1532-1585)

Composers in database

17th century

Claudio Monteverdi (1567-1643)
Heinrich Schütz (1585-1672)
Adriano Banchieri (1568-1634)
Girolamo Frescobaldi (1583-1643)
Ruggero Giovannelli (1560-1625)

18th century

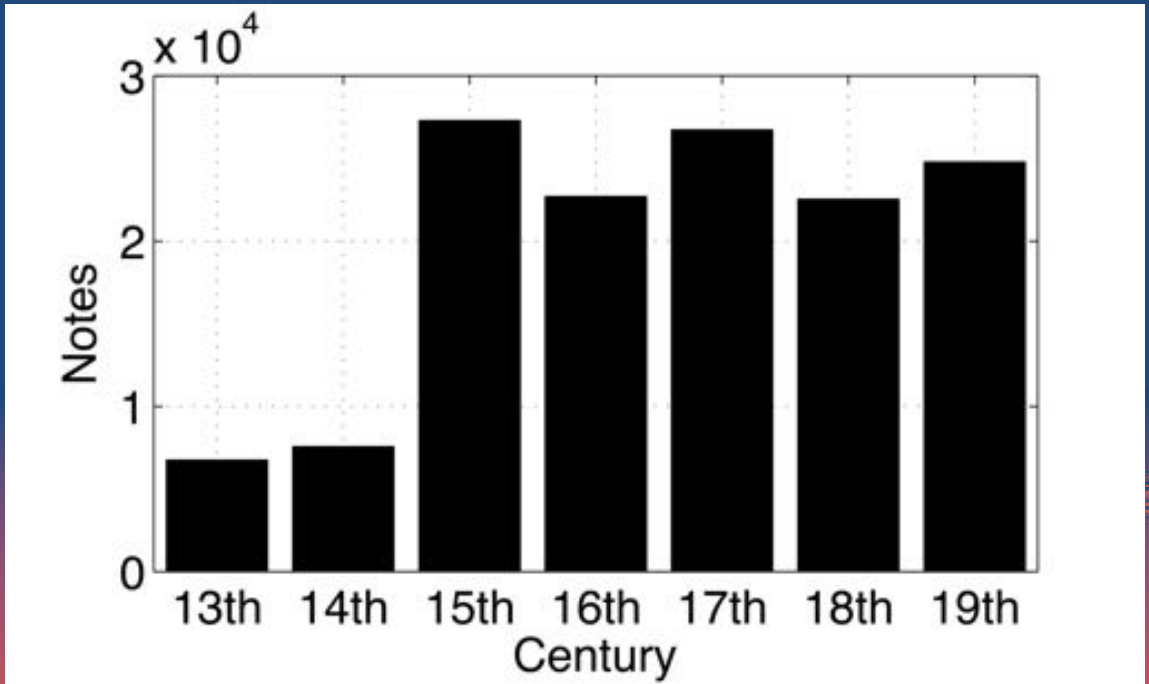
Johann Joseph Fux (1660-1741)
Georg Philipp Telemann (1681-1767)
Johann Sebastian Bach (1685-1750)
Georg Friedrich Händel (1685-1759)
Giovanni Battista Pergolesi (1710-1736)
Niccolo Jommelli (1714-1736)
Christof Willibald Gluck (1714-1787)
Carl Philipp Emanuel Bach (1714-1788)
Johann Friedrich Doles (1715-1797)
Joseph Haydn (1732-1809)
Dmitri Stepanowitch Bortniansky (1751-1825)
Wolfgang Amadeus Mozart (1756-1791)

Composers in database

19th century

Ludwig van Beethoven (1770-1827)
Franz Schubert (1797-1828)
Felix Mendelssohn Bartholdy (1809-1847)
Robert Schumann (1810-1856)
Charles Gounod (1818-1893)
Anton Bruckner (1824-1896)
Robert Lowry (1826-1899)
Johannes Brahms (1833-1897)
Josef Gabriel Rheinberger (1839-1901)
Peter Iljitsch Tschaikowsky (1840-1893)
Antonin Dvorak (1841-1904)
Nikolai Rimski-Korsakow (1844-1908)

