

Harmonic Models

CS 275B/Music 254

General questions

- ▶ Can harmony be separated from pitch and rhythm?
- ▶ Should harmony be computed top-down or bottom up?
- ▶ How should harmonic change be segmented?
- ▶ How can harmonic information best be communicated?

Krumhansl on Rhythm and Pitch Organization

Psychological Bulletin (2000). 126/1, 159-179.

Rhythmic phenomena

- ▶ Periodic pulse
- ▶ Grouping
- ▶ Objective rhythmicization
- ▶ Ratios of durations
- ▶ Patterns of duration (rather than absolute values) of primary psych importance (*motoric involvement*)

Pitch phenomena

- ▶ Discreet frequencies
- ▶ Melodic intervals
- ▶ Consonance, dissonance
- ▶ Pitch patterns

Bottom-up approach

Krumhansl (2): Pitch aspects of harmony

- ▶ Categorical perception of pitch (intervallic sizes)
 - ▶ Tonal hierarchies
 - ▶ Key estimation
 - ▶ Virtual pitch (missing fundamental)
 - ▶ Transposition (not always recognized)
 - ▶ Modulatory distance (circle-of-fifths)
 - ▶ Large-scale musical form
-
- ▶ *Conclusion:* musical patterns organized into hierarchies of events

Melodic change vs. Harmonic change

1. Same melody, changing harmony

Allegretto Beethoven, 7th Symphony

p

Allegretto

p

A: I V I
Harmonic rhythm

Dynamic properties of structure

In regular circumstances

- How many times is the **theme** (re)stated?
- How many times is the **melody** the same?
- How many times is the **harmony** the same?

Mozart, Symphony K. No.550

The image displays five systems of musical notation for Mozart's Symphony K. No. 550. Each system consists of a piano (p) staff and a bass (b) staff. The first system includes dynamic markings *p* and *mf p*. The fifth system includes a dynamic marking *f*. The notation includes various musical symbols such as notes, rests, and bar lines, illustrating the dynamic properties of the structure.

Hugo Riemann (Riemann-esque analysis)

The image displays a musical score for piano, marked "Allegro" and "p" (piano). The score is written in treble and bass staves. The first system includes a Riemann-esque harmonic analysis below the notes, consisting of the sequence: **I V I IV I V V₇ I**. The second system features a "cresc." (crescendo) marking and a fermata over the final measure. The third system includes a "p" (piano) marking and a fermata over the final measure.

Metrical reductions

The image displays three staves of musical notation, likely from a piano score, with red hand-drawn circles highlighting specific rhythmic patterns. The first staff is marked "Allegro" and "p" (piano). The second staff includes a "cresc." (crescendo) marking and a "8" below the staff. The third staff is marked "p" (piano). The red circles are drawn around groups of notes and rests, indicating a metrical reduction or a specific rhythmic analysis.

Harmonic evaluation

► Musical texture:

- interval of assessment
- Harmonic bald spots
- Thematic neutrality

The image displays a musical score for piano, consisting of three systems of staves. The first system is marked 'Allegro' and 'p' (piano). It features a treble staff with a melodic line and a bass staff with a rhythmic accompaniment. Two large blue arrows point down to the first and second measures of the treble staff. The second system continues the piece, with a 'cresc.' (crescendo) marking in the treble staff. The third system shows a transition, with a blue rectangular box covering the middle section and a red rectangular box covering the final section. The score is written in a standard musical notation style, with notes, rests, and dynamic markings.

Joseph Swain: *Harmonic Rhythm* (1998)

- Six levels of harmonic rhythm

- Phenomenal rhythm
- Bass-pitch rhythm
- Root analysis
- Within-key analysis
- Density
- Harmonic function
- Interpretation

Ex. 4-1. Corelli, Concerto op. 6, no. 8, III, mm. 9-14.

Allegro

Tex.
Phen.
Bass pitch

These are the famous three levels of harmonic rhythm.

Schenker (Schenkerian analysis)

Foreground/
background

BACH: Brandenburg No 2, Movement No. I, bars 111 - 113
Reduction

112.

