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Singing Register Differences in Vocal Fold Oscillations Observed Across Three Octaves Through Laryngeal High-Speed Videoendoscopy

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Introduction

Because the definition of voice registers is mostly based on perceptual characteristics and singers' interior sensations, understanding their physiological differences requires analyzing quantifiable parameters. Therefore, the objective of this study is to look for relevant vocal-fold (VF) vibration parameters which are able to discriminate between the "modal" register (M, speech-like voice sound) and the "head" register (H, flutey sound) [1,2]. This study investigated a professional singer who demonstrated a unique ability to choose between the two registers regardless of pitch throughout her entire singing range [3].

Methods

The professional singer (LP) performed short phonation on all pitches from C3 = 131 Hz to C#6 = 1109 Hz, first in M then in H, using the same 'laryngoscopic vowel' reminding of [e:]. The VF vibration was registered using a high-speed camera connected to a rigid 90° endoscope, at 7200 frames per second (fps). Some of the higher pitches were also registered at 13600 fps. A condenser omnidirectional microphone registered the radiated sound and an ElectroGlottoGraph (EGG) registered the VF contact area. PhonoVibroGrams (PVG) and digital kymograms were computed and used for analysis.

Results and Discussion

Visual observations of the high-speed videos, kymograms, glottal area waveforms (GAW), PVG, and EGG signals suggest that the whole range can be separated in a lower (C3 = 131 Hz to G4 = 392 Hz) and a higher (G#4 = 415 Hz to C#6 = 1109 Hz) subranges. In the lower subrange, clear differences in the VF contact duration were observed in EGG and kymographic signals revealing on VF adduction changes between M and H. Further analysis of the Normalized Amplitude Quotient (NAQ) from GAW (suggesting changes in VF lower margin vibration amplitudes), the closed quotient from PVG, and the sharpness of the lateral peaks from the kymograms (reflecting VF vertical phase differences) confirmed these differences in VF vibratory patterns. In the higher range, clear differences between M and H were found only for the NAQ parameter.

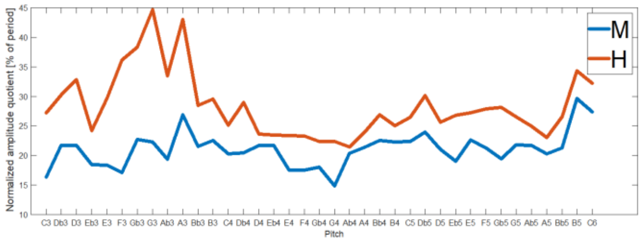

Figure 1: Normalized Amplitude Quotient (NAQ) derived from GAW showing consistent register differences across all pitches. Smaller NAQ suggests larger vibratory amplitudes of the lower VF margin in M register.

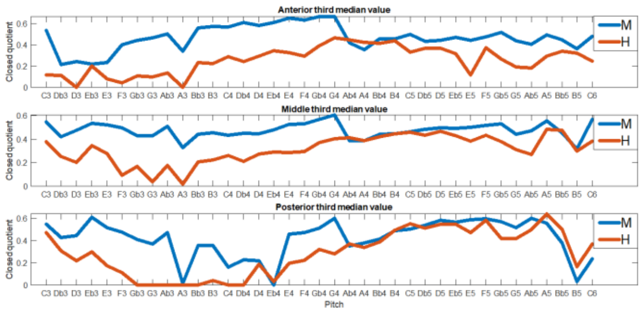

Figure 2: Closed Quotient derived from PVG Contour revealing on M/H register differences in membranous (anterior, middle) and cartilaginous (posterior) VF adduction.

In conclusion, the analysis of vocal fold vibratory patterns reveals there are parameters allowing differentiating both registers. The M/H differences present themselves more clearly in the lower pitch range of voice, however.

Acknowledgments

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