# The tonic as triad

## The emergence of major-minor tonality

***Theoretical, historical and psychological approaches***

Richard Parncutt

Center for Systematic Musicology

University of Graz

Lecture series „Spektrum Musikwissenschaft“

Österreichische Gesellschaft für Musikwissenschaft

Vienna, 19 November 2008

# Hegemony of major-minor tonality

- most Western styles:
  - baroque, classical, romantic, jazz, rock, pop, folk, religious, national anthems…
- spreading to non-Western music
  - political or psychological reason?

# Contents

1. General issues
2. History of major and minor triads
3. General issues (continued)
4. Modeling Krumhansl’s key profiles
5. The leading tone
6. The falling-fifth (DT) cadence

# 1. General issues

- Definitions
  - tonality; the tonic
- Epistemology and approach
  - psychoacoustics of consonance
- History of tonal syntax
  - processes; milestones
- History of tonal theory
  - processes, milestones
- Irrelevant?
  - ratios and exact tuning
  - enharmonic spelling

# Tonality:
## a hierarchy of tonal stability

| ***More stable*** | ***Less stable*** |
|---|---|
| *in a chord:* | |
| root | third, fifth |
| consonant tones | dissonant tones |
| harmonic tones | non-harmonic tones |
| *in a major or minor tonality:* | |
| tonic | third, fifth |
| tones of tonic triad | leading tone |
| diatonic tones | chromatic tones |
| *in a piece:* | |
| background | foreground |

# What is the *tonic*, exactly?

- A pitch? (based on pitch relations)
  - Fétis
  - Krumhansl
- A chord/sonority? (relations among chords)
  - Riemann: tonality is based on harmonic functions SDT
  - Schenker: tonal passage is a prolongation of the tonic triad
- My approach
  - Why are falling fifths preferred between roots?
  - How are a tonal passage and its tonic triad related?

# Epistemology and approach

- Simpler theories are better (Ockam)
  - details are important (Dahlhaus)
  - but simpler theories are easier to falsify (Popper)
- Multidisciplinary theories are better
  - relevant knowledge should be considered
  - multidisciplinary theories are easier to falsify
  - BUT author/s should be appropriately qualified
- Generative theories are better (Lerdahl)
  - algorithm that generates tonal-harmonic syntax?
  - parameter adjustment → stylistic differences
  - applications: theory, history, psychology, composition

# Tonality: The role of perception

Richard Norton (1984)
*Tonality in western culture* (pp. 10.11)

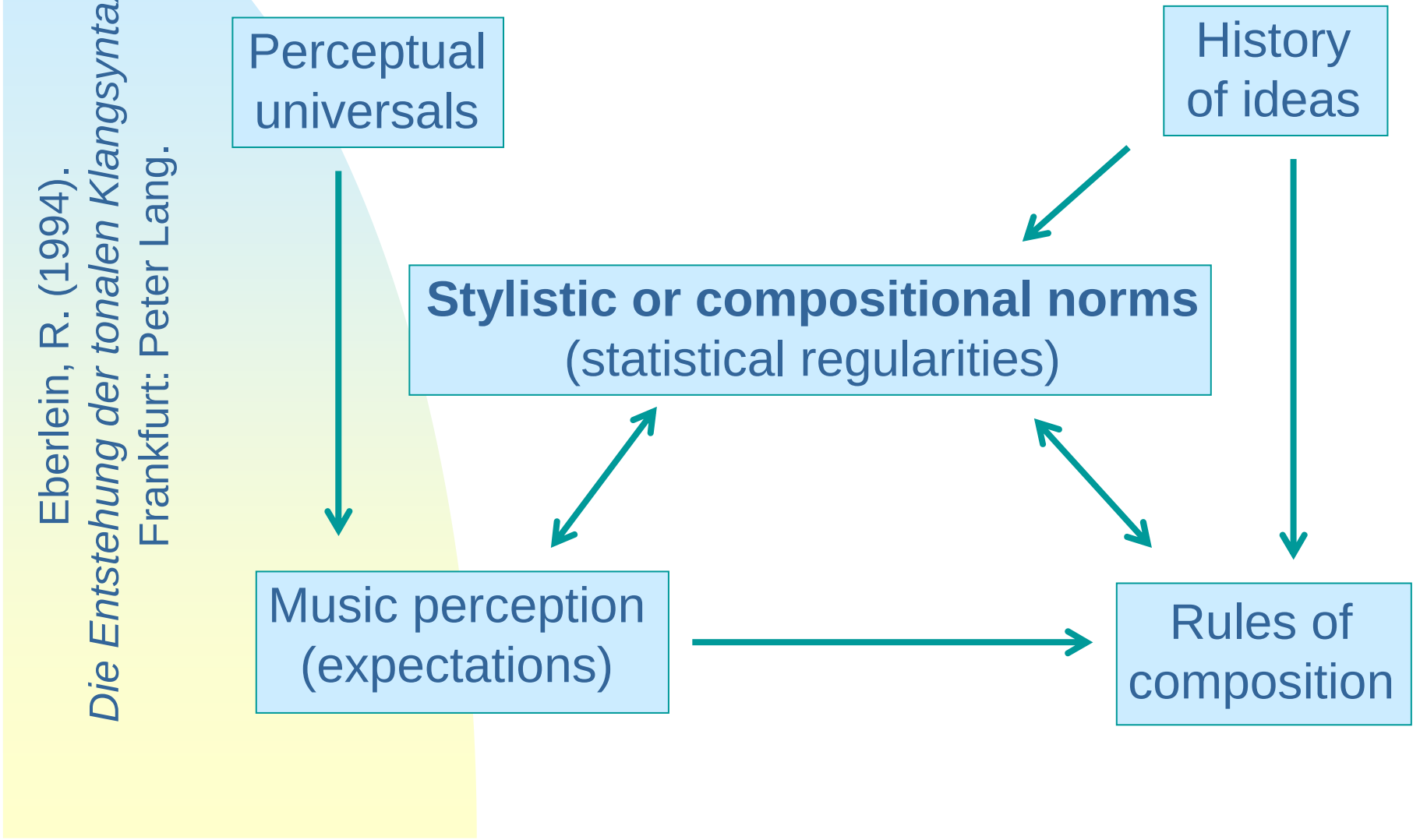
- Assumption:
  - subject (ego) ⇔ object (tonality)
- Aim of research:
  - „ontology of tonality as a human endeavor“
- Relevant disciplines:
  - physics and neurophysics
  - psychology and sociology
  - acoustics and psychoacoustics
  - politics and economics

# Psychoacoustics of consonance

*3 well established psychological factors*

- Roughness (Helmholtz)
  - interference between nearby partials on the basilar membrane
  - universal, based on physiology
- Fusion (Stumpf)
  - holistic perception of complex sounds
    - e.g. speech vowels, musical chords
  - involves neural processing
- Familiarity (Cazden, Tenney)
  - exposure promotes liking

# History of tonal syntax: Processes




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

# History of tonal syntax: Milestones

| | | |
|---|---|---|
| pretonal | 12th | ▪ 2-part counterpoint, discant improvisation |
| | 13th | ▪ 3- and 4-part ctpt, 3rds & 6ths imperfect consonances |
| | 14th Cent | ▪ Ars Nova (Vitry, Machaut)<br>▪ double-leading-tone cadence<br>▪ parallels forbidden but tolerated |
| "emergence" of tonality | 15th Cent | ▪ Dunstable, Dufay, Ockeghem<br>▪ falling fifth cadence in 3 and 4 parts<br>▪ *Fauxbourdon:* parallel 6/3 triads<br>▪ *Falsobordone:* chains of root positions |
| | 16th Cent | ▪ Palestrina, Lassus<br>▪ most sonorities are major and minor triads<br>▪ final fifth replaced by triad; *tierce de Picardie* |
| | 17th Cent | ▪ all final sonorities become triads<br>▪ seventh chords, clear SDT progressions |

