Progress from Analytic to Global Perception of Modulations with Increased Familiarity with Music

W. Jay Dowling

Music Perception and Cognition Laboratory (MPaC)
The University of Texas at Dallas
Tonal Hierarchy

• Provides a framework for encoding the pitches of a melody
• Selects 5-7 pitches out of the 12 semitones to form a “scale”
• Establishes a tonal center – “tonic” pitch – and a hierarchical pattern of importance of the other pitches
• This can be seen in tonal profiles that describe the hierarchies in different keys.
Two Western Tonal Hierarchies

- Krumhansl & Kessler (1982)
- Key profiles
- Notice “in-scale” vs. “out-of-scale” pitches
Melody and the Tonal Hierarchy

• The tonal hierarchy defines a set of expectancies

• Expectancies guided by general, “schematic” knowledge of the tonal system, and “veridical” knowledge of particular melodies (Bharucha)

• For example, out-of-key pitches in Schubert’s Ave Maria – note that they sound perfectly natural in a well-known melody

• Increasing familiarity with a piece develops expectancies such that formerly surprising events begin to sound “natural” – and so are no longer sharply differentiated from their context
Ave Maria

(Walter Scott)

German translation by
Adam Stork

English adaptation by
Dr. Theo. Baker

Franz Schubert. Op. 52, No. 6

Molto lento (sehr langsam)

Voice

Piano

Ah, listen to a maiden's prayer;
For Thou canst hear amid the

mild,
erhöre einer Jungfrau Flehen, aus diesem Felsenstarr und

na,
Maria, gratia plena, Maria, gratia ple-

mild,
Modulation

• Modulation from one “key” to another involves replacing the tonal profile with a new one. This can involve:
  – Changing the set of pitches (e.g., C major to C minor)
  – Changing the tonal center (e.g., C major to A minor)
  – or both (e.g., C major to A major)

• Modulation can take us to a closely related key that shares many pitches with the starting key (e.g., C major to G major), or to a distant key that doesn’t (e.g., C major to B major)

• Close modulations often heard simply as variants of the original key (tonic-dominant)
Experiments

• Listeners hear a musical excerpt in one ear, along with a probe tone in the other ear (one of the 12 possible semitones)

• They rate the probe tone continually for how well it goes with the music (Toiviainen & Krumhansl, 2003)

• They go through the excerpt 12 times, each time with a different probe

• Different listeners hear the 12 probes in different orders, randomly determined
TASK

Item 1 of 2

Judgement of Fitness

50

Jarring

Moderate fit

Perfect Fit

Use mouse to move slider to desired position.
Experiments

• We use the ratings to put together tonal profiles that may change as the listener progresses through the piece

• We correlate those profiles with the standard profiles for the possible keys that the listener will encounter

• If the listener is following the modulations in their ratings, the correlations will show the shifts from key to key
Experiment 1

• There are two kinds of modulation in Carnātic (South Indian classical) music: grahabēdham (like C major to A minor), and rāgamālikā (like C major to C minor)

• We used one excerpt of each type, about 1 min long

• 10 Indian & 10 Western music teachers participated

• The Indian teachers were familiar with the excerpts, especially the rāgamālikā excerpt, whereas Western teachers were unfamiliar with both excerpts
Grahābēdham
(Raman & Dowling, 2016)
Grahabēdham

![Graph showing mean correlation coefficient over time periods]

- **Indian**
  - Panthuvarāli
  - Mōhanam

**Time periods:** T1, T2, T3, T4, T5
Rāgamālikā
Rāgamālikā
Results

• MANOVA: 2 Nationalities X 5 Time Periods
• There were main effects of time period for both modulation types: rāgamālikā, $F(8,11) = 5.25$, $p<.01$; grahabēdham, $F(8,11) = 8.57$, $p<.001$.
• The Time Period X Nationality interaction approached significance overall for rāgamālikā, and was significant for the Sriranjani rāgam in particular, $F(4,15) = 4.60$, $p<.01$. 
Results

• For grahabēdham, the Time Period X Nationality interaction was not significant overall ($p<.18$), but was significant for the individual ragams: Panthuvarāli, $F(4,15) = 5.22$, $p<.01$; Mōhanam, $F(4,15) = 6.47$, $p<.01$.

