Intonation in SATB vocal ensembles

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Introduction

Experimental Method

Extraction Intonation Data

Some Preliminary Results

Introduction

- We are interested in explore how consistent professional singers are in their intonation practices

  - How harmonic context impacts vertical and horizontal tuning

- Three-part experiment

  - Individual singers - pitch matching and interval tuning

  - Individual singers - SATB *karaoke* with short progressions

  - SATB Ensemble - short exercises and musical passages

Method – Part 1

- Individual Singers with recorded reference pitches
  - Stimuli
    - Quasi-randomized 24 note sequence of 4 instances of 6 notes sung by an alto
    - 6 notes included 3 equal tempered notes and 3 notes detuned by 50 cents (a quarter tone) from Melodyne
    - Simultaneous (vertical): unison, minor thirds, major thirds, perfect fifths
    - Sequential (horizontal): unison, major seconds, minor thirds, major thirds

Method – Part 2

- Individual Singers with recorded parts
  - SATB ensemble recorded singing simple harmonic progressions
  - Singers re-recorded individually (while listening to original recordings) to create multi-track version
  - Recordings retuned to Equal Temperament and Just tunings
  - Subjects subject sing with the composite recordings
    - 2-part (subject + bass & subject + soprano)
    - 3-part (subject + bass + [alto | tenor] & subject + soprano + [alto | tenor])
    - 4-part (subject + 3 other voices)

Method – Part 3

- SATB ensemble

  - Set of exercises where the melodic whole tone and semitone intervals are set in a variety of harmonic contexts, e.g.,

- Chord Progression by Benedetti

- Praetorius 'Est ist ein Ros' Entsprungen'

Method – Recording set-up

- Room – 4.85m x 4.50m x 3.30m lab with low noise, reflections, and reverberation time (ITU-standard)

- Singers were recorded on a stereo pair of AKG C 414s

- For ensemble performances, each singer was miked with a cardiod headband mic (DPA 4088-F)

- The microphones were run through a RME Micstasy 8 channel microphone preamplifier and RME Madi Bridge

- Recording was done on a Mac Pro

Extraction of Intonation Data

- Labelling of note onsets and offsets in the recordings was done automatically using a hybrid dynamic time warping(DTW)/hidden Markov model(HMM) alignment algorithm optimized for the singing voice

- Fundamental frequency (F_0) estimation for each frame of audio
    - This research uses the YIN algorithm (de Cheveigné & Kawahara 2002)
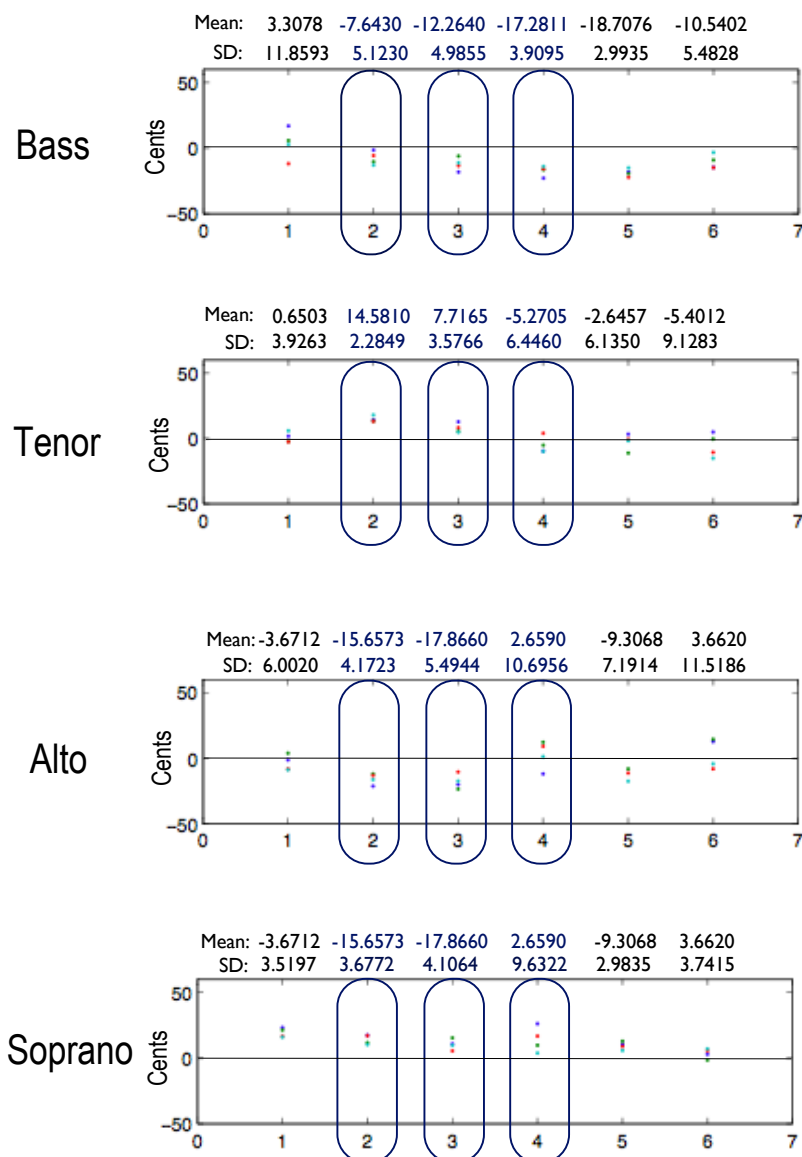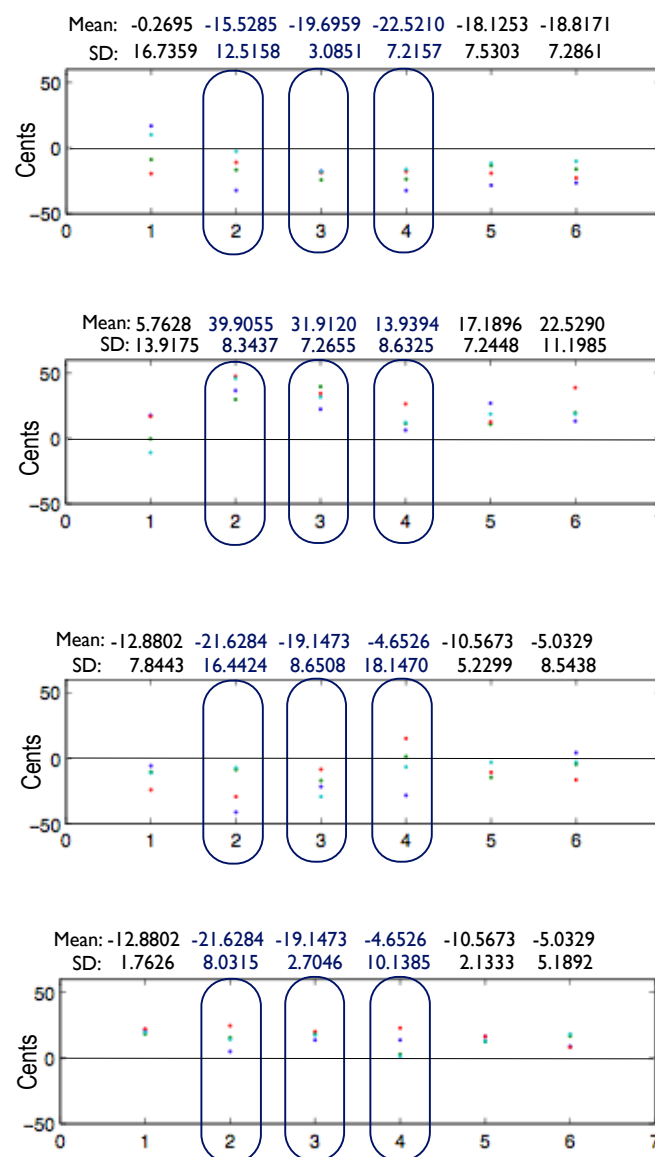   - Currently validating the F_0 estimates with an electroglottograph from VoceVista

