Effects of song familiarity, singing training and recent song exposure on the singing of melodies

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ISMIR 2003, Baltimore, USA
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Motivation

• ‘Query by humming’ requires people to sing
• But, how well do people sing

• We do not know that well!
  Lack of knowledge on
  singing skills of the general public
  long-term memory issues
  how that all relates to the singing by ‘professionals’ and
  real-world song material (everyday singing)

• How can knowledge on singing be used in ‘query by humming’ applications?
What do we know?
Memory for melodies

• What properties are essential for a melody?
• Almost always essential are:
  – rhythm
  – intervals
  – contour
• But, you can change
  – key
  – tempo
  – timbre
  – loudness
without changing the melody
What do we know?

Memory for melodies

- Rhythm is essential
  (Marilyn Boltz, Mari Riess Jones, Edward Large, Carolyn Drake)
  - Listeners attend rhythmically to music
  - Just tapping the rhythm can be sufficient to recognise well-known melodies
  - Melodies under a different rhythm are hard to recognise
  - Melodies with complex rhythms are hard to remember
What do we know?

Memory for melodies

• Contour and intervals are essential
  (W. Jay Dowling, Dane Harwood, Judy Edworthy, Wouter Croonen)
  – The contour is the first thing you learn about a new melody
  – Melodies with the same contour get easily confused

  – For cueing long-term memory, intervals are required

• Only with
  – increasing song familiarity
  – increasing cognitive abilities (child ➔ adult)
  – musical training

intervals become more important
What do we know?

Singing melodies

• Singing refers to articulating a recalled melody

• Voice is the most difficult musical instrument
  (Lee Davidson, Daniel Levitin, Perry Cook, Johan Sundberg)
  – Delicate control of muscles with auditory feedback
  – Untrained singers tend to
    • use only a contour to control their singing
    • sing large intervals flat
    • accumulate interval errors (ending in a different key)
    • be unable to reflect on and improve their singing
  – However, some people can sing their favourite song at the correct pitch and at the correct tempo
Experiment

• Study of
  – singing familiar and less familiar songs of ‘the Beatles’
  – being a trained singer or an untrained singer
  – singing from memory and after listening to the song on CD
    (trial 1 and 2: singing from memory; trial 3: singing after listening)

• Participants
  – Trained singers: 8 students ‘Classical voice’ and ‘Musical theatre’ from Tilburg school of music
  – Untrained singers: 10 colleagues without any singing education

• Material
Sort the 12 cards with Beatles song titles

Sing 2 (most) familiar songs and 2 less (least) familiar songs twice from memory

Sing the songs once more after listening to the song on CD
Experiment
Measures

• Singing measured by
  – Tuning (‘starting at the correct pitch?’)
  – Contour (‘following the ups and downs?’)
  – Intervals (‘singing the correct tone distances?’)
  – Tempo (‘singing at the correct tempo?’)

Using reference melodies and tempo measurements of the original songs on CD

All reproductions were manually segmented
Experiment

Results: general

• 216 (18*4*3) reproductions of 12 Beatles songs

• Trained singers sang more notes (45) than untrained singers did (28)

• For familiar songs
  – 36 notes were sung (min: 12, max: 94)

• For less familiar songs
  – 19 notes were sung (min: 3, max: 65)
Experiment
Results: tuning

• Measure: deviation from the correct tone in semitones

• When singing from memory
  – participants chose randomly a pitch to start with
  – no absolute memory for the correct pitch

• After listening
  – trained singers (15/32) were better in adopting the correct pitch than untrained singers (9/32)
  – familiar songs (15/36) were better pitched than less familiar ones (9/36)
Experiment
Results: tuning

![Bar charts for 1st, 2nd, and 3rd trials showing deviation from correct pitch in semitones.]

- a. 1st trial
- b. 2nd trial
- c. 3rd trial

- trained singers
- untrained singers

Deviation from correct pitch in semitones
Experiment
Results: tuning

![Graph showing deviation from correct pitch in semitones for 3 trials.](image)
Experiment
Results: contour

• Measure: percentage correctly going ‘up’ or ‘down’

• In general
  – trained and untrained singers performed equally well (80%)
  – contours of familiar (82%) and less familiar songs (78%) were sung equally well

• After listening
  – contours of less familiar songs improved (75% → 82%)
Experiment
Results: interval

• Measure: percentage correctly sung intervals

• In general
  – trained singers (62%) sang more correct intervals than untrained singers (56%) did
  – familiar songs (63%) were better sung than less familiar ones (55%)

• After listening
  – the singing of less familiar songs improved (53% ➞ 61%)
  – the singing of familiar songs did not
Experiment
Results: tempo

• Measure: average beats per minute sung, correlated and compared with actual tempo on CD

• In general
  – trained and untrained singers performed equally well ($r > 0.9$)
  – tempo of familiar songs came close to actual tempo ($r > 0.9$)
  – tempo of less familiar songs came *not* that close to actual tempo ($0.8 < r < 0.9$)

• After listening
  – matching the actual tempo improved
Experiment
Results: tempo

• People cannot perceptually discriminate tempi that differ less than 6% (JND = 6%)
  – A tempo of 100 bpm is perceived similar to all tempi in the range of 94-106 bpm

• Taking this finding into account
  – 30% of reproductions had the ‘correct’ tempo, when singing from memory
    • Evidence for latent absolute memory for tempo
  – 49% of reproductions had the ‘correct’ tempo, after listening
Experiment
Results: tempo

![Bar charts showing percent deviation from actual tempo for different trials.](image)
Experiment
Discussion

• Study did not assess
  – the beauty and the willingness of singing
  – song complexity
  – music idiomatic differences

• It did assess singing performance while varying
  – singing training (trained and untrained singers)
  – song familiarity (familiar and less familiar songs)
  – recent exposure (singing from memory and after CD listening)
Experiment
Discussion

• No absolute memory for pitch; trained singers adopted the correct pitch only after listening to the song
• Some latent absolute memory for tempo: 1 out of 3
• Trained and untrained singers did not differ on contour (80%), they did on interval (62-56%)
• Except for contour, familiar songs were better sung than less familiar ones, but less familiar ones improved after listening to them
• Both trained and untrained singers improved their singing after listening to the song
Conclusion

Implications for ‘query by humming’

• Query by humming
  – Melody retrieval by search algorithms
  – Finding optimal alignment between pitches and durations of sung melody with melodies in database while taking into account singing errors
Conclusion

Implications for ‘query by humming’

• Users choose a random pitch to start
• Users sing contour and tempo most reliably
• Users sing intervals less precisely

• Singing performance differ on song familiarity, singing training and recent exposure, retrieval performance likewise

• Important user data for accurate retrieval
  – How familiar are you with the song?
  – When was the last time you listened to the song?
  – What is your singing ability (training)?
• and change search accordingly
Conclusion
Implications for ‘query by humming’

Retrieval performance statistics of ‘CubyHum’ QBH system on singing data using 1000-melody database (melody ~ 300 notes)