# History of triadic theory: Processes

- Harmonic dyads are heard in 2-part textures
- Composers and listeners become sensitive to the *roughness* and *fusion* of harmonic dyads
- Thirds and sixths become more prevalent → familiar → consonant
- In 3-part writing, major and minor triads become more prevalent → familiar → consonant
- Composers and listeners become sensitive to the roughness and fusion of harmonic triads
- Theorists regard major/minor triads as entities rather than collections of tones and intervals
- Theorists invent and use terms for triad, root and inversion

# History of triadic theory: Milestones

| Century | Idea | Theorists |
|---|---|---|
| 14th | lowest voice "governs" sonority | Tewkesbury (mid 14th), other *contrapunctus* tracts |
| 15th | triads as intervals or entities | Tinctoris (1477), Podio (1495), Gafori (1496) |
| 16th | triads ok, but not inversions | Zarlino (1558), Sancta Maria (1565), Avianus (1581) |
| 17th | increasingly clear concept of root and inversion | Burmeister 1606), Harnisch (1608), Lippius (1612), Campion (1618), Crüger (1630) |
| 18th | implied roots | Rameau (1721) |

# Tuning and ratios: Irrelevant?

- 12-tone chromatic scale
  - approximately equally tempered
  - idea dates to ancient Greece
- Categorical perception of pitch
  - A scale step is a “pc category”
    - octave-generalized
    - perceived categorically
  - Tuning does not affect scale-step identity!
- Frequency or length ratios
  - not directly perceptible (Aristoxenus)

# Enharmonic spelling: Irrelevant?

- Spelling ($F^{\#}$ vs $G^{b}$)
  - depends on tonal context
  - the rules were originally pragmatic
- Tonal context (in chr. scale) influences:
  1. enharmonic spelling
  2. tonal meaning, stability etc.
  3. intonation in performance
- Relationships 1 ⇔ 2 ⇔ 3 are *indirect*

# 2. History of major/minor triads

- definition
- pc-set theory and consonance
- history of thirds and triads

# What are major and minor triads?

- Ratio theory
  - major = 4:5:6, minor = 10:12:15?
    - What about 5:6:7? 6:7:8?
    - What about Pythagorean tuning?
- Relative to chromatic scale
  - major = 047, minor = 037
- Consonance theory
  - smoothness, fusion, familiarity

# pc-set theory and consonance:

## 19 Tn-types of cardinality 3

after Rahn (1980)

| prime form | 012 | 013 | 014 | 015 | 016 | 024 | 025 | 026 | 027 | 036 | 037 | 048 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| inversion | | 023 | 034 | 045 | 056 | | 035 | 046 | | | 047 | |

012 = e.g. C-C#-D

013 = e.g. C-C#-D#

037 = minor triad

047 = major triad

The major and minor triads are clearly the most consonant Tn-types of cardinality 3.

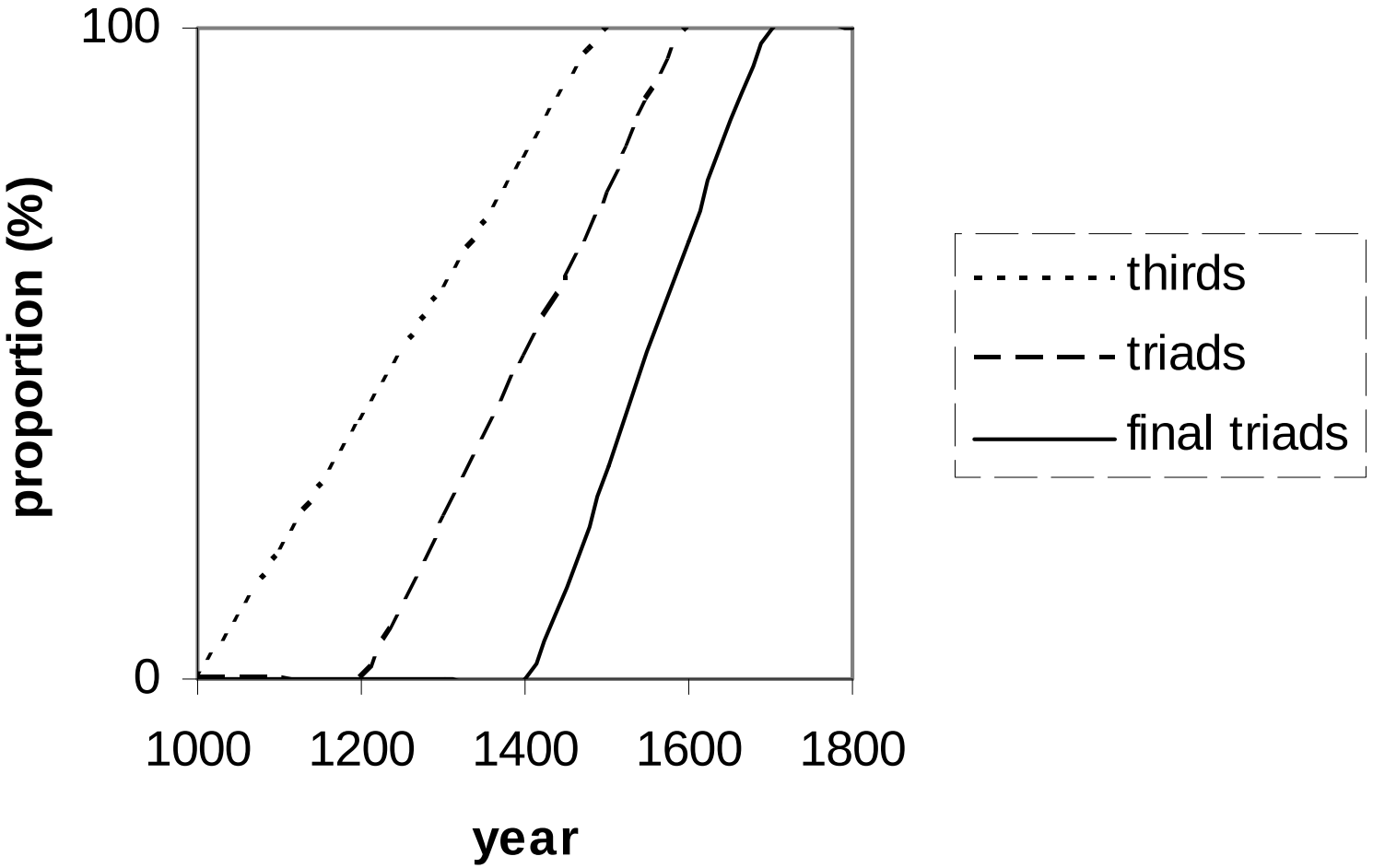
Only they have a fourth/fifth (*fusion*) and no major or minor seconds (*roughness*).