Preliminary Results - Matching

- Professional SATB ensemble
  - Average age: 42 (SD=9)
  - Average number of years of private voice lessons: 7.75 (SD=0.5)
  - Average number of years of regular practice: 24 (SD=10)
  - Average amount of daily practice: 1.75 hours (SD=1)

Simultaneous (Vertical)

Sequential (Harmonic)

Bass

Mean: 3.3078 -7.6430 -12.2640 -17.2811 -18.7076 -10.5402
SD: 11.8593 5.1230 4.9855 3.9095 2.9935 5.4828

Mean: -0.2695 -15.5285 -19.6959 -22.5210 -18.1253 -18.8171
SD: 16.7359 12.5158 3.0851 7.2157 7.5303 7.2861

Tenor

Mean: 0.6503 14.5810 7.7165 -5.2705 -2.6457 -5.4012
SD: 3.9263 2.2849 3.5766 6.4460 6.1350 9.1283

Mean: 5.7628 39.9055 31.9120 13.9394 17.1896 22.5290
SD: 13.9175 8.3437 7.2655 8.6325 7.2448 11.1985

Alto

Mean: -3.6712 -15.6573 -17.8660 2.6590 -9.3068 3.6620
SD: 6.0020 4.1723 5.4944 10.6956 7.1914 11.5186

Mean: -12.8802 -21.6284 -19.1473 -4.6526 -10.5673 -5.0329
SD: 7.8443 16.4424 8.6508 18.1470 5.2299 8.5438

Soprano

Mean: -3.6712 -15.6573 -17.8660 2.6590 -9.3068 3.6620
SD: 3.5197 3.6772 4.1064 9.6322 2.9835 3.7415

Mean: -12.8802 -21.6284 -19.1473 -4.6526 -10.5673 -5.0329
SD: 1.7626 8.0315 2.7046 10.1385 2.1333 5.1892

Stimuli
1: D
2: D 1/2 sharp
3: E 1/2 flat
4: F 1/2 sharp
5: F3
6: G

ICMPC Presentation

- Thursday, August 26th, 9:30am

- Exploring the relationship between voice leading, harmony, and intonation in *a cappella* SATB vocal ensembles

  - Detailed discussion of Section 3 of the experiment

  - Analysis of four ensemble's performances of a chord progression by Giambattista Benedetti (1530–90)
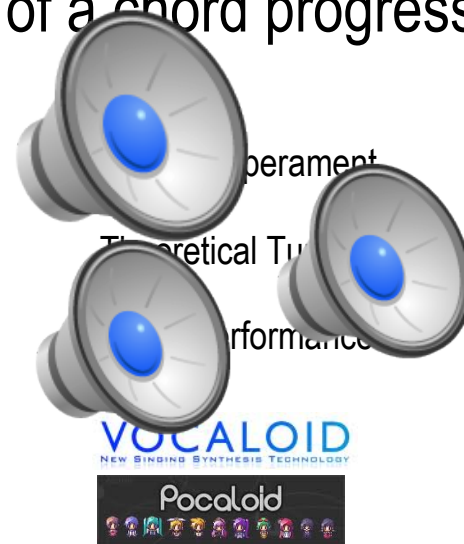
Many thanks to Gabriel Vigliensoni
for creating the Vocaloid versions

Thank you!