Frequency-Modulation Vowel Maps in Normal-Hearing and Hearing-Impaired Listeners

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FREQUENCY-MODULATION VOWEL MAPS IN NORMAL-HEARING AND HEARING-IMPAIRED LISTENERS

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INTRODUCTION

Sound emitted by most natural vibrating sources is not steady in pitch but contains frequency fluctuations over time. This is due to the harmonic complexity of the sound source and the temporal variability of the vibration. In addition, the auditory system itself is sensitive to frequency modulation (FM) and can extract information from it. The ability to perceive and interpret FM is crucial for the perception of speech and music, as FM cues are used to distinguish between different sounds.

METHODS

Subjects

The study included 14 NH listeners and 12 HI listeners. NH listeners were selected on the basis of normal hearing sensitivity at all frequencies tested. HI listeners were selected on the basis of hearing loss in both ears.

Stimulus Configuration

A harmonic complex tone was used as the stimulus. The tone consisted of 8 harmonics of the vowel /oh/, with frequencies of 500, 1000, 1500, 2000, 2500, 3000, 3500, and 4000 Hz. The fundamental frequency (F0) was 200 Hz.

Procedure

The procedure involved measuring the perception of vibrato in HI listeners and comparing it to NH listeners. The listeners were presented with a synthesized-vowel stimulus with added CFM. The CFM was varied in rate (3, 4, 5, 6, 7, 8 Hz) and excursion (21, 35, 49, 63, 77, 91 cents). The listeners were asked to judge whether the stimulus sounded like a singing voice or not.

RESULTS

The results showed that HI listeners were less able to perceive vibrato than NH listeners. This was true for both CFM rate and excursion. HI listeners were more likely to perceive the stimulus as a nonsinging voice, especially for higher CFM rates and excursions.

CONCLUSIONS

The results suggest that hearing loss affects the perception of vibrato in HI listeners. This could have implications for the ability to perceive speech and music, particularly in environments with high background noise levels.

REFERENCES

"These values may provide some guidelines when constructing synthetic-vowel stimuli for which a realistic sung vibrato is desired.

Figure 1: Spectrogram of the vowel stimulus. The first temporal segment contains the fundamental frequency (F0) of 200 Hz, the second segment all high harmonics, and the third segment all harmonics with different CFMs.

Figure 2: Hypothetical vowel maps for NH and HI listeners. The mean and standard error of the mean for each condition are shown.

Figure 3: Average frequency-modulation vowel maps for NH and HI listeners. The mean and standard error of the mean for each condition are shown.

Figure 4: Individual sweet spots plotted as convex hulls. The plots are grouped according to the musical experience (musicians vs. non-musicians).

Figure 5: Marginal means and standard errors for each of the four sweet-spot areas, showing the difference between the perception of NH and HI listeners.

Figure 6: Individual sweet spots plotted as convex hulls. The plots are grouped according to the perception of NH and HI listeners.