• Clearly, the Indian teachers were responding in a more global fashion to the modulations than the Western teachers, who were more analytic.

• Could this global responding be due to their greater familiarity with the pieces?
Experiment 2

• In Experiment 2, we were able to look at possible effects of increasing familiarity

• Since listeners heard the excerpts 12 times in the continuous probe-tone method, we could look at their responses during the first 3 hearings compared with the last 3 hearings

• The excerpts were the first 2 min of Haydn’s Quartets op. 76, no. 2 (“Quinten”) and op. 76, no. 3 (“Emperor”), starting at the beginning and stopping at the end of the exposition section

• The excerpts contained 3 or 4 modulations:
  – d minor, F major, f minor, F major
  – C major, G major, g minor, E♭ major, G major
QUARTET No. 76
"Quinton" (Filths)
in D minor
Joseph Haydn, Op. 76 No. 2
(1732 - 1809)

Allegro

Violino I
Violino II
Viola
Violoneello
Experiment 2

- Blocks of 12 listeners with the same level of musical training complete a Latin square, so that for each trial each of the 12 probes is represented.
- We will look at the responses of the 60 listeners with more than 5 years of musical training, and the 60 with no musical training.
- We use the ratings to put together tonal profiles that (we hope) will change as the listener progresses through the piece.
- We correlate those profiles with the standard profiles for the possible keys that the listener will encounter.
76/2 Exp trials 1-3
76/2 Exp trials 10-12
76/2 Inexp trials 1-3
76/2 Inexp trials 10-12
76/3 Exp trials 1-3

C   G

\[ g \quad E^b \quad G \]
76/3 Exp trials 10-12
76/3 Inexp trials 1-3

![Graph showing data points for different categories and trials.](image)
76/3 Inexp trials 10-12
Conclusions

• The more experienced listeners differentiated the changes of key more clearly

• With repeated exposure to the pieces, the sharp differentiation of keys tended to get smoothed out, suggesting that familiarity leads to a more global approach to hearing the piece
Experiment 3

- This led us to manipulate familiarity even more strongly
- 12 student orchestra members performed the task with a piece they were going to learn, but had not seen yet (the finale of Dvorak’s “American” String Quartet)
- Then they did the task in the middle of the semester after practicing the piece for 6 weeks
- Finally they did the task after playing the piece in their concert
Experiment 3

• There were 5 modulations in the first 2 min of the piece, involving 4 keys:
  – F major
  – A minor
  – C major
  – Ab major

• We looked at sessions 1 and 3, where the difference in familiarity was strongest
Results

• ANOVA: 2 Sessions X 10 Time Periods X 4 Keys
• Strong Period X Key interaction, $F(27,297) = 27.30$, $p<.0001$
• The only interaction involving session was Session X Key, $F(3,33) = 2.39$, $p<.09$, in which the key means were more spread out in Session 1
• This could be taken as a very indirect indication of a global shift, but clearly these listeners started out and finished with quite sharp differentiation among keys
Conclusions

• In some cases there are indications of a tendency toward more global perception with increasing familiarity (Indian vs. Western differentiation of Indian modulations; loss of sharp differentiation throughout session by more experienced musicians)

• Less knowledgeable listeners tend to a more global pattern of response, correctly tracking the principal keys of an excerpt, but not always tracking shifts of key
Conclusions

• However, our attempt at manipulating familiarity with the orchestra members failed to show convincing evidence of a shift from analytic to global perception.

• It may be that the demands of playing the piece helped maintain those listeners in their more analytic mode.

• This might contrast with familiarity derived from listening, where expected deviations come to blend into their context, with a resulting more global perception of the piece.
THANK YOU

- Kieth Gryder
- Kevin Herndon
- Jaicey Johnson
- Chris Lo
- Parisa Najafigol
- Bhavana Penmetsa
- Rachna Raman
- Ashwin Ramesh
- Franco Sabatini
- Alan-Michael Sonuyi
- William Stanford
- Naveen Subramanian
- David Tram
- Sahiti Yarakala