# History of thirds and triads

- Historical prevalence
  - harmonic thirds: ca. 1000→1500
  - major & minor triads: 1300→1600
  - final triads: 1500→1750
- Theory of gradual “emergence”
  - perceptual familiarity of each stage
    - prerequisite for next stage
  - perception of tonality
    - depends on history of tonal syntax

# Historic emergence of triads

*an educated guess*



# 3. General issues (continued)

- Karl Popper’s “three worlds”
- How important is a pitch?
- Octave generalisation (pc)

# Karl Popper's "three worlds"

*can help us understand Medieval music perception!*

- We need to clearly separate
  - physics: measured frequencies and durations
  - experience: perceived pitches and durations
  - notation: symbolic pitches and durations
- Popper's "cosmology":
  - World 1: physical, material
  - World 2: experience, subjectivity
  - World 3: knowledge, information

# How important is a pitch?

- Stability (music theory)
  - lack of tendency to move
  - tonicization
  - no. of hierarchical levels
  - Popper: World 2 (experience)
- Prevalence (statistics)
  - frequency of occurrence in scores/performances
  - total duration in scores/performances
  - Popper: World 3 (information) or 1 (physics)
- Salience (psychoacoustics)
  - probability of noticing a tone
  - clarity or strength of tone sensation
  - Popper: World 2 (experience)

# Octave generalisation

*the 2-component theory of musical pitch*

- Geza Révész (1913): Tonqualität, Tonhöhe
- Erich von Hornbostel (1926): Tonigkeit + Helligkeit
- Albert Wellek (1934, 1935): Tonigkeit + Helligkeit
- Bachem (1950): *tone chroma* → US music psychology
- Milton Babbitt (???): *pitch class* → *US music theory*


Révész, G. (1913). *Zur Grundlegung der Tonpsychologie.* Leipzig.

Hornbostel, E. M. von (1926). Psychologie der Gehörserscheinungen. In A. Bethe et al. (Hrsg.), *Handbuch der normalen und pathologischen Physiologie, 11,* 701-730.

Wellek, A. (1934). Die Aufspaltung der „Tonhöhe“ in der Hornbostelschen Gehörpsychologie und die Konsonanztheorien von Hornbostel und Krueger. *Zeitschrift für Musikwissenschaft, 16,* 481-496 u. 537-553.

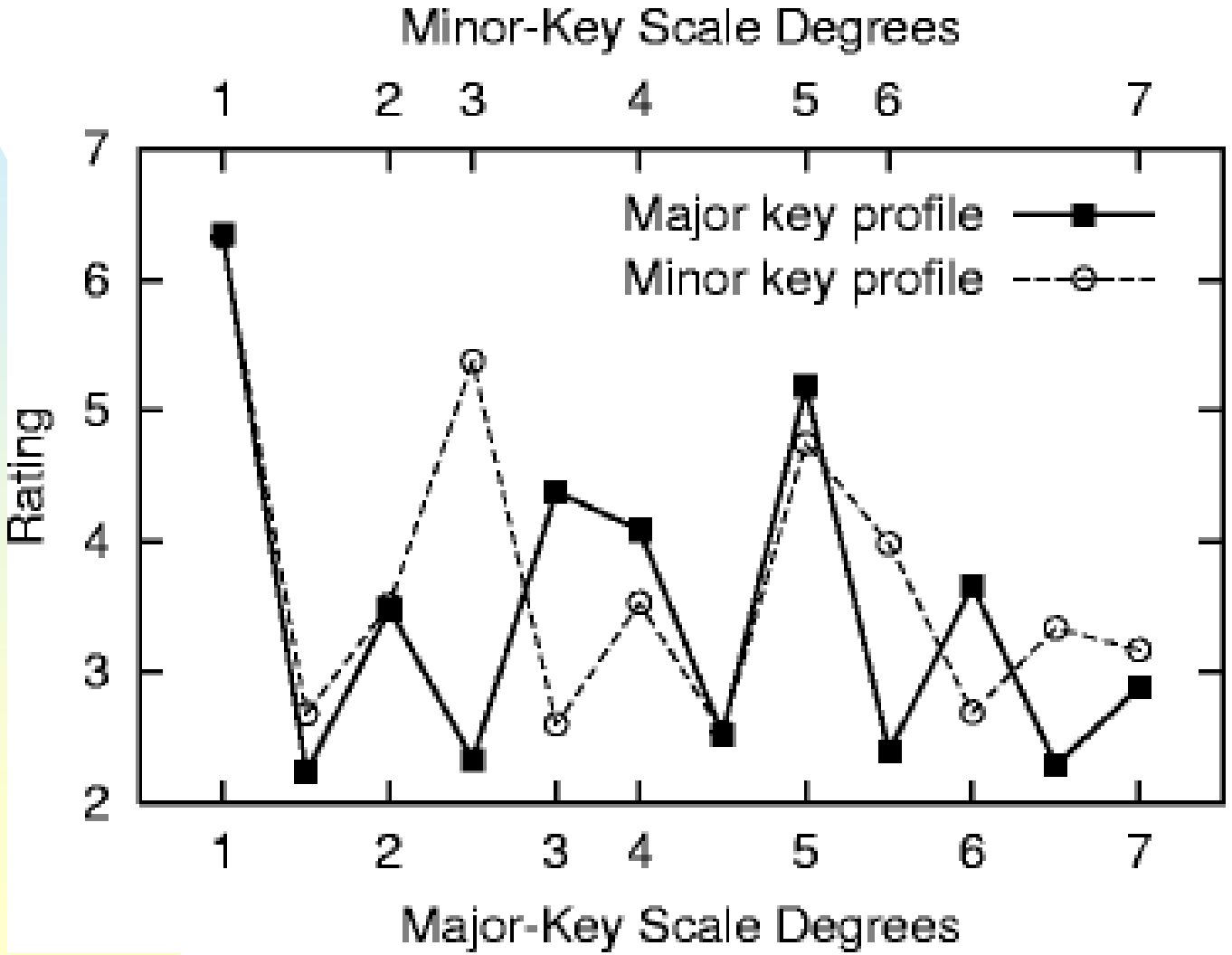
Bachem, A. (1950). Tone height and tone chroma as two different pitch qualities. Acta psychologica, 7, 80-88.

# 4. Modeling Krumhansl's key profiles

- her method and results
- models of her profiles
  - *music ficta*
  - pc-prevalence
  - roughness
  - hierarchical depth
  - pitch salience in tonic triad

# Krumhansl's key profiles

*pc-stability profiles*




Krumhansl, C. L., & Kessler, E. J. (1982). Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys. *Psychological Review*

# Krumhansl's key profiles

*pc-stability profiles*

- Method
  - stimulus: SDT progression, probe tone
  - listener's task: goodness-of-fit rating
  - design: all 12 pcs for each progression
  - random transposition and order of trials
- Interpretation of result
  - cognitive representation of tonality?
- Problem (or virtue?)
  - ignores voice leading
- Immediate origin
  - exposure to tonal music