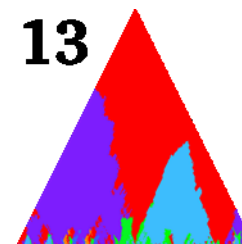
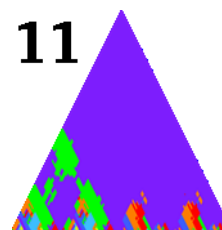
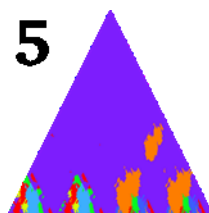
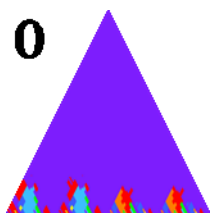
VI₇ II₇ V₇

α α

Example 3.16.

Evaluation and detection (Sapp)

- ▶ Riemannesque analysis: root-based chord analysis
 - ▶ kern > eval > new spine > gmn
 - ▶ chord quality tool (Sapp)
- ▶ Visualization of chord root/quality > key (Sapp)
- ▶ Pattern violations (#13)



Schubert: Piano Variations D 576

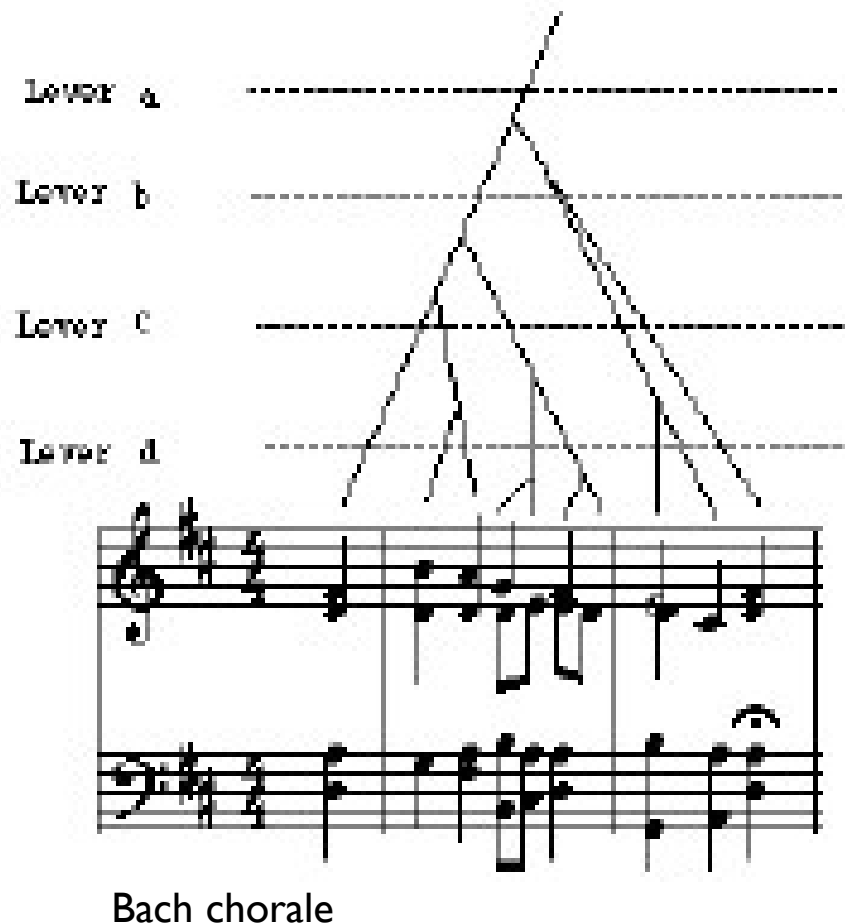
Lerdahl (Gestalt readings)

Lerdahl & Jackendoff:

Generative Theory of Tonal Music (MIT, 1983)

Grammatical structures

- Grouping structures
 - Motives, phrases
- Metrical structures
 - Strong, weak beats
- Time-span reductions
 - Tree structures
- Prolongational reductions
 - Psychological awareness



Lerdahl: *Tonal Pitch Space* (2001)

GTMM rules

1. Well-formedness **rules** (structure)
2. Preference rules (listener-based)
3. Transformational rules (grouping, deceptive situations)

Preference rules

1. Harmonic tension
2. Melodic attraction
3. Attraction, expression



FIGURE 4.1 Mozart's Sonata, K. 282, I, bars 1-9.

