

Empirical evaluation of intonation practices in singers and their relationship to musical context

Johanna Devaney



McGill



Schulich School of Music
École de musique Schulich



Centre for Interdisciplinary Research
in Music Media and Technology



Fonds de recherche
sur la société
et la culture

Québec



Social Sciences and Humanities
Research Council of Canada

Conseil de recherches en
sciences humaines du Canada

Canada



Northeast Music Cognition Group
NEMCOG

Introduction

Introduction

Extraction of intonation data from recordings

Introduction

Extraction of intonation data from recordings

Preliminary results from experiments on
solo singers and vocal ensembles

Introduction

Extraction of intonation data from recordings

Preliminary results from experiments on
solo singers and vocal ensembles

Open questions

Introduction

- The question of which tuning system is used by singers has been debated since the Renaissance
 - Empirical evaluations have shown that singers do not sing in any fixed tuning system (Howard 2007a, 2007b; Prame 1997)
- In order to make generalizations about what singers are doing requires the examination of a large number of performances
- This talk presents some work I have undertaken with Ichiro Fujinaga (McGill University), Dan Ellis (Columbia University), and Michael Mandel (University of Montreal)

Extraction of Intonation Data

- Labeling of note onsets and offsets in the recording
 - Onset detection techniques work for instruments with percussive onsets, e.g., piano, but generally perform poorly for non-percussive instruments (MIREX Audio Onset Detection, 2007)
 - MIDI/Audio alignment is another option for onset and offset detection
 - This research uses a hybrid dynamic time warping(DTW)/hidden Markov model(HMM) alignment algorithm optimized for the singing voice (Devaney, Mandel, & Ellis 2009)

Extraction of Intonation Data

- Fundamental frequency (F0) estimation for each frame of audio
 - F0 estimation for monophonic signals is a solved problem
 - This research uses the YIN algorithm (de Cheveigné & Kawahara 2002)
- Perceived pitch over the duration of each note
 - Calculated as the geometric mean of the frame-wise F0 estimates (Brown and Vaughn 1996)
- Evolution of F0 over the duration of the note
 - Slope (1st Discrete Cosine Transform Coefficient) - whether the singers are gliding up or down into the next note

Preliminary Results - Solo Singers

- Subjects
 - Six undergraduate sopranos from McGill University
 - Six Montreal-based professional singers (ongoing)
- Task
 - 3 performances of Schubert's 'Ave Maria' a cappella and 3 with recorded accompaniment
- Analysis of singer's self-consistency and intra-singer consistency under various conditions
 - A-Bb a cappella and accompanied
 - Bb-A a cappella and accompanied
 - other semitones ascending a cappella and accompanied
 - other semitone descending a cappella and accompanied

Preliminary Results - Solo Singers

- Fundamental frequency analysis
 - Weak effects for singer identity and accompaniment
 - No effects were found leading tone function or intervallic direction
- Slope
 - Weak effects for direction, accompaniment, and singer identity
- Overall
 - No observable effects for leading tone function
 - General tendency for small semitones

Preliminary Results - Vocal Ensembles

- Subjects
 - Professional SATB ensemble (four singers)
- Task
 - Perform a *cappella* four exercises
 - Exercises were designed to explore
 - potential points of opposition between beat-free tuning of vertical sonorities and melodic intonation tendencies
 - pitch drift

Preliminary Results - Vocal Ensembles



- Horizontal and vertical intervals tended to be smaller than Equal Temperament and (in some cases) Just-Intonation
 - Amount of variation was singer dependent
- Generally singers glided down in descending intervals and up in ascending intervals
 - Rate of change was singer dependent

Open Questions

- Data Analysis Issues
 - How much variation (in cents) is significant across performances?
 - How to determine what is “typical” intonation and what is “expressive”?
- Research Questions
 - How accurately can singers replicate a tuning?
 - What is the effect of training?
 - What is the effect of absolute pitch?
 - What is the effect of a conductor?
 - What happens when there is more than one singer to a part?

Thank you!

References

de Cheveigné, A. and H. Kawahara. 2002. YIN, a fundamental frequency estimator for speech and music. *Journal of the Acoustical Society of America*. 111(4): 1917–30.

Devaney, J., M. I. Mandel, D. P. W. Ellis. 2009. Improving MIDI-audio alignment with acoustic features. In *Proceedings of the IEEE Workshop on Audio and Signal Processing to Audio and Acoustics*. 45–8.

Howard, D.M. 2007a. Equal or non-equal temperament in a cappella SATB singing. *Logopedics Phoniatrics Vocology*. 32: 97—94.

Howard, D.M. 2007b. Intonation Drift in A Capella Soprano, Alto, Tenor, Bass Quartet Singing With Key Modulation. *Journal of Voice*. 21(3): 300—15.

Prame, E. 1997. Vibrato extent and intonation in professional western lyric singing. *Journal of the Acoustical Society of America*. 102(1): 616–21.