



SINGING IN TUNE: PERCEPTUAL DETERMINANTS OF ACCURACY

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INTRODUCTION

Non-musicians typically consider themselves as unable to carry a tune. This is likely to be true for tone-deaf individuals (i.e. about 4 % of the population; see Ayotte et al., 2002). Still, it may not apply to the majority of non-musicians.

Indeed, adult non-musicians, even without much practice, possess the basic capacities to sing simple songs. Singing abilities emerge early during development (e.g. see Ostwald, 1973) and elementary properties of sung performance (i.e. tempo and pitch) are quite consistent in adults (e.g. Bergeson & Trehub, 2002). Thereby, it is likely that singing abilities in the general population are more widespread than generally estimated.

Goals

Assess pitch and temporal accuracy of sung performance in adult non-musicians

Examine the perceptual determinants of the judgment of singing accuracy

GENERAL METHOD

Participants

Group 1: 20 non-musicians (10 males, 10 females, $M = 23.9$ years of age) from the university of Montreal community.

Group 2: 42 non-musicians (19 males and 23 females $M = 41.4$ years of age) recruited in a public park

Singers: 4 professional singers ($M = 11$ years of vocal training; range = 8-17 years)

Procedure

Participants were asked to sing the chorus of the song *Gens du pays* by Gilles Vigneault (see score below). *Gens du pays* is well-known in Quebec. Performance from Group 1 and singers was recorded in the laboratory. Participants were asked to sing *Gens du pays* three times: at the beginning of the experiment (Test 1), immediately afterwards (Test 2), and one week afterwards (Test 3). Performance from Group 2 was recorded in a public park during summer time.

Performances were assessed for accuracy by a group of 10 judges. The judgment was provided on a 10-point scale with 1 indicating "very inaccurate" and 10 "very accurate".



SUNG PERFORMANCES' ANALYSIS

The recording of each sung performance was submitted to a customized computer-guided analysis in order to extract pitch and time variables.

Pitch dimension variables

Pitch first note: pitch height of the first note in Hz.

Tonality stability: stability of the tonal center (i.e. the tonality). It is the difference between the produced pitch in the melody segment *a* and in the repetition *a'*. The larger this measure the more instable tonality will be.

Number of pitch errors: an error was scored when the produced interval was larger or smaller than at least 1 semitone as compared to the interval prescribed by the score.

Number of contour deviations: number of contour deviations with respect to the score.

Interval deviation: mean absolute interval deviation of the performance from the score.

Time dimension variables

Mean eight-note IOI: measure of tempo.

CV IOIs (coefficient of variation of the eight-note IOIs obtained by dividing the Standard Deviation of the IOIs by the mean IOI): measure of temporal variability.

Number of time errors: an error was scored when the produced note was at least 50% longer or shorter than the duration predicted from the preceding note, as prescribed by the score.

Rubato: consistency of tempo variation within the musical piece. The eight-note IOIs for the segment *a* was correlated to the IOIs for segment *a'*. High correlation reflects high consistency in the rubato pattern.

1. Are non-musicians accurate?

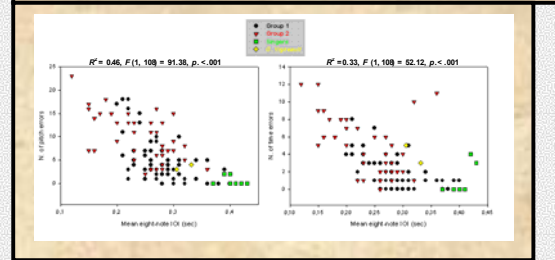
Non-musicians were less accurate than singers in particular with regard to the pitch dimension.

Non-musicians sung at a faster tempo than professional singers.

Tempo differences accounted for pitch accuracy differences, thus indicating that lower pitch accuracy in non-musicians may result from a speed-accuracy trade-off.