Lerdahl: Tonal Pitch Space (2001)

Riemannian functions

Octatonic vs hexatonic spaces

Chromatic spaces

Whole-tone spaces

Metrical attractions

Psycho-acoustical factors



Lerdahl, Krumhansl (2007), 1

“Modelling Tonal Tension,” *Music Perception* 24, 329-366 (2007)

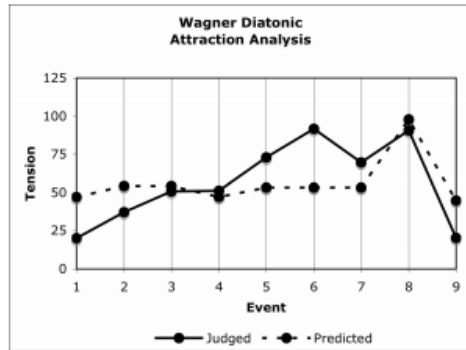


FIGURE 18. Attraction analysis of the Grail theme.

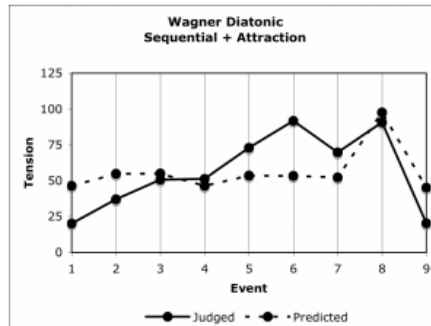


FIGURE 19. Combined sequential + attraction analysis of the Grail theme.

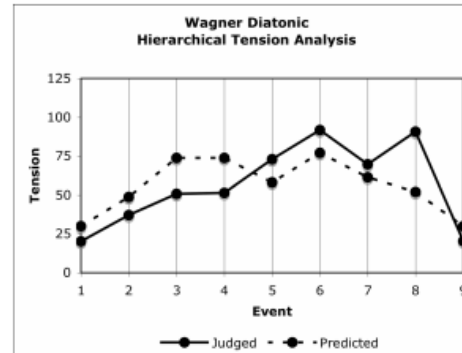


FIGURE 20. Tension graph for the theoretically preferred hierarchical analysis of the Grail theme.

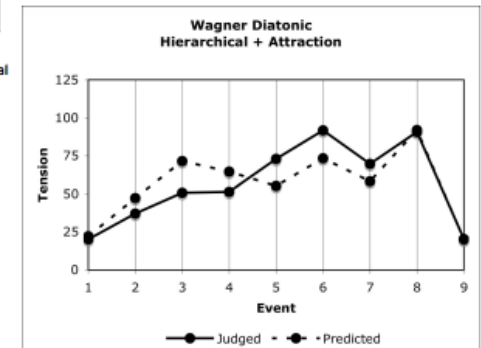


FIGURE 21. Combined hierarchical (theoretically preferred) + attraction analysis of the Grail theme.

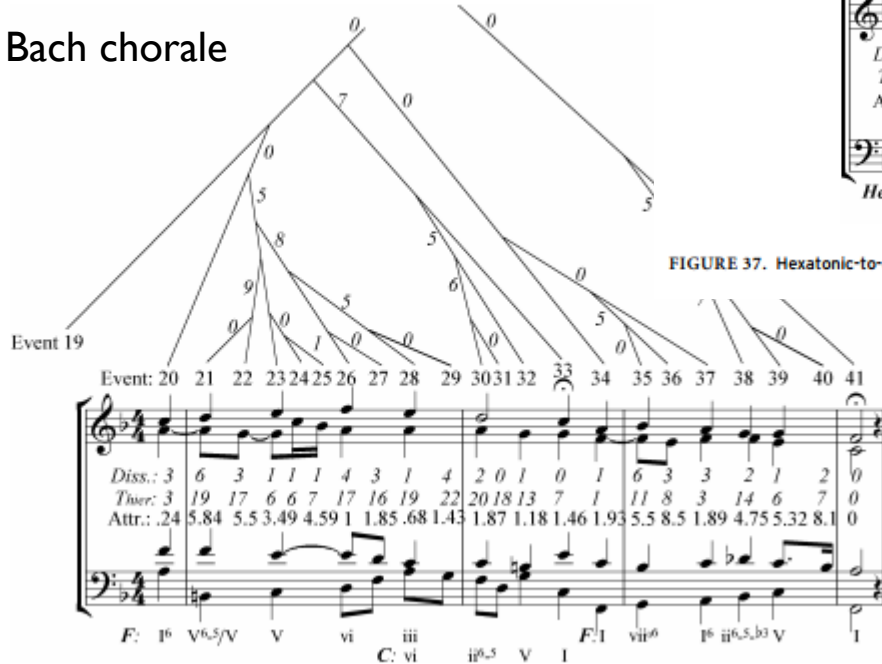
Attraction
←
Tension
→

Combo attraction
←
Combo hierarchical
→

Principles: Prolongational structure, pitch-space model, surface-tension model, attraction model--
Experimental results