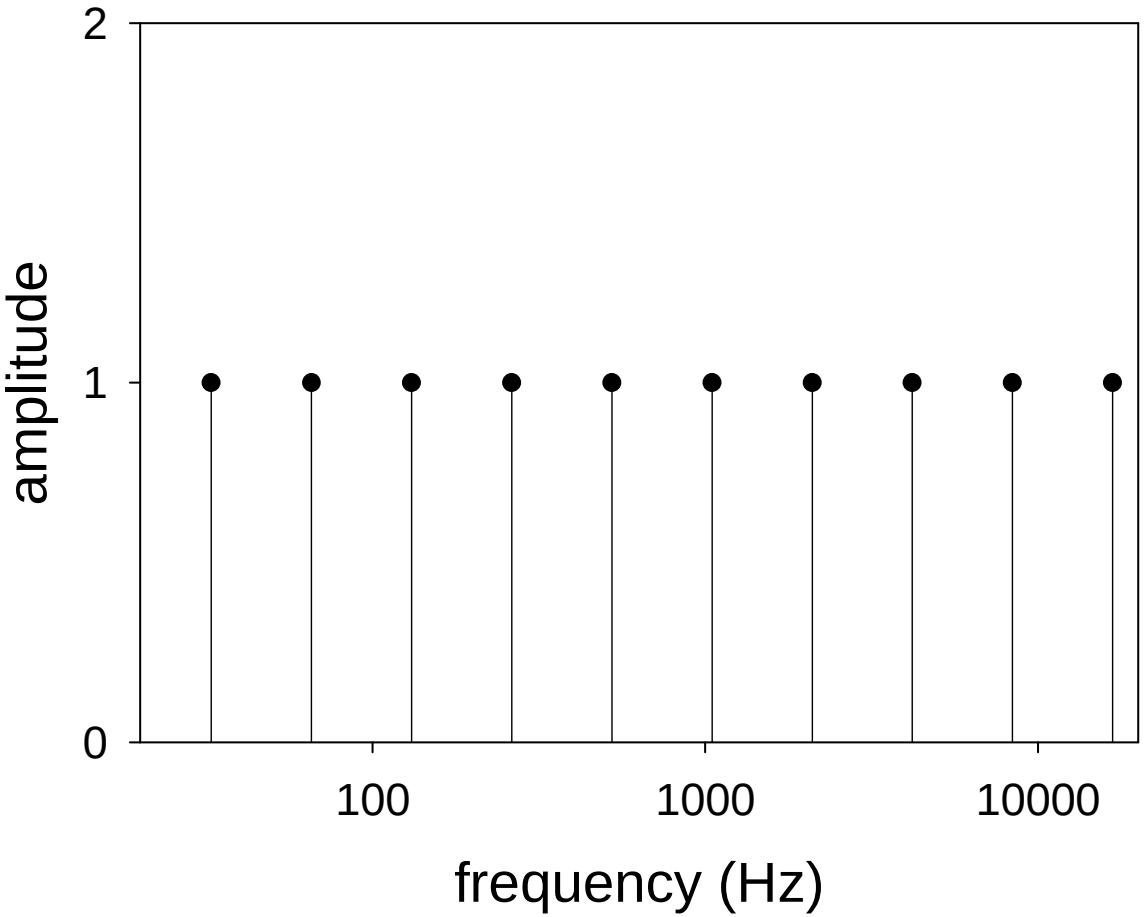
# Octave-Complex Tone (OCT)

*or Shepard tone*

An OCT is a physical representation of a pc.

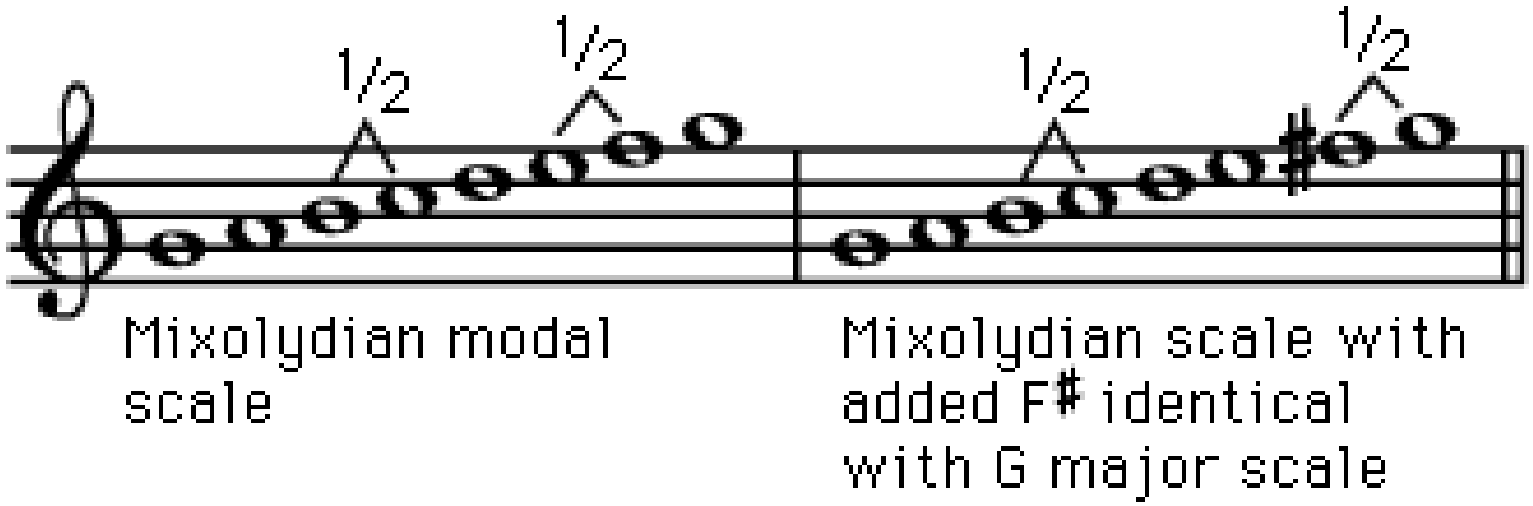
All of Krumhansl's chords were constructed from OCTs.

All of her probe tones were OCTs.



# *Music ficta* and the emergence of major-minor tonality

*sharpen leading tones, avoid tritones…*

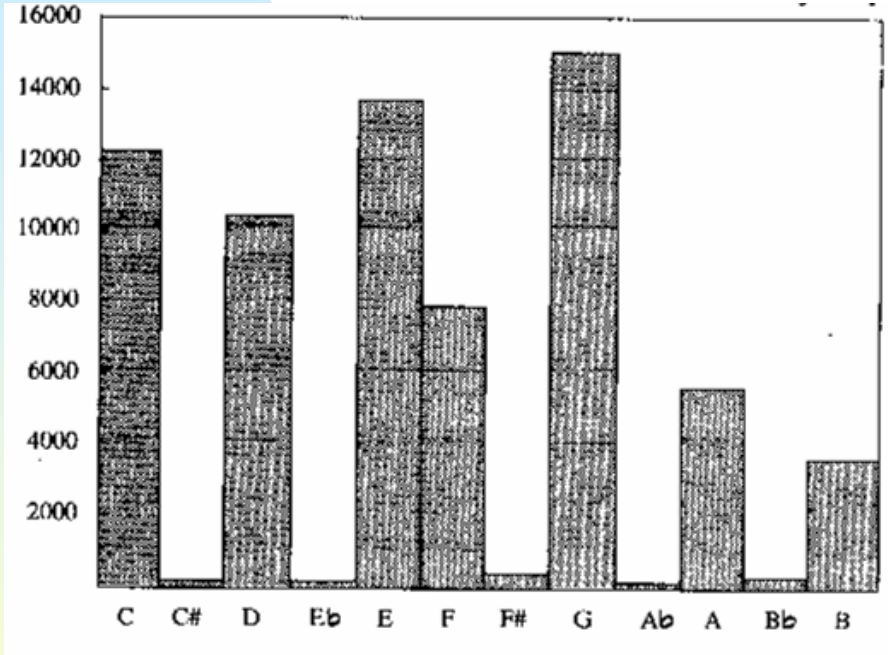



Mixolydian → major, Dorian → minor, usw.

