Percieving language elements in high pitch singing

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1. Introduction

This paper investigates, using reaction time experiments, the perception of sung vowels with rising contours, falling contours, or high pitch steady state.
Previous research in speech perception, especially with sung speech, has shown that perceptual difficulties of speech generally increase with rising pitch (see e.g. Gottfried / Chew (1986) Hollien et al. (2000); Morozov, V. P. (1965); Scotto die Carlo / Germain (1985); Sundberg (1999)).
As repeatedly reported with pitch, up to a level of F5 or a phonation frequency of around 700 Hz, the rate of vowel intelligibility decreases below a level of 50% (see e.g. Morozov (1965)).
Most of the experiments conducted in intelligibility of sung vowels have been focussed on steady state vowels or level tones. Even in those studies that did investigate contour tones, the intervals tested were less than one octave.

2. Methods

To avoid priming effects due to lexical access, only monosyllabic pseudowords with a CVC-structure were previously produced by a professionel soprano singer and have been used as stimuli for the reaction time experiments. All tones were realized on one of the tensed German vowels /a, e, i, o, u/ at the nucleus position of the syllable.
Three tones (500 Hz, 650 Hz, 850 Hz) were used for steady state elements and three intervals (a quart, a seventh, and a tenth) were used for the contour conditions. The lowest contour tone was realized by 350 Hz, the highest contour tones were realized by 850 Hz.
The voiced plosives /d, g/ and the unvoiced plosives /p, t, k/ were in the onset position. The coda was filled by one of the three possible German plosives /p, t, k/.
The subjects had to concentrate on the vowel, and a response box with three keys was labeled with three of the five vowels. After hearing each item, listeners were required to press the correct key as fast as they could. The recorded responses included the number of the correct vowel identification, as well as the reaction time.

3. Results

As expected, a change in pitch (F0) had a profound effect on vowel perception. For steady state conditions in general, perceptual difficulty in vowel recognition increases as F0 is raised. The contour tone experiments deviate partly from this: the vowel identification was contour-dependent but there was no effect observed between interval differences and vowel identification. Most of the correct vowel identifications were found not only at a low pitch level but at almost all of the contour conditions. Significantly better recognition for /a/ than for all of the four other vowels /e, i, o, u/ have been observed. There are better results for the rising than for the falling contour conditions.
By comparing the contour tone experiments with the steady state condition, an effect was found for the reaction time. Fast reactions have been observed at a low pitch level and at a slightly rising contour, and slow reactions for the contour conditions, in particular for the falling contour.
Independent of the steady state or contour conditions, there were better results observed for vowels with unvoiced onset plosives than for the voiced plosives in the onset position.

4. Discussion

The data reflect that vowel identification is not only influenced by contour but also by the direction of vowel or tonal movement.
The longer reaction time for the falling contour conditions could be interpreted as a result of a more demanding processing in the working memory. It is still an open question, if more complex multisyllabic stimuli could cause a decrease of intelligibility.
As generally known for speech, the voice onset time for the sung unvoiced consonants in the syllable initial position is characterized by longer duration then the voice onset time for the voiced consonants.
The possibility that there is more information connected with onset lenght could be responsible for better vowel processing with unvoiced onset elements.

5. Conclusions

Due to these results it is possible to compose an easily comprehensible high pitched line for a soprano, when one creates a rising contour on a syllable with an unvoiced onset element and a German /a/ in the nucleus of the syllable.

The presented data support some but not all assumptions about the complexity and markedness of contour tones (e.g. Hyman 2003); here falling tones seems to be more marked than rising tones.

5. References (extract)

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