Lerdahl, Krumhansl (2007), 2

Bach chorale



5. Analysis of the Bach chorale, phrases 3-4.

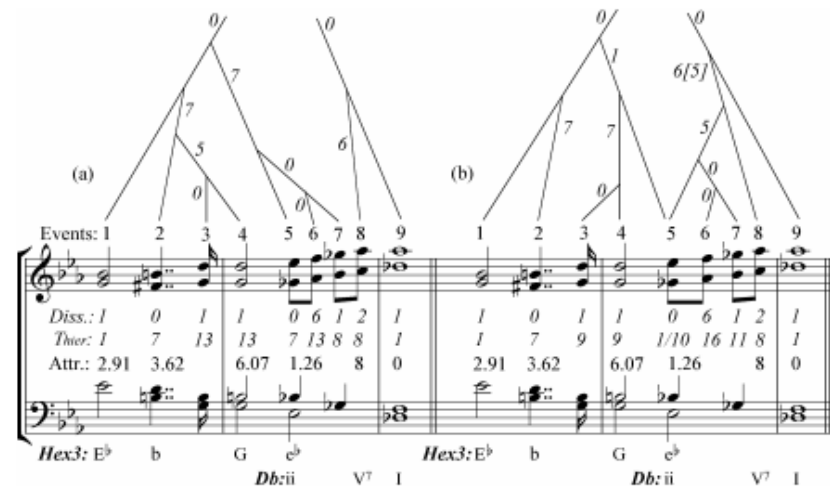


FIGURE 37. Hexatonic-to-diatonic analyses of the chromatic version of the Grail motive: (a) right-branching interpretation; (b) TPS interpretation.

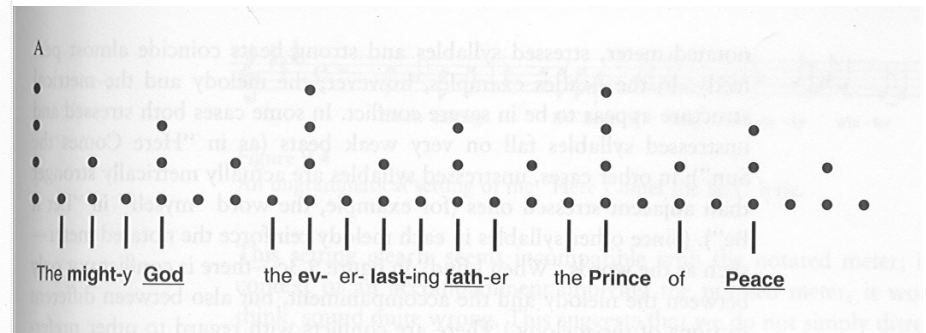
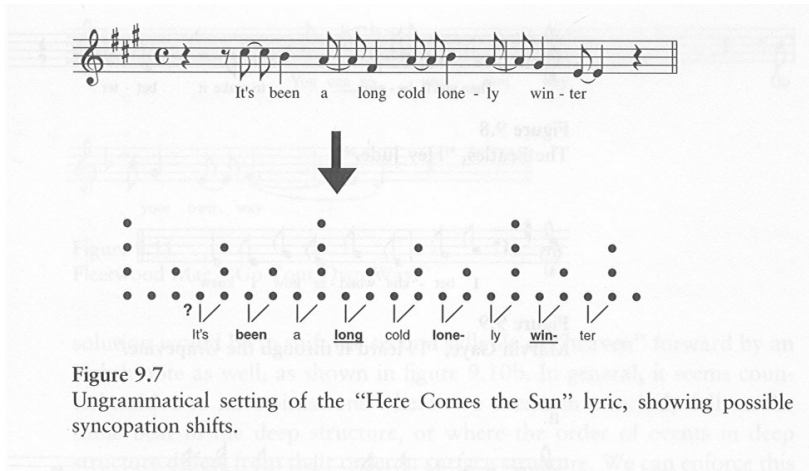
Wagner “Grail” motif.