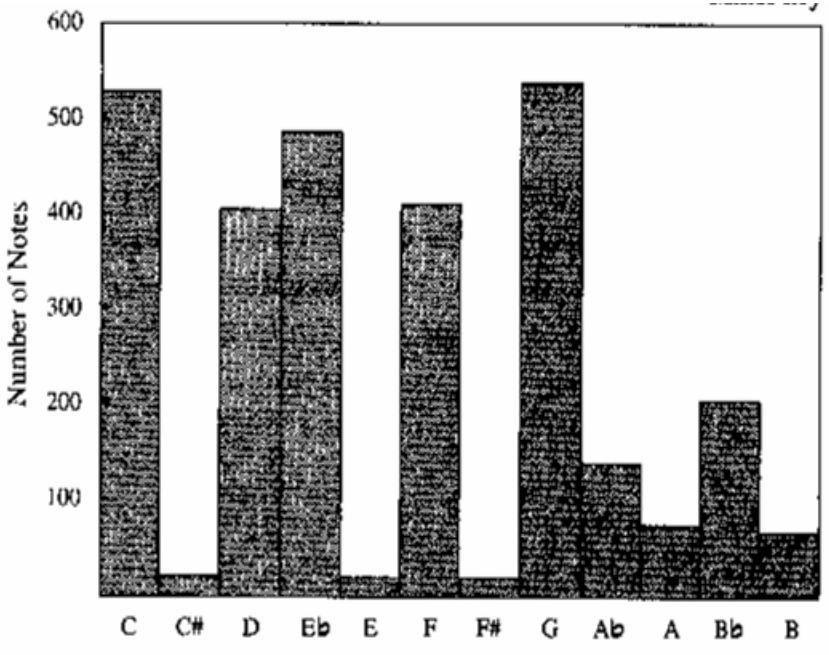
Musica ficta can explain the *scale steps* in major/minor keys.
But it cannot explain their *relative stability*

# Prevalence model of key profiles

**major key**




**minor key**




Aarden, B. (2003). *Dynamic melodic expectancy.*
PhD dissertation, Ohio State University.

*Why is G more* prevalent *that C in C major - but C is more* stable*?*

# Prevalence model

*of Krumhansl's key profiles*

- Theoretical basis
  - exposure to tonal music
- Data
  - Krumhansl: classical scores
  - Järvinen: jazz improvisation
  - Aarden: melodic database
- good correlation (r~0.8…0.95)
  - but clear differences based on pitch salience relations within sonorities
- Theoretical problem
  - ultimate origin of prevalence patterns?

# Roughness model

*of Krumhansl's key profiles*

- Roughness
  - physiological aspect of dissonance
  - limited frequency resolution of ear
  - fast beating
- Hypothesis
  - stable scale steps are "smooth" rel. to tonic
- Moderate correlation (r~+0.4…+0.9)
- Theoretical problem
  - simultaneous vs successive tones?

# Lerdahl's "basic pitch space"

*for the key of C major – after Deutsch & Feroe*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| level a | C | | | | | | | | | | | |
| level b | C | | | | | | | G | | | | |
| level c | C | | | | E | | | G | | | | |
| level d | C | | D | | E | F | | G | | A | | B |
| level e | C | Db | D | Eb | E | F | F# | G | Ab | A | Bb | B |
| hierarchical depth | 5 | 1 | 2 | 1 | 3 | 2 | 1 | 4 | 1 | 2 | 1 | 2 |


Lerdahl, E. (2001). *Tonal pitch space* (p. 47). New York: Oxford.

Deutsch, D., & Feroe, J. (1981) The internal representation of pitch sequences in tonal music. *Psychological Review, 88,* 503-522.

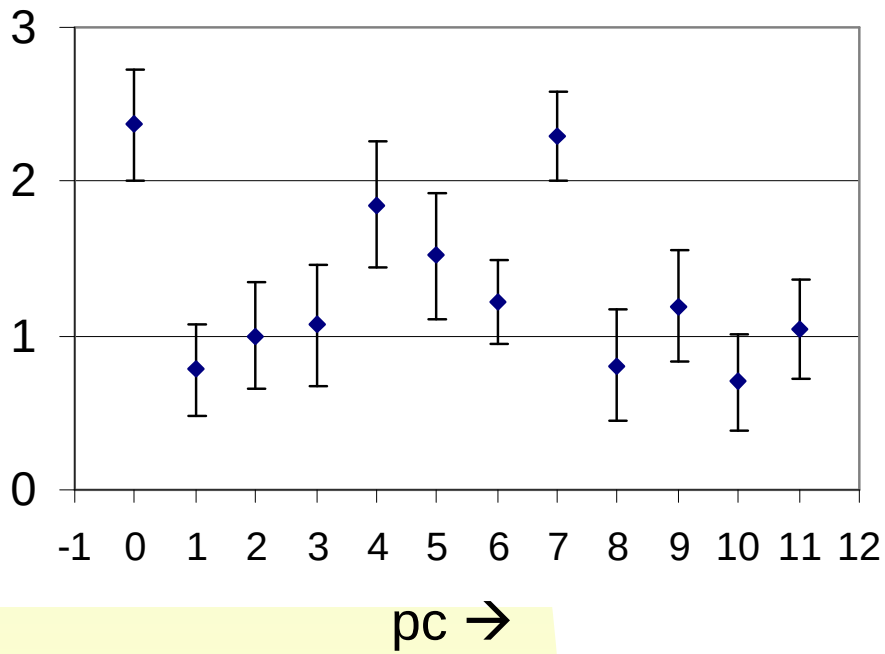
# Hierarchical depth model

*of Krumhansl's key profiles*

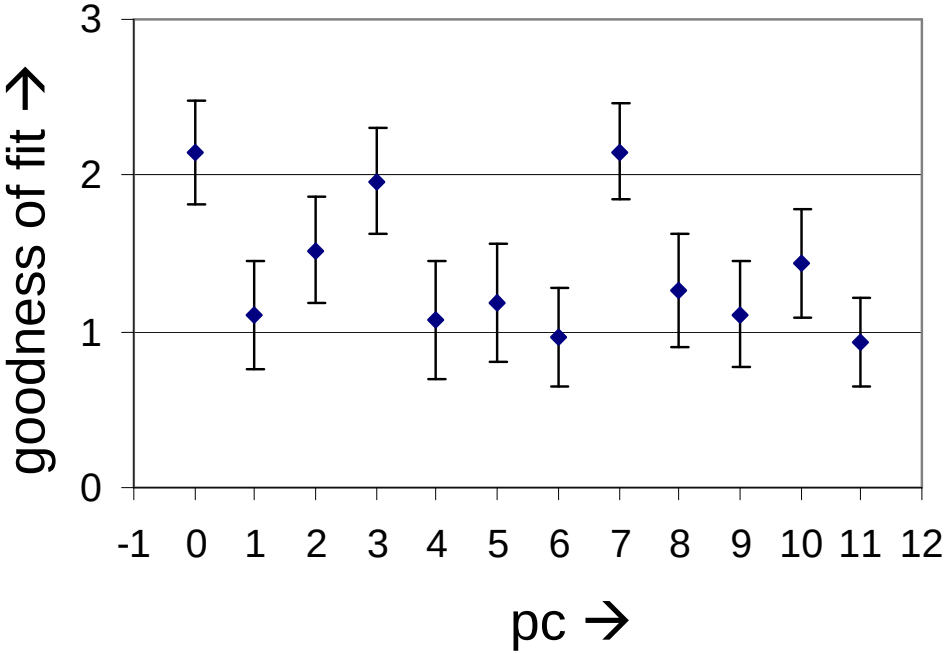
- Lerdahl's (1993) *tonal pitch space*
  - tonality as specific hierarchy of pcs
  - predictor: hierarchical depth profile
  - corr. with stability (Krumhansl) r~0.95
- Problems
  - psychological reality of hierarchy?
    - empirical method?
    - hierarchy or network?
    - separation and importance of levels?
  - origin of hierarchy?

