Definition of vocal pitch accuracy in a melodic context

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In tune?
Musical errors
Musical errors

Contour error

Interval error

Tonality error
Musical errors

□ Young age

- Categorisation of contour errors: 10 months (Ferland & Mendelson, 1989)
- Discrimination of tonality and intervals (Hannon & Trainor, 2007; Gooding & Stanley, 2001; Plantinga & Trainor, 2005; Stalinski et al., 2008)

□ Errors perceived by adults

Dowling & Fujitani, 1970; Edworthy, 1985; Stalinski et al., 2008; Trainor & Trehub, 1992

Peretz & Cortheart (2003) « perception »
Method

166 performances

Computer assisted method
3 criteria

Judges

http://sldr.org/sldr000774/en

1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9
Out of tune

In tune

March 28th, 2014
Manual segmentation
AudioSculpt (Ircam)

F0 information
AudioSculpt and OpenMusic (Ircam)

Quantification of errors
Excel (Microsoft)

## Participants

<table>
<thead>
<tr>
<th></th>
<th>Experts</th>
<th>Non experts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>8 women</td>
<td>8 women</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>$M = 29.89; SD = 14.47$</td>
<td>$M = 33.06; SD = 9.57$</td>
</tr>
<tr>
<td><strong>Expertise</strong></td>
<td>5 professional musicians</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 professional singers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 music students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 speech therapists</td>
<td></td>
</tr>
<tr>
<td><strong>Musical or vocal practice</strong></td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td><strong>Audiometry</strong></td>
<td></td>
<td>OK</td>
</tr>
<tr>
<td><strong>MBEA (Peretz et al., 2003)</strong></td>
<td>____</td>
<td>OK</td>
</tr>
<tr>
<td><strong>Production task « Happy Birthday »</strong></td>
<td>____</td>
<td>OK</td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Non experts</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>$F(3,165) = 104.44; p &lt; .01$</td>
<td>$F(3,165) = 231.51; p &lt; .01$</td>
</tr>
<tr>
<td>% variance</td>
<td>66%</td>
<td>81%</td>
</tr>
<tr>
<td>Criteria</td>
<td>Interval deviation</td>
<td>Interval deviation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tonality modulations</td>
</tr>
</tbody>
</table>

Definition

- **Musical errors**
  - Intervals are important in the definition of vocal pitch accuracy in a melodic context

- **But ...**
Pitch categories
Pitch discrimination
- http://www.musicianbrain.com/pitchtest/
- http://tonometric.com/adaptivepitch/

In a melodic context
- Semitone (100 cents) Berkowska & Dalla Bella, 2009; Dalla Bella et al., 2007, 2009a, 2009b; Pfordresher & al., 2007, 2009, 2010
- Quartertone (50 cents) Hutchins & Peretz; 2012; Hutchins, Roquet, & Peretz, 2012; Pfordresher & Mantell, 2014

Which threshold in a melodic context?
Effect of the direction of the error?
Two melodies

Familiarity?

- Online questionnaire
- 399 participants from 13 to 70 years old ($M = 29.81$)
- $t(398) = 20.92, p < .001$
Participants and procedure

- 30 non musicians ($M = 21.33$ years; $SD = 2.45$)
- Two times with 8 to 15 days in between

Method of limits
van Besouw et al., 2008
✓ Good intra-judges and inter-judges reliability

✓ No effect of familiarity

- Familiar: $t = -4.94, p < .001$
- Non Familiar: $t = -3.27, p = .003$

✓ Threshold depends on the direction of the error
Definition

- **Musical errors**
  - Intervals are important in the definition of vocal pitch accuracy in a melodic context

- **Pitch categories**
  - < quarter-tone, depend on the direction of the error, whatever the melody

- **But ...**
Complex signal (Sundberg, 2013)

Effects of pitch fluctuation on pitch perception (Castellengo, 1994; d’Alessandro & Castellengo, 1994; Hutchins et al., 2012; van Besouw et al., 2008)

The case of operatic voices (Larrouy-Maestri, Magis, & Morsomme, 2014, in press a, in press b)

What is a “normal” voice?