Size of database in each century



Database: Assumptions

Transcription to modern notation is ok

- Vertical alignment of parts
- Musica ficta
- Editorial assumptions

Transcription to computer format is ok

- No transcription errors
- No format conversion errors

If it sounds ok (proof reading) by comparison to commercial recordings it is probably good enough for our purposes

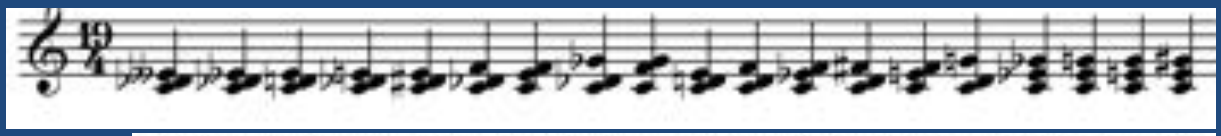
Modern piano

88 *chromatic pitches*

Octave-generalized approach

12 *pitch classes (pcs, chroma)*

19 Tn-types of cardinality 3



012 013 023 014 034 015 045 016 056 024 025 035 026 046 027 036 037 047 048

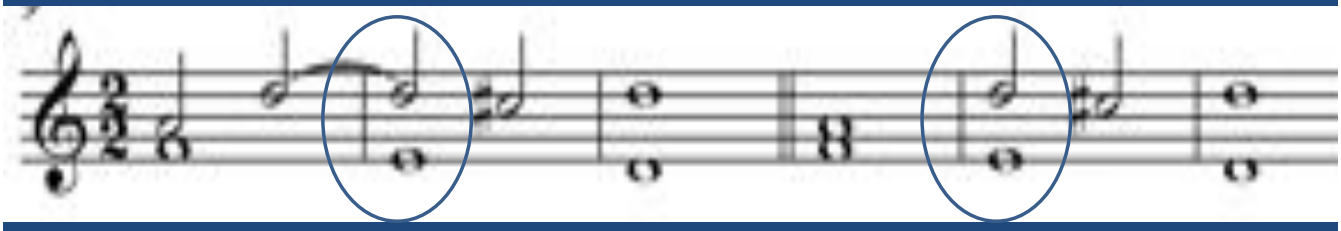
Some basic pitch-class (pc) set theory

Pc-sets enumerate all possible combinations of chromatic pitches.
"Cardinality" is the number of pcs in the set.
There are 12 pc-sets and 19 Tn-types of cardinality 3.
Major 047, minor 037: different Tn-types, same pc-set.
(Rahn, 1980)