# Experiment on pitch salience in musical chords

*major triad 047*




*minor triad 037*




Parncutt, R. (1993). Pitch properties of chords of octave-spaced tones. *Contemporary Music Review*, *9*, 35-50.

# Experiment on pitch salience in musical chords

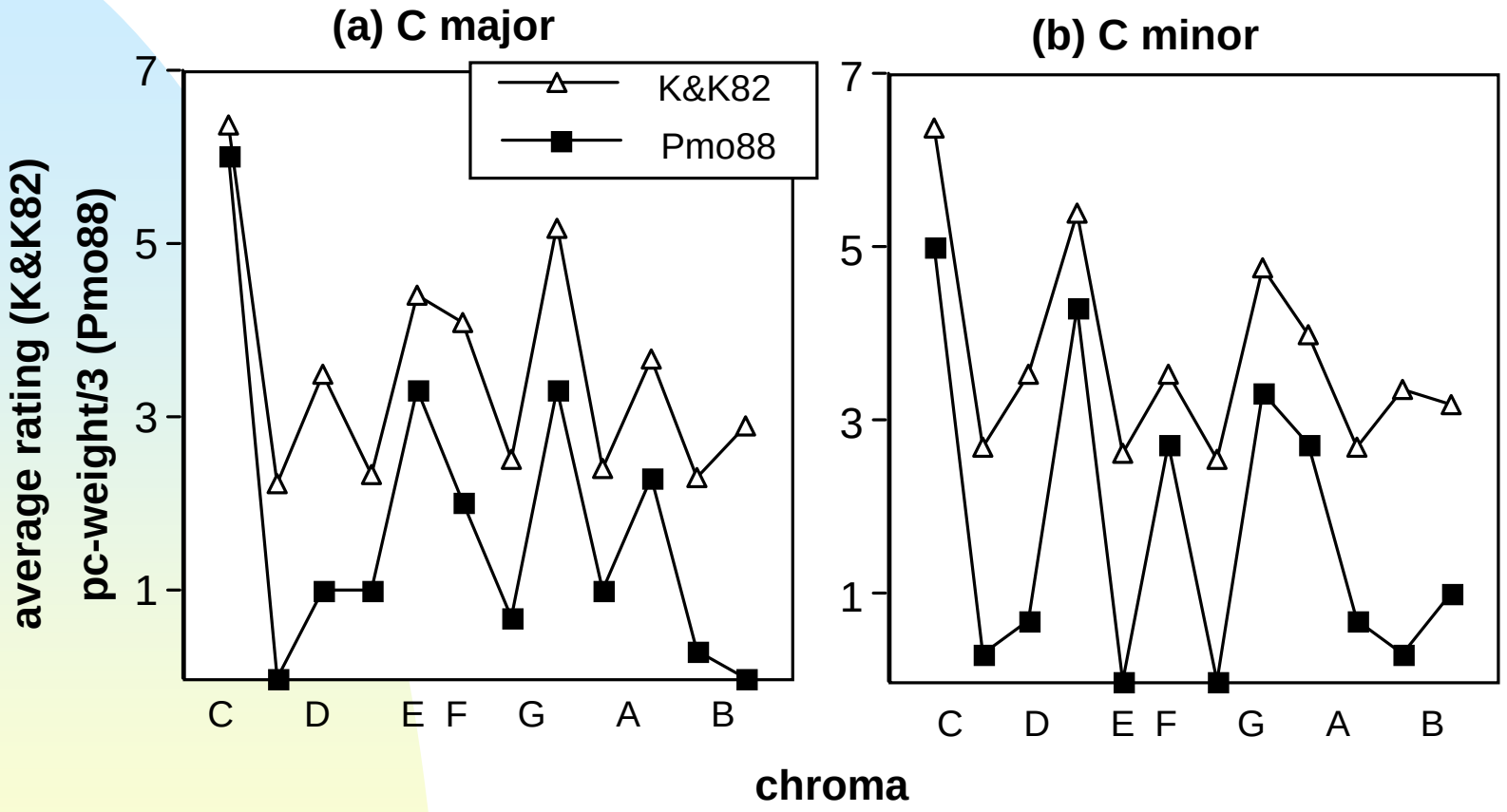
- Method: similar to Krumhansl
  - stimulus: chord of OCTs, single OCT
  - listener's task: goodness-of-fit rating
  - design: all 12 pcs for each chord
  - random transposition and order of trials
- Interpretation of result
  - perceptual representation of chord
- Origin:
  - general principles of pitch perception?
  - exposure to tonal music?

# pc salience model

*of Krumhansl's key profiles*

- Assumption: the tonic is a triad
  - not a tone
- Data
  - pc stability profiles (Krumhansl)
- Model
  - pc salience profile of tonic triad
- Correlation
  - r~0.95

# pc stability profile of tonality (K&K82)
# pc salience profile of tonic triad (Pmo88)





Krumhansl, C. L., & Kessler, E. J. (1982). Tracing the dynamic changes in perceived tonal organization in a spatial representation of musical keys. *Psychological Review*

Parncutt, R. (1988). Revision of Terhardt's psychoacoustical model of the root(s) of a musical chord. *Music Perception*