Temperley 2003, 1

Music Cognition: *The Cognition of Basic Musical Structures* (2003)

Areas covered:

- Metrical structure
- Phrase structure
- Melodic phrase structure
- Contrapuntal structure
- Harmonic structure
- Key structure



Temperley 2003, 2

▶ Repertories and perspectives

- ▶ Ambiguity
- ▶ Rock
- ▶ African music
- ▶ Generative processes
- ▶ Non-metrical music
- ▶ Arbitrariness

Method: mainly based on GTTM (Lerdahl...) and extensions to it

Software: ([Melisma](#)): mainly written Daniel Sleator

[cf on KernScores]

Temperley (3)

- *Music and Probability* (2006)

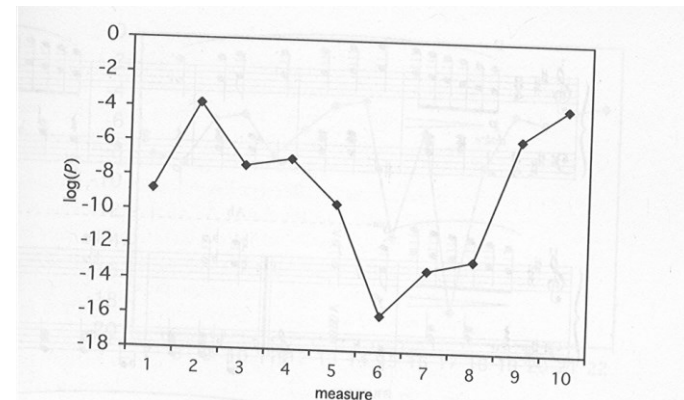
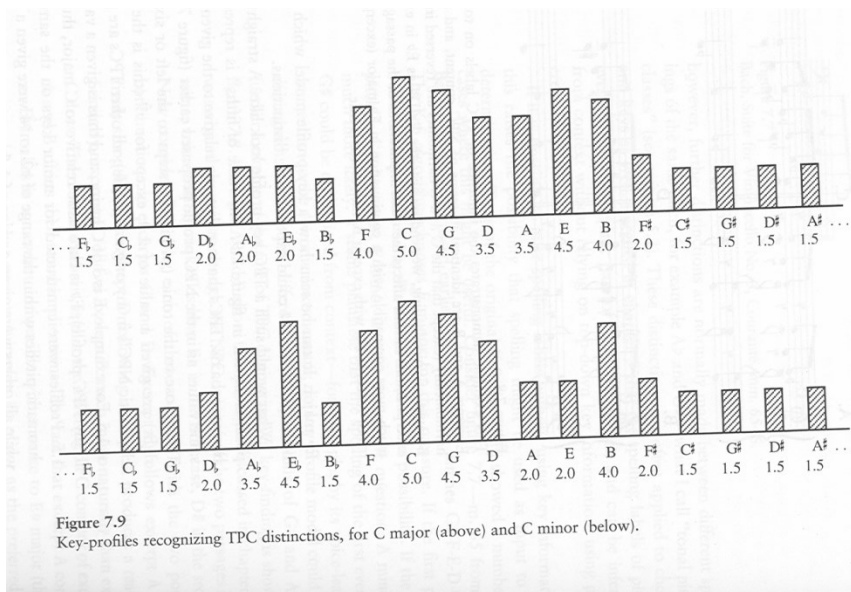


Figure 7.7
The model's probability scores for the Chopin Mazurka excerpt in figure 7.6.



Figure 7.6
Chopin, Mazurka Op. 6, No. 1, mm. 1-10.

Harmonic generation

Generation of **harmony from melody**

Kemal Ebcioglu (SUNY Buffalo, 1986; IBM)