Part 1

Simultaneous / vertical C/D

Prepared versus unprepared dissonance

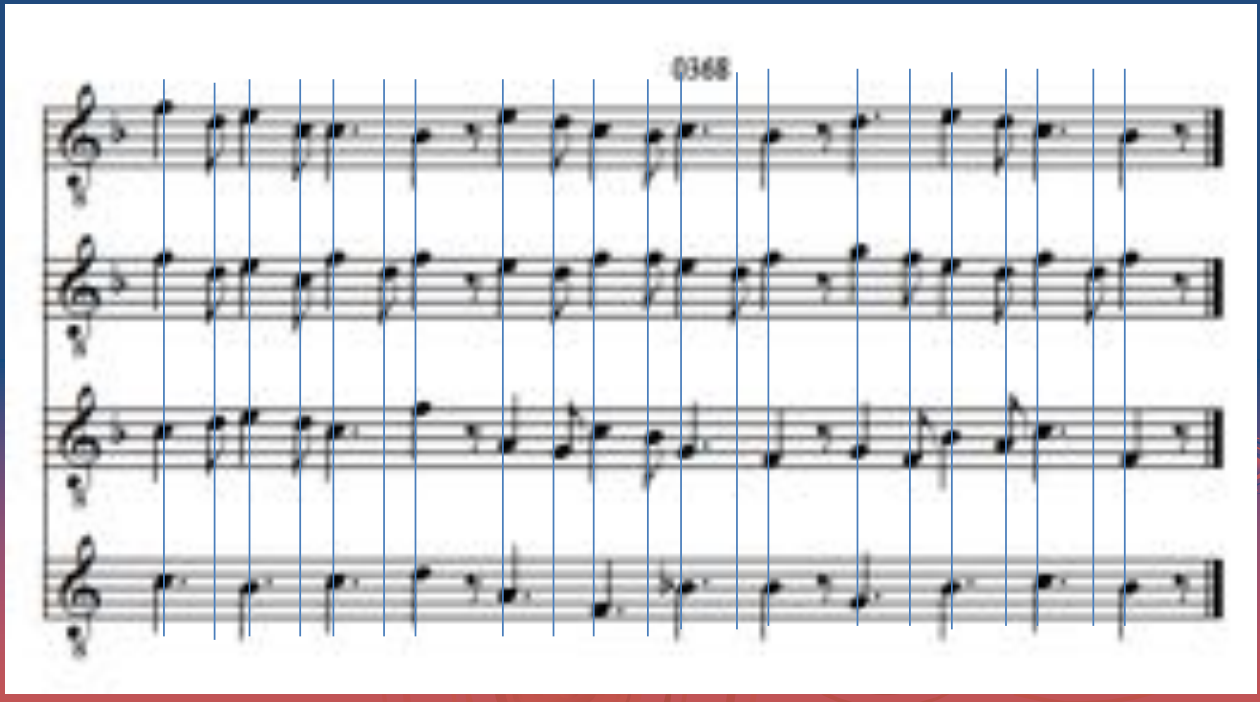


Less dissonant

More dissonant

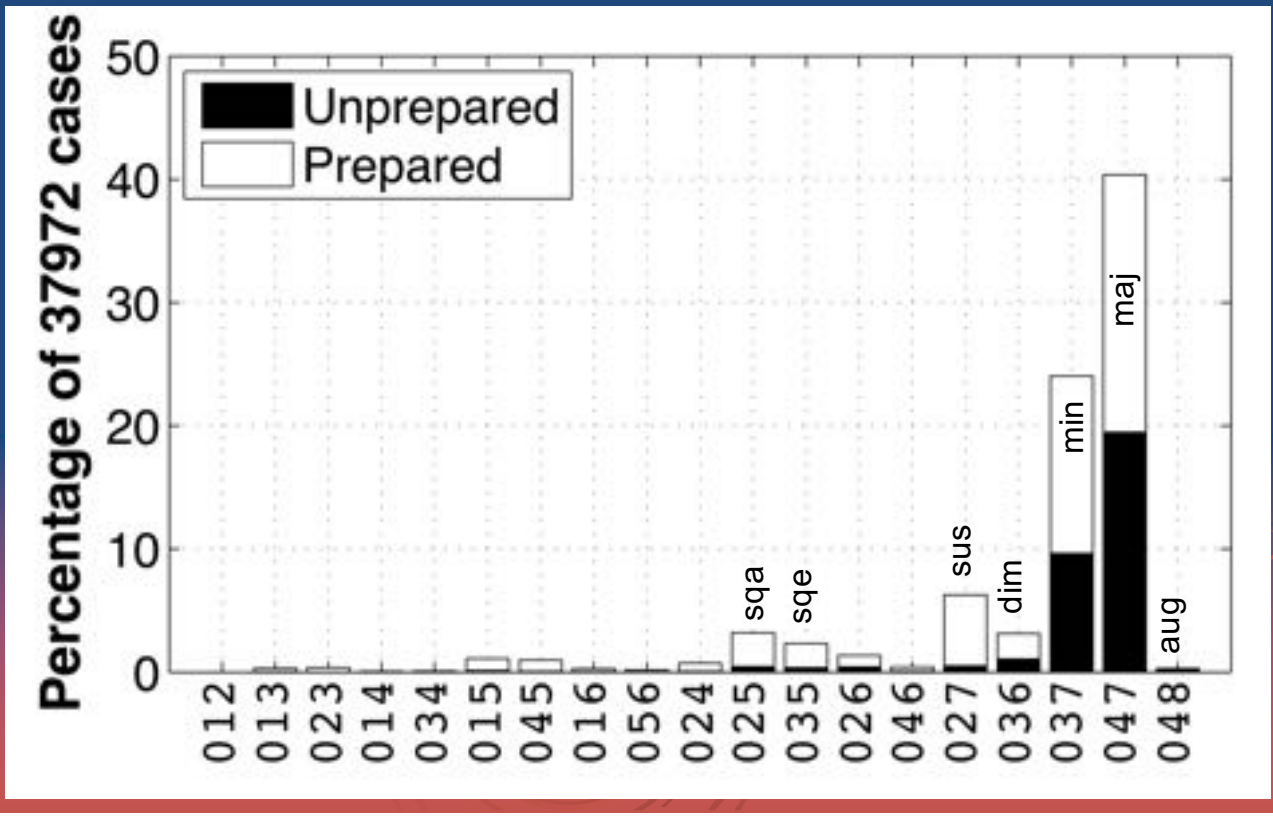
Method

Define a new “chord” at every onset in any voice



Trichord prevalence 1200-1900

Not “maj, min, dim, aug” like in theory books!