Perception of “non ideal” sung performances?
Modification of the temporal adaptation model of Large, Fink & Kelso (2002)

Not a cognitive model … just designed to get relevant summary statistics for pitch fluctuations

Pitch at time $t$
Comes from “start” fluctuations and “end” fluctuations influencing an asymptote

$$Pitch_t = Y_{s_t} + Y_{e_t} + \text{asym}$$
Descriptive model of pitch fluctuation

\[ \text{Pitch}_t = Y_{s_t} + Y_{e_t} + \text{asym} \]

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

- **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

March 28th, 2014
Starting fluctuations: magnitude (A) and rate of approach (b)
Oscillation around approach (f)

What the model does
Starting and ending fluctuations: $A_s$ (and $A_e$), $b_s$ (and $b_e$)
What the model does

- **Fitted parameters**
  - Rate of approach: $b_s, b_e$
  - Oscillation around target: $f_s, f_e$

- **Parameters from data**
  - $\text{asym}$: from middle portion of tone (median)
  - $A_s$ values from difference of beginning to $\text{asym}$
  - $A_e$ values from difference of end to $\text{asym}$
  - $\theta$ is effectively a ‘toggle’
How the model fits the datas

- **Database**
  - Pfordresher & Mantell (2014)
  - 12 “poor” and 17 “good” singers
  - Imitation of accurate singers
  - Melodies of 4 notes
  - 1902 tones to analyse

- **Distribution** (Shapiro-Wilk $p < .001$)

- **Not different depending on the quality of the singer**
  - $t(1459) = .473; p = .637$
Comparison poor/good singers

<table>
<thead>
<tr>
<th></th>
<th>Poor M (SE)</th>
<th>Good M (SE)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>bs</td>
<td>5.03 (.64)</td>
<td>6.02 (.57)</td>
<td>ns</td>
</tr>
<tr>
<td>be</td>
<td>5.55 (.41)</td>
<td>5.16 (.37)</td>
<td>$p = .003$</td>
</tr>
<tr>
<td>fs</td>
<td>1.11 (.32)</td>
<td>.68 (.30)</td>
<td>ns</td>
</tr>
<tr>
<td>fe</td>
<td>-.41 (.19)</td>
<td>-.35 (.11)</td>
<td>ns</td>
</tr>
<tr>
<td>As above</td>
<td>86.41 (5.40)</td>
<td>60.53 (2.55)</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>As under</td>
<td>-113.90 (6.01)</td>
<td>-76.11 (3.66)</td>
<td>$p &lt; .001$</td>
</tr>
<tr>
<td>Ae above</td>
<td>113.81 (10.38)</td>
<td>77.04 (8.39)</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Ae under</td>
<td>-148.96 (5.93)</td>
<td>-115.86 (3.34)</td>
<td>$p &lt; .001$</td>
</tr>
</tbody>
</table>
Focus on As and Ae

As

Ae

cents

March 28th, 2014
Creation of melodies

- Mean As and Ae in a particular context
- Pitch deviations on the 3rd note: O; +/- 50 cents
- Insertion of pitch fluctuation (As and Ae)
- Different combinations of As and Ae

Pairwise comparison

- Ranking: 1 point if “more in tune”, 0 point for the other, 0.5 point if similar

Exp 1:

- Task 1: modification of As OR Ae, with and without pitch deviation
- Task 2: modification of As AND Ae, without pitch deviation
Perception of pitch fluctuation

- **Exp 2:**
  - Same as Exp 1 but in another melodic context

- **Exp 3:**
  - Threshold / tolerance
  - Magnitude of As and Ae
  - Combination

- **Questions**
  - Effect of the direction of the attack/ending?
  - Effect of the size of the attack/ending?

**Pitch accuracy perception of natural voices**
Definition

- **Musical errors**
  - Intervals are important in the definition of vocal pitch accuracy in a melodic context

- **Pitch categories**
  - < quarter-tone, depend on the direction of the error, whatever the melody

- **Pitch fluctuation**
  - Coming soon 😊
Conclusion

- Perception of pitch accuracy
  Musical errors, pitch categories, pitch fluctuation

- Evaluation
  Is Marilyn in tune?
  Tools to evaluate singer quality
  Tease apart good and poor pitch singers

- Representation of melodic accuracy
  Toward speaking accuracy
Definition of vocal pitch accuracy in a melodic context

Thank you!
References

- d’Alessandro C., Castellengo M. (1994), The pitch of short-duration vibrato tones. JASA., 95(3)
References


References