- rule (“expert”) systems

 - (100 for thesis,

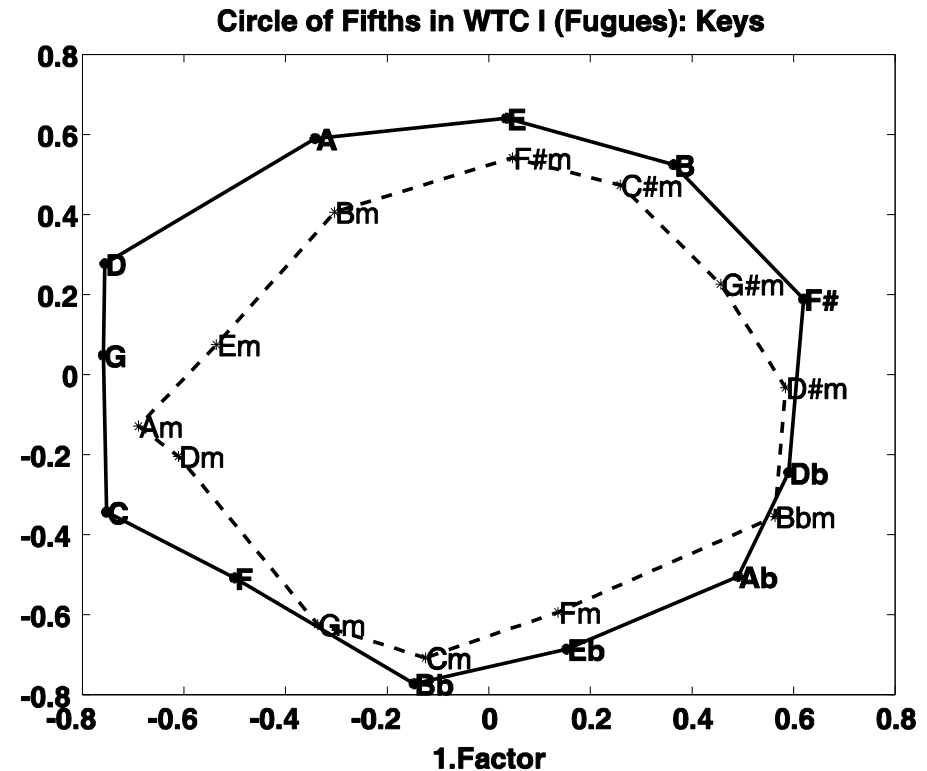
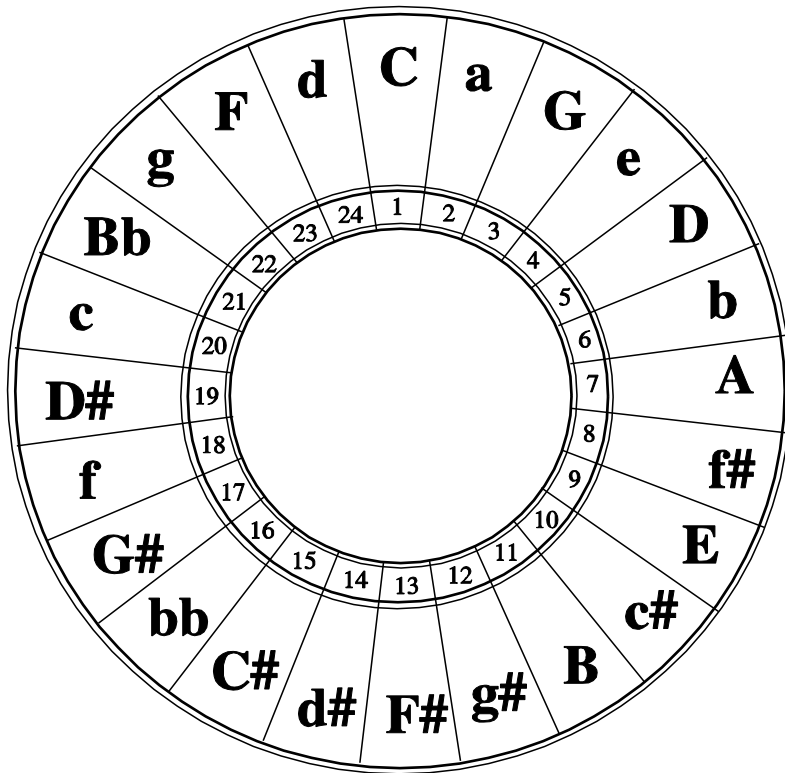
 - 300 in post-thesis work)

Generation of **entire chorales**

David Cope (UC Santa Cruz, 2005)