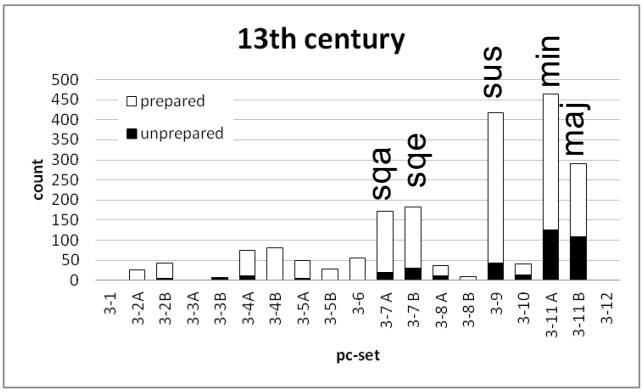


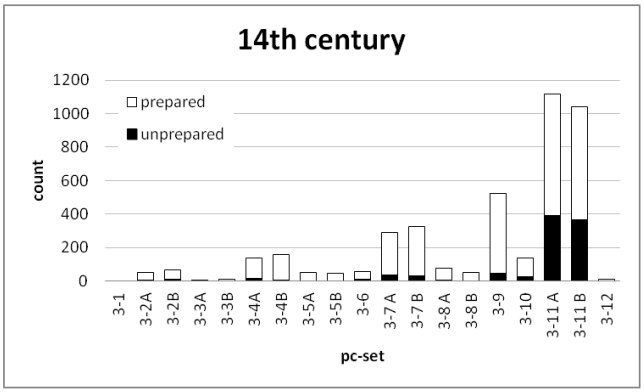
Common triads in MmT

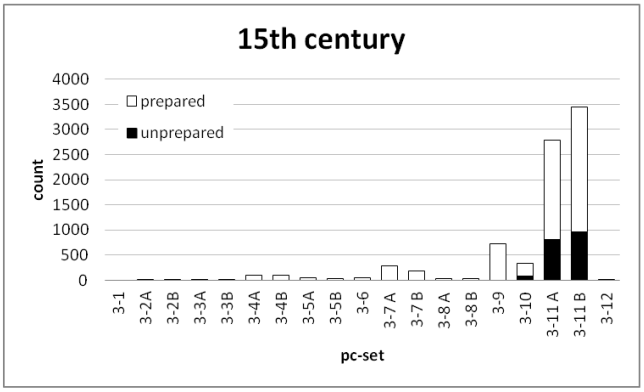
Name	Abbre-viation	Examples	In semi-tones
major	maj	CEG	047
minor	min	ACE	037
suspended	sus	CFG, CDG	027
diminished	dim	BDF	036
squashed	sqa	CDF	025
squeezed	sqe	DFG	035
augmented	aug	CEG#	048

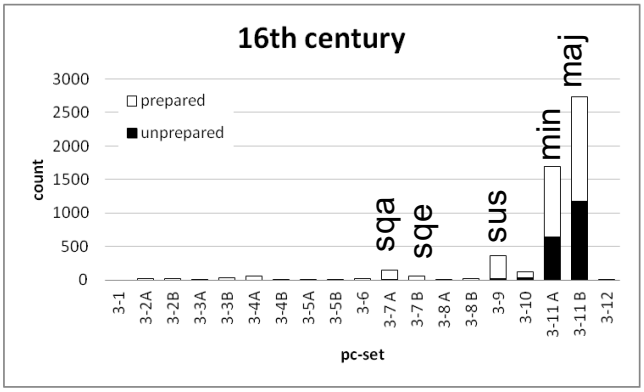
Trichord prevalence by century

Chord vocabulary gets smaller! → C/D depends on familiarity









Tetrachord prevalence 1300-1900