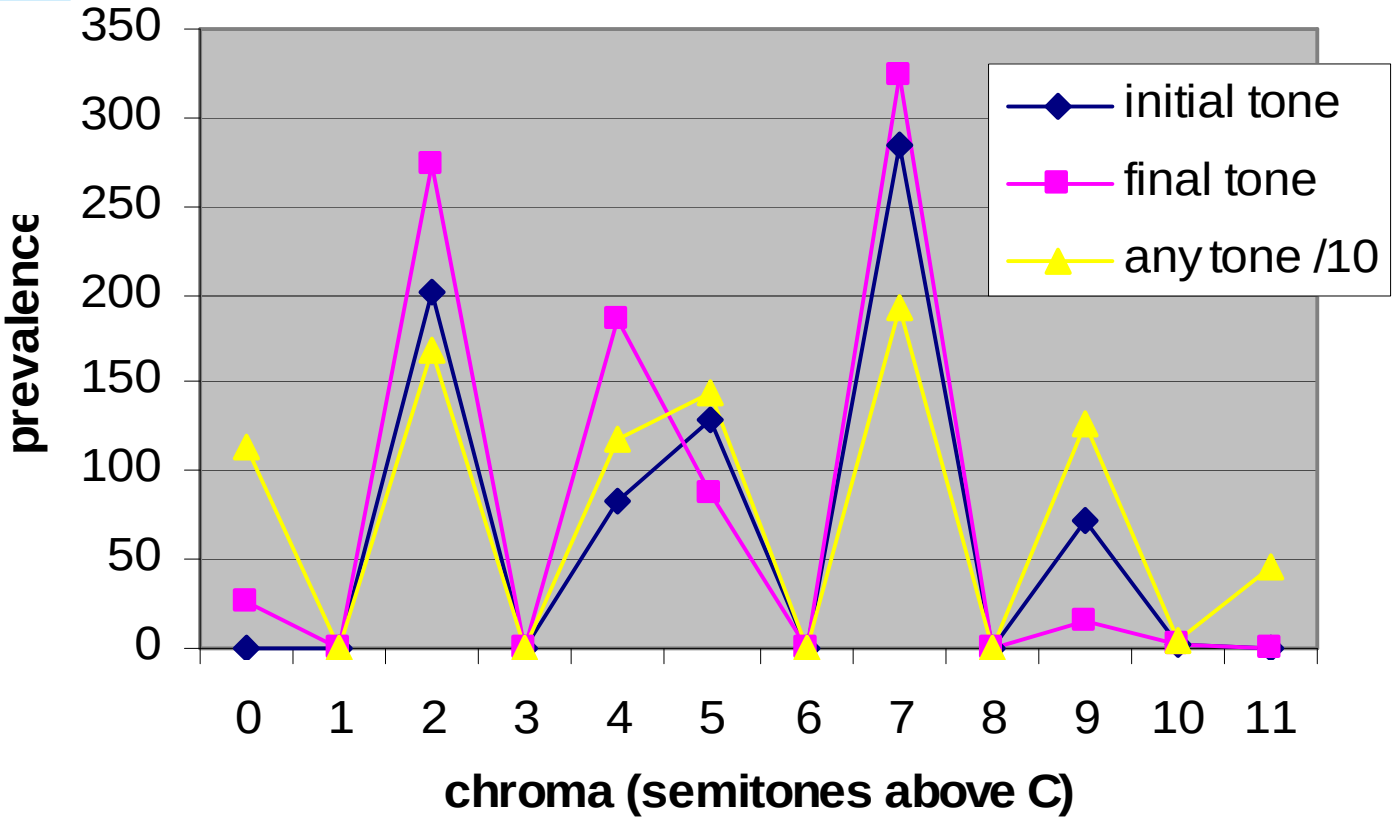
# 5. The leading tone

*in major-minor tonality*

- The pc-salience model does not explain the leading tone's role in major-minor tonality.
- The leading tone emerged in a different historical period (<13th century)
- Ultimate origin in Gregorian chant?

# Instability of the tone B in Medieval chant

*Origin of the leading tone?*




B (11) is the least frequent tone at any position.
Source of data: Bryden, J. R., & Hughes, D. G. (1969).
*An index of Gregorian chant.* Cambridge, MA: Harvard University Press.).

# Prevalence of tones/modes in chant

- Theory:
  - prefer harmonic series above final
    → salience of final
  - prefer whole tone above & below final
    - consonance of three central pitches
  - avoid tone B near final
    - unstable!

- Predictions:
  - most prevalent modes/tones: G, D
  - F more prevalent/stable than E
  - C more prevalent/stable than B

  → leading tone effect

# 6. The falling-fifth (DT) cadence

*asymmetries of chord progressions in tonal music*

- Data from the tonal repertoire
  - Eberlein (1994)
- Theories to explain the data
  - Leading tone
    - Are chord pairs with a rising semitone preferred?
  - Cultural imprinting
    - Do early voice-leading conventions persist today?
  - Are chord roots harmonics of the tonic?
    - Rameau, Lipps-Meyer
  - Root newness
    - Does “progression” mean the root of the 2nd chord is not in 1st?
  - Implication-realisation
    - Should the tones in the 2nd chord be implied in the 1st?

# Prevalence of 2-chord progressions

Eberlein, R. (1994). *Die Entstehung der tonalen Klangsyntax* (pp. 422-423). Frankfurt: Peter Lang.

| Eberlein's sample | |
|---|---|
| J. S. Bach | 7 chorales; *kleine harmonische Labyrinth* |
| Händel | Trio sonata Op. 5 No. 5 |
| Mozart | *Missa brevis* KV 65 (Kyrie, Gloria, Agnus Dei) |
| Beethoven | Mass in C (Kyrie, Gloria) |
| Mendelssohn | Motets Op. 78, Nos. 1 & 2 |

| | **rising P4** | **falling P4** | **rising 3rd** | **falling 3rd** | **rising M2** | **falling M2** | **total** |
|---|---|---|---|---|---|---|---|
| **maj-maj** | 64 | 19 | 0 | 0 | 6 | 2 | **91** |
| **maj-min** | 60 | 1 | 2 | 9 | 5 | 0 | **77** |
| **min-maj** | 5 | 20 | 1 | 15 | 5 | 3 | **49** |
| **min-min** | 21 | 5 | 0 | 0 | 1 | 0 | **27** |
| **total** | **150** | **45** | **3** | **24** | **17** | **5** | **244** |

# Asymmetries in chord progressions

- Clear in the tonal literature
  - e.g. rising>falling fourth between roots
- Unclear in listening experiments
  - Do isolated DT or ST cadences sound equally similar and equally final?

Why are falling fifths/thirds between roots preferred?

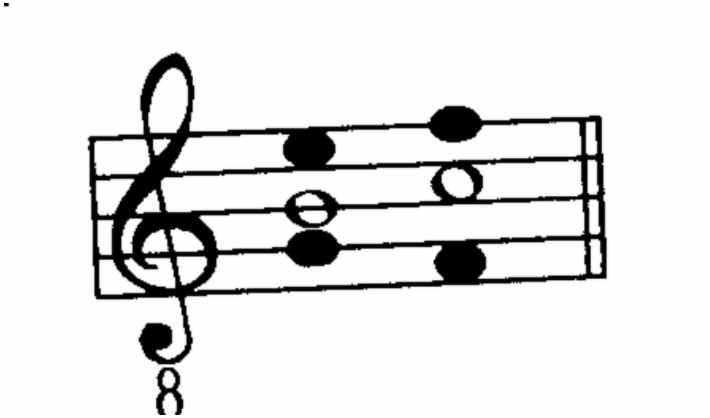
# Role of the leading tone?

- If chord progressions in which one voice rises by a semitone are preferred, falling fifths between roots will be preferred.
- But that does not explain the preference for falling-third over rising-third progressions.

Why are falling fifths/thirds between roots preferred?

# Double leading-tone cadence?

*14th century*



## Origin: two-part cadences (12th Century)

- major sixth → octave; major third → fifth; etc.

## → double-leading-tone cadence (14th)

- two intervallic resolutions simultaneously

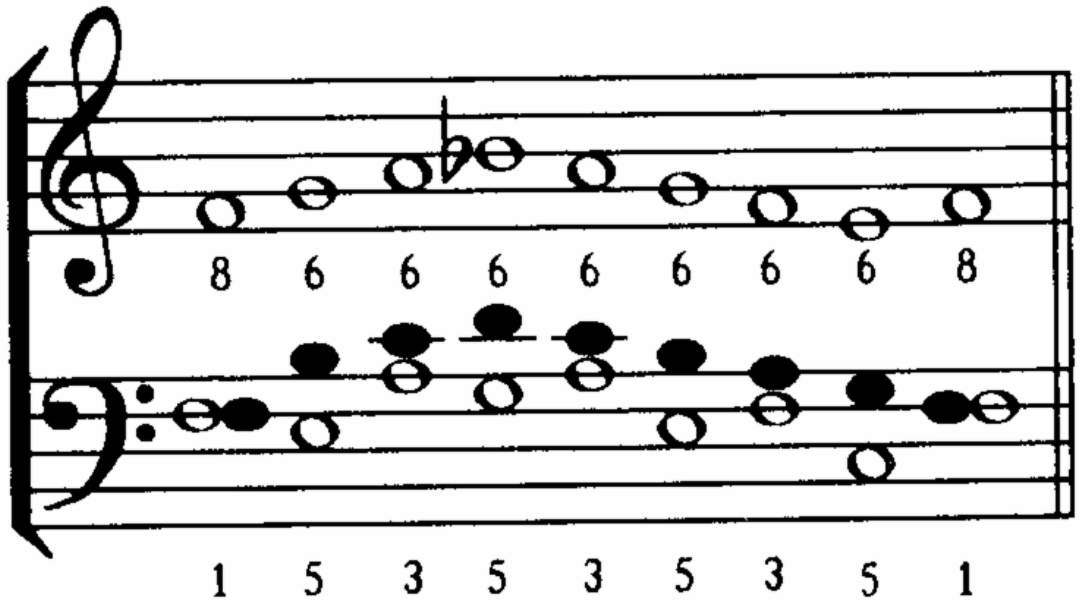
## → falling-fifth cadence (16th)