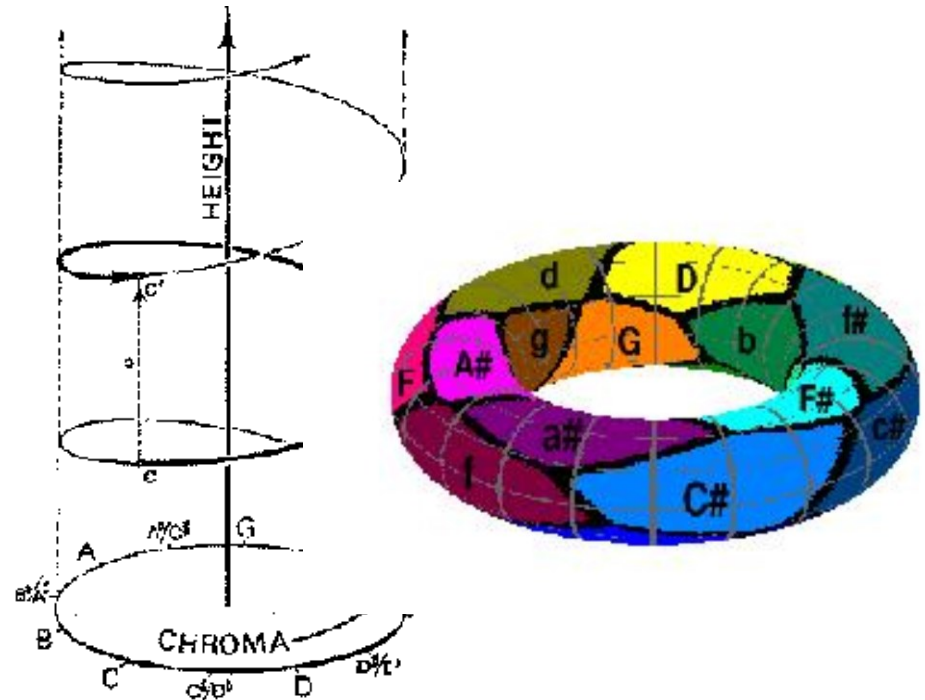
- augmented transition network

Izmirli: Acoustics vs. Circle of Fifths



Geometrical models of tonality (2000-2010)

- 18th century
 - Heinichen
 - Euler
- 19th century
 - Riemann
- 20th century
 - **Shepard (SU)**
 - **Krumhansl (SU, Cornell)**
 - **Lerdahl (Columbia)**
 - **Chew (SU, MIT, London)**
 - **Purwins (Berlin, Barcelona)**
 - **Sapp (SU)**



Toroidal models of tonality

G. Weber key chart

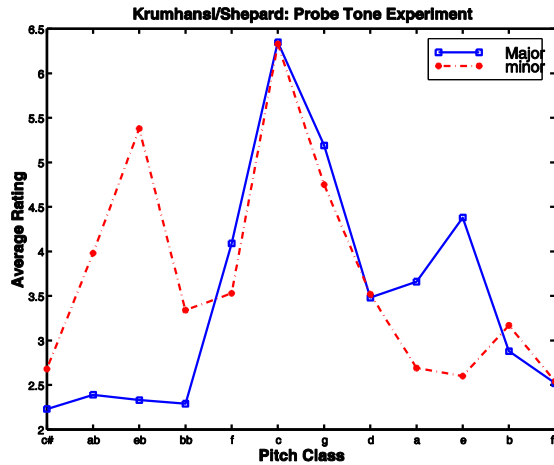
d#	F#	f#	A	a	C	c
g#	B	b	D	d	F	f
c#	E	e	G	g	Bb	bb
f#	A	a	C	c	Eb	eb
b	D	d	F	f	Ab	ab
e	G	g	Bb	bb	Db	db
a	C	c	Eb	eb	Gb	gb

eb	bb	f	c	g	d	a	e	b	f#	c#	g#	d#
Gb	Db	Ab	Eb	Bb	F	C	G	D	A	E	B	F#
gb	db	ab	eb	bb	f	c	g	d	a	e	b	f#

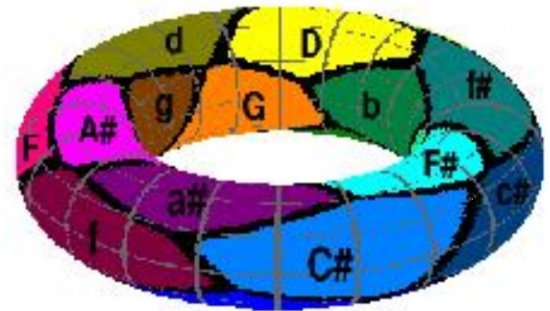
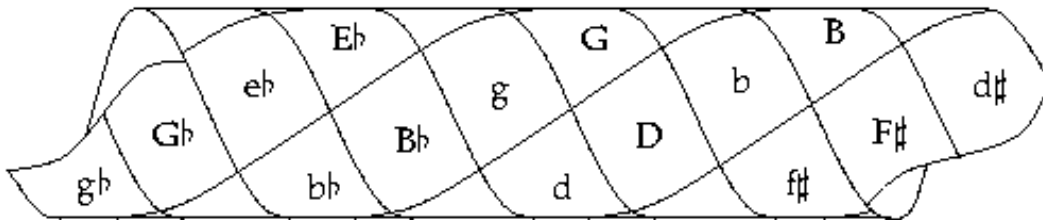
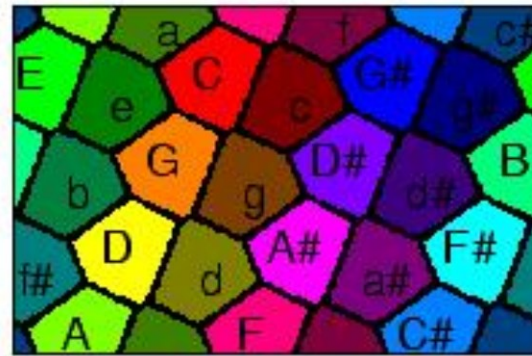


