

# Vocal-fold vibratory patterns in normal male and female voices derived from high-speed digital imaging of the larynx.

Kartini Ahmad\*, Diane M Bless\* & Yuling Yan\*\*

\*University of Wisconsin- Madison, USA

\*\*University of Hawaii, Honolulu

kartiniahmad@wisc.edu

## Abstract

Vocal fold vibratory patterns of normal and pathological voices have not been comprehensively described due to problems related to instrumentation and measurement. Direct laryngeal visualization using high-speed digital imaging (HSDI) has the potential to overcome some of these problems but until recently, the technique lacks an analytical approach and customized software program to process the huge amounts of image data and effectively extract from these images useful information on the vocal fold vibrations. In a previous paper we introduced a Hilbert transformation-based method for novel analyses of vocal fold vibrations from high-speed laryngeal images (Yan et al 2004). Specifically, an analytic phase plot was used to present and describe the vibratory characteristics of the vocal folds. In this study we use this approach to investigate the vocal fold vibratory patterns exhibited in normal voices using the high-speed digital image recordings acquired from 63 normal speakers (males and females) when producing sustained phonation at comfortable pitch and loudness. A custom made software program is used for all analyses and our results reveal 4 distinct glottal configurations that are associated with specific open-close characteristics and perturbation patterns produced by this group of normal speakers. It is also observed that patterns related to pressed and breathy voice productions differ across age and gender groups. We speculate that the limits of normal and pathological voices could be defined based on the distinctive patterns revealed from the analytic phase plots, or also called “Nyquist” plots in this paper.

the cycles. The average open quotient is reduced to 0.6. This pattern is associated with a pressed voice pattern.

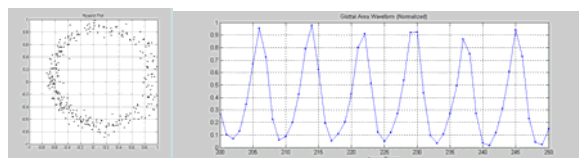


Figure 3: The Nyquist plot is similar to pattern 1 but the scattering around the rim is wider reflecting a wider amplitude variations throughout the cycles (Pattern3). The normalized glottal area waveform showed an almost sinusoidal waveform with a very short closed phase. The average open quotient for this pattern is about 0.83. This pattern is consistent with a more breathy voice.

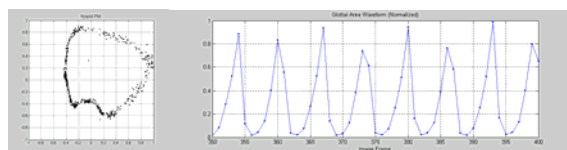


Figure 4: An example of a Nyquist plot showing wide distortions in shape and roundness different from the plots of patterns 1-3 (Pattern 4). The variation in distortion is not restricted to this form only.

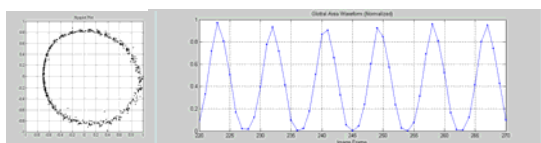


Figure 1: Nyquist plot showing a thin rim around the circumference (pattern 1). Normalized glottal area waveform is near sinusoidal, opening phase is long and average open quotient is about 0.74. This pattern is associated with a clear voice pattern.

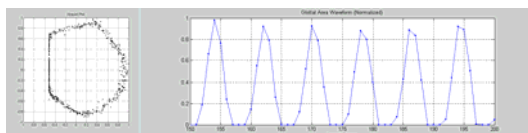


Figure 2: Nyquist plot showing a straight edge on the left side of the plot that coincides with the closed phase of the cycle (pattern 2). The closing phase is relatively longer throughout

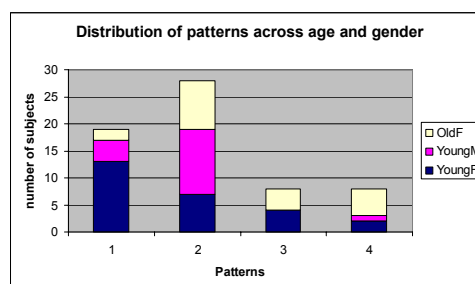


Figure 5: Graph showing the distribution of patterns among the normal speakers. The majority of young females showed pattern 1 (50%) followed by pattern 2 (27%). The majority of young males showed pattern 2 (70%) followed by pattern 1 (24%). No males showed pattern 3. The majority of older females showed pattern 2 (45%), followed by pattern 4 (25%) and pattern 3 (20%).

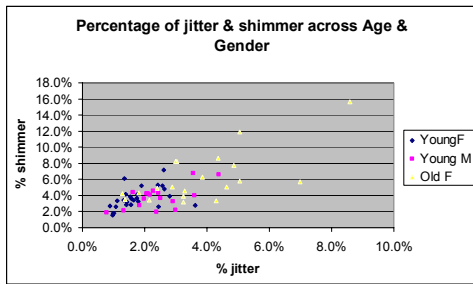


Figure 6: Graph showing the distribution of jitter and shimmer among the speakers. Jitter and shimmer values in the younger groups is small (average is 2.01% and 3.72% respectively). There was a significantly higher value and larger variation in jitter and shimmer among the older female speakers (average 3.8% and 6.2% respectively).