- transition from 3 to 4 voices
- voicing GDGB-CCGC avoids parallels

Why are falling fifths/thirds between roots preferred?

# Fauxbourdon?

*vocal improvisation in the 15th century*




Did not lead to a lasting preference for falling-**fourth** cadences.
This casts doubt on any “cultural imprinting” theory.

Source: Eberlein, R. (1994). *Die Entstehung der tonalen Klangsyntax* (pp. 113). Frankfurt: Peter Lang.

*Why are falling fifths/thirds between roots preferred?*

# Are roots harmonics of the tonic?

- Rameau:
  - dominant = 3rd harmonic, tonic = 2nd
- Lipps-Meyer:
  - power of 2 corresponds to tonic
- Problems:
  - frequency ratios are not directly perceptible
  - there are often two ratios for one interval

*Why are falling fifths/thirds between roots preferred?*

# “Root newness” theory

- Is a feeling of “progression” created if the root of the second chord is *not* a tone in the first?
- Problem: you could also argue the opposite!

Why are falling fifths/thirds between roots preferred?

# Implication-realisation theory

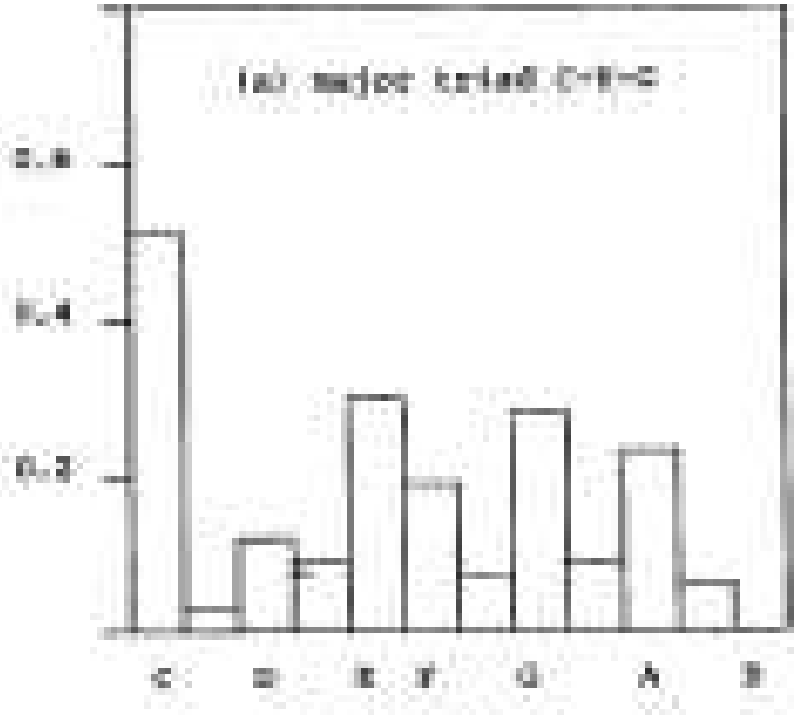
Meyer, L. B. (1956).
*Emotion and meaning in music.*
Chicago: U Chicago Press.

- Theory:
  - fulfilment of expection
  - = realisation of implication
  - → emotion
- Example: melody
  - implication: rising leap
  - realisation: stepwise descent

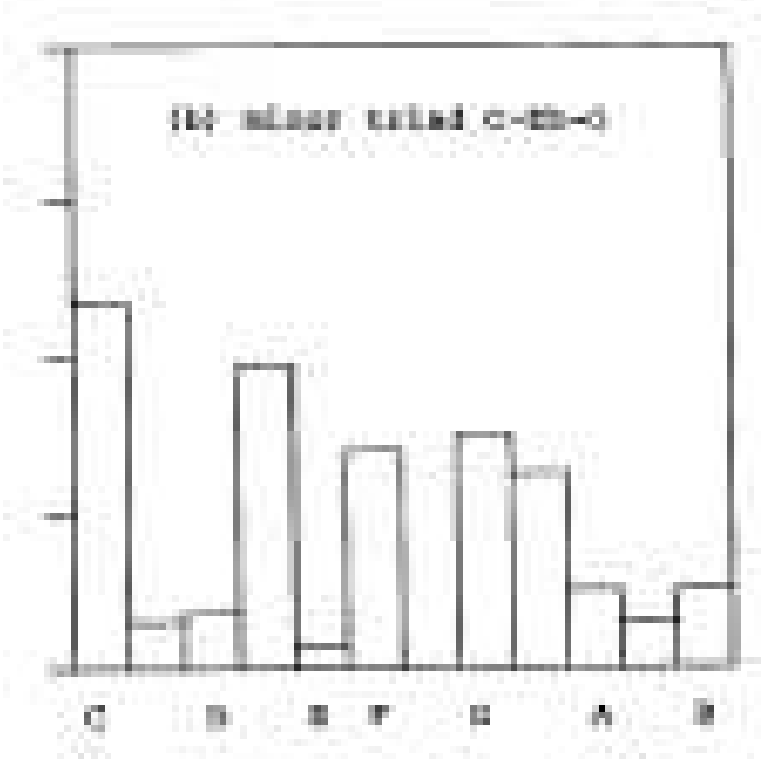
# Model of pitch salience in chords

Parncutt (1988)

major triad



minor triad



- The “implied pitches” at scale degrees 6, 4 and 2 correspond to missing fundamentals
- Individual differences in perception of missing fundamentals are large (Schneider et al., 2005)
- Time and frequency models of pitch perception make essentially the same predictions

# Chord progression asymmetry: The role of pitch salience

**Thesis:**

In “strong” chord progressions,

the *implied* pitches in the first chord

are *realised* in second chord.

- an elaboration of “root newness”

# Implication-realisation at cadences

at several different levels simultaneously

- tonal passage → tonic triad
  - implication: prevalence profile
  - realisation: salience profile
- any two chords
  - implication: implied pitches in first chord
  - realisation: real pitches in second chord
- leading tone → tonic
  - unstable → stable
- seventh on dominant → third on tonic
  - dissonant → consonant

# Pitch salience model: Implications

- Composition: new tonic sonorities
  - Ferguson & Parncutt (RITM, 2005)
- A new music-theoretic paradigm?
  - root, implied scale
  - melodic and harmonic relationship
  - voice leading
  - tonality
- Phenomenology in musicology
  - humanities meet sciences