Pitch fluctuations in accurate and inaccurate singers: Are they the same?

Pauline Larrouy-Maestri & Peter Q Pfordresher
What we know

- Complexity of the signal
  (e.g. Larrouy-Maestri et al., 2014; Sundberg, 2013)

- Parameters contributing to the beauty of the voice
  (Ekholm et al., 1998; Garnier et al., 2007; Rothman et al., 1990)

- Pitch fluctuation (vibrato) associated with quality for Western operatic voices
  (Larrouy-Maestri et al., in press)
Occasional singers

What we know

- Not « operatic » but pitch fluctuations
- Evaluation of melodic accuracy based on median or mean F0 of stable portion of tones
- Difference between accurate and inaccurate singers regarding deviation from the target
- Several possible causes
  (e.g. Hutchins et al., in press; Hutchins & Peretz, 2012; Pfordresher & Brown, 2009; Pfordresher & Mantell, 2014)
Occasional singers

What we don’t know

- Which pitch fluctuations?

- Depends on the quality of the singer?
Occasional singers

What are we doing?

- Which pitch fluctuations?
  - Model describing pitch fluctuations
- Depends on the quality of the singer?
  - Comparison accurate/inaccurate singers

Larrouy-Maestri & Pfordresher
June 2014
Description of pitch fluctuations
Modification of the temporal adaptation model of Large, Fink & Kelso (2002)

- Goal: evaluating adaptation to changes in pitch space

- Designed to get relevant summary statistics for pitch fluctuations
  - Not based on physiology of phonation

Pitch at time $t$

Comes from “start” fluctuations and “end” fluctuations influencing an asymptote

$$Pitch_t = Y_{st} + Y_{et} + \text{asym}$$
Descriptive model of pitch fluctuation

\[ \text{Pitch}_t = Y_{st} + Y_{et} + \text{asym} \]

\[ Y_{st} = \begin{bmatrix} A_s \end{bmatrix} \cdot \exp(-b_s t) \cdot \cos(2\pi f_s t + \theta_s) \]

- Beginning perturbation
- Approach to asymptote
- Oscillation around target (overshoot)
- Approach is down (= 0)
  Or up (= pi)

Similar to starting fluctuations, except
- Time values mirror reversed
- New and adjusted parameters
Description of pitch fluctuation in accurate singers?

Difference between accurate/inaccurate singers?
Pfordresher & Mantell (2014)

- Melodic sequences imitation (Pfordresher & Brown, 2007)
  - Using the first 5 notes of C-major scale
  - Adapted to the gender of the participant
  - Presented at a slow rate (1s per tone)
- Several conditions
  - Accurate singers as a model
  - Inaccurate singers as a model
  - Self-imitation
- Categorization of the singers according to their global deviation from the target to imitate (limit: 50 cents)

Present study

- 12 “inaccurate” and 17 “accurate” singers
- Imitation of accurate singers
- Melodies of 4 notes
- 1854 tones (already segmented) to analyse
Goodness of fit: VAF (>25%)

- Not different depending on the quality of the singer \( (p = .82) \)
- \( \text{Mean VAF}_{\text{accurate}} = .61, \ SE = .02 \)
- \( \text{Mean VAF}_{\text{inaccurate}} = .61, \ SE = .01 \)

\[
\begin{align*}
\text{VAF} &= 0.172 \\
\text{VAF} &= 0.522 \\
\text{VAF} &= 0.876
\end{align*}
\]
Accurate singers

- Scoop at the start: up (49.5%) or down (50.5%)
- Scoop at the end: majority down (81.3%)

\[ Y_{s_t} + Y_{e_t} + \text{asym} \]

\[ Y_{s_t} = \left[ 71.91 \exp(-5.27 \times t) \times \cos(2\pi \times 0.58 \times t) \right] \]

\[ Y_{e_t} = \left[ 106.07 \exp(-4.55 \times t) \times \cos(2\pi \times -0.26 \times t) \right] \]

\[ \text{asym} = 110 \]
Comparing accurate/inaccurate singers

- **Start**
  - No difference regarding the direction (up or down)
  - Greater scoop for inaccurate singers
    - \( t(27) = -2.91, p = .007 \)
  - No difference for other parameters

- **End**
  - No difference regarding the direction (up or down)
  - Greater scoop for inaccurate singers
    - \( t(27) = -1.98, p = .058 \)
  - No difference for other parameters

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**June 2014**

Absolute value of A (in cents)
Comparison for each condition

- **Global deviation**
  - Sharp of flat

- **Melodic context**
  - No previous tone
  - Higher previous tone
  - Lower previous tone
Start and global deviation

- Four possibilities

  - Flat
  - Sharp

  Target

  Global deviation closer to the target

  Direction « toward the target »
### Start and global deviation

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<th>% of trials</th>
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<td></td>
<td>Accurate</td>
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<td>% of trials</td>
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<td>Accurate</td>
<td>111.4 (20.90)</td>
<td>86.15 (16.34)</td>
<td>71.38 (5.36)</td>
<td>56.49 (6.08)</td>
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<tr>
<td>Inaccurate</td>
<td>108.3 (10.20)</td>
<td>103.3 (27.88)</td>
<td>103.6 (12.59)</td>
<td>69.30 (11.27)</td>
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Start and melodic context

- Six possibilities

- No previous tone

- Higher previous tone

- Lower previous tone

« Logical » direction (link between the tones)
### Start and melodic context

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<td>118.71 (12.24)</td>
<td>86.44 (11.05)</td>
<td>60.92 (7.62)</td>
<td>49.85 (8.25)</td>
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<td>163.05 (21.13)</td>
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Conclusions

- **Acoustical description of vocal tones**
  Modeling voices of occasional singers

- **Profile of inaccurate singers**
  No difference with accurate singers regarding direction of scoops
  Difference for amplitude of scoops at the start
  \( \rightarrow \) An indicator of singing ability in addition to the pitch deviation?
  Depends on the condition
  - Scoop up
  - Going closer to the target
  - Logical condition regarding the context
  \( \rightarrow \) Fine motor control deficit or preconceived plan not precise enough

- **Perceivers’ judgment of pitch accuracy influenced by these fluctuations?**
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Thank you!