| Variable | GROUP 1 | | | SINGERS | |
|-------------------------------|----------------|----------------|----------------|----------------|-----------------------|
| | Test 1 | Test 2 | Test 3 | M (Range) | M (Range) |
| | M (SD) | M (SD) | M (SD) | | |
| Pitch dimension | | | | | |
| Pitch first note (Hz) | 114.0 (6.4) | 131.1 (8.8) | 129.3 (4.9) | 145.0 (16.5) | 165.0 (136.1 - 200.0) |
| Stable | 25.1 (9.7) | 25.9 (8.1) | 25.7 (8.6) | 234.4 (16.1) | 308.9 (216.4 - 388.3) |
| Tonality instability (semit.) | 8.5** (3.1) | 8.4* (3.1) | 8.4 (3.0) | 8.7** (3.2) | 8.3 (0.1 - 10.4) |
| N. of pitch errors | 5.5** (1.2) | 4.8** (1.2) | 4.4** (1.0) | 9.8** (3.8) | 8.5 (0.0 - 20.0) |
| N. of contour deviations | 8.7** (3.3) | 1.2** (0.4) | 1.2** (0.3) | 2.5** (0.4) | 0.0 (0.0) |
| Interval deviation (semit.) | 8.6** (3.1) | 8.6** (3.1) | 8.6** (3.1) | 0.9** (0.1) | 0.3 (0.2 - 0.4) |
| Time dimension | | | | | |
| Mean eight-note IOI (sec) | 278.8** (46.2) | 281.8** (54.4) | 289.7** (46.5) | 239.7** (55.8) | 398.8 (366.9 - 427.6) |
| CV IOIs (sec) | 0.12 (0.05) | 0.10 (0.05) | 0.10 (0.05) | 0.17 (0.06) | 0.10 (0.06 - 0.16) |
| N. of time errors | 2.2 (2.07) | 1.5 (1.3) | 2.2 (1.8) | 4.7* (1.4) | 0.9 (0 - 4.8) |
| Rubato | 0.6 (0.3) | 0.7 (0.2) | 0.6 (0.3) | 0.6 (0.2) | 0.6 (0.3 - 1.0) |

Note: Plus or minus 3 SD (***) or 2 SD (**) from the mean of professional singers



2. Are non-musicians consistent?

Pitch and temporal properties of sung performance were remarkably consistent across renditions in non-musicians.

In addition, non-musicians starting pitch was quite close to the original of "Gens du Pays" (i.e. 50% and 30% of the performances were within one semitone of the correct pitch in Group 1 and 2, respectively).

Less consistency was found with regard to tempo.

| Variable | Correlation Test 1 - Test 2 | Correlation Test 1 - Test 3 |
|--------------------------|-----------------------------|-----------------------------|
| | r | r |
| Pitch dimension | | |
| Pitch first note | 0.90** | 0.97** |
| Tonality stability | 0.35 | 0.63** |
| N. of pitch errors | 0.80** | 0.82** |
| N. of contour deviations | 0.80** | 0.87** |
| Interval deviation | 0.91** | 0.87** |
| Time dimension | | |
| Mean eight-note IOI | 0.80** | 0.78** |
| CV IOIs | 0.71** | 0.56** |
| N. of time errors | 0.78** | 0.68** |
| Rubato | 0.47** | 0.12 |

** p < .01 * p < .05

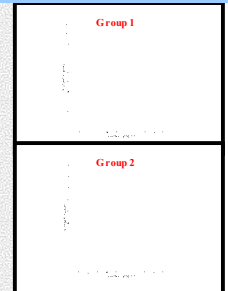
3. What are the perceptual determinants of singing accuracy?

Mean accuracy rating was 5.2 (SE = 0.2) for Group 1 and 4.4 (SE = 0.2) for Group 2.

Accuracy ratings were normally distributed in both groups.

To identify the main perceptual determinants of singing accuracy multiple regression analyses were run in which comparable variables in the pitch and time dimension have been entered two-by-two to predict accuracy ratings.

Pitch errors and interval variability were better predictors for accuracy than time dimension variables.



| Variable | B | SEB | Beta | Pt |
|--------------------|-------|------|-------|--------|
| GROUP 1 | | | | |
| % of pitch errors | -0.18 | 0.04 | -0.48 | 0.001* |
| % of time errors | -0.17 | 0.05 | -0.39 | 0.00 |
| Interval deviation | -0.13 | 0.07 | -0.21 | 0.061* |
| CV IOIs | -0.04 | 0.02 | -0.07 | 0.02 |
| GROUP 2 | | | | |
| % of pitch errors | -0.11 | 0.02 | -0.23 | 0.001* |
| % of time errors | -0.03 | 0.02 | -0.05 | 0.00 |
| Interval deviation | -0.10 | 0.05 | -0.13 | 0.001* |
| CV IOIs | 0.04 | 0.03 | 0.06 | 0.14 |

CONCLUDING REMARKS

Non-musicians' sung performance appears less accurate than in professional singers. This group difference can be ascribed to a speed-accuracy trade-off. **Non-musicians singing at a similar tempo as professional singers have comparable accuracy.**

Non-musicians' performance is very consistent across renditions. Moreover, performances' tonality is very close to the original recordings (as in Bergeson & Trehub, 2002).

Accuracy of singing is mainly related to pitch variables than to rhythm.

These results indicate that singing is widespread and stable in non-musicians. The norms for sung performance in non-musicians obtained in our study are being used to assess sung performance in non-musicians with brain damage and with developmental music disorders.

REFERENCES

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