Krumhansl: *Cognitive Foundations of Musical Pitch* (1990)

Hendrik Purwins



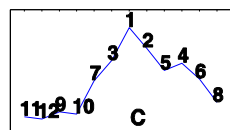
Stephen Malinowski



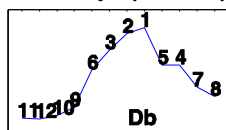
Weber

Well Tempered Clavier (Purwins)

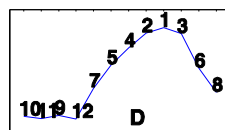
CQ-Profiles of WTC I Preludes in Major (G. Gould)



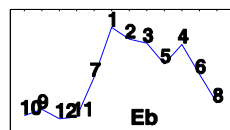
c#g#e bbb f c g d a e b f#



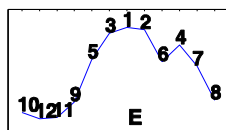
d a f b c b g d b a b e b b b f c g



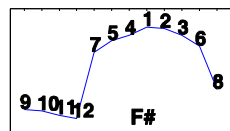
d#a# f c g d a e b f#c#g#



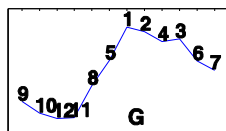
e b g b d a b e b b b f c g d a



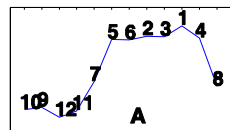
e#b#g d a e b f#c#g#d#a#



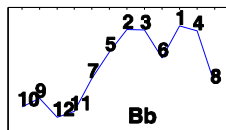
f#f#f#a e b f#c#g#d#a#e#b#



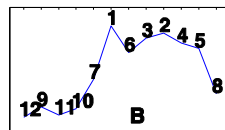
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a#e#c g d a e b f#c#g#d#

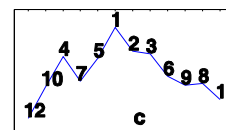


b f#d a b e b b b f c g d a e

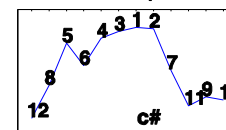


b#f#d a e b f#c#g#d#a#e#

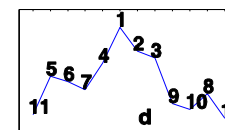
CQ-Profiles of WTC I, Preludes in Minor (G. Gould)



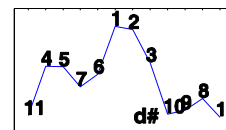
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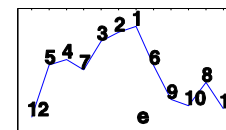
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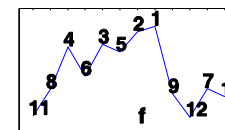
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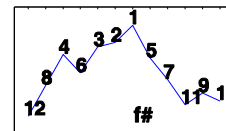
f b c b g d b a b e b b b f c g d b b b



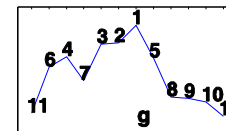
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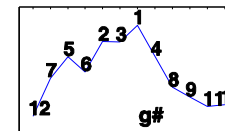
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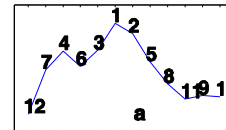
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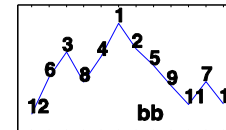
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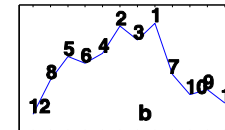
b b f b c b g d b a b e b b b f c g e b b



b b f c g d a e b f#c#g#e b



c b g d b a b e b b b f c g d a f b



d b b b b b b f b c b g d b a b e b b b g b b

Harmonic usage profiles of individual preludes and fugues from JS Bach's WTC (1722)