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Voice Onset Time as a Clinical Indicator of Hypofunctional Voice Disorders.

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Voice Onset Time as a Clinical Indicator of Hypofunctional Voice Disorders

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Abstract

The purpose of this study was to measure and compare the voice onset times (VOTs) of healthy individuals using a normal and breathy voice in an effort to determine if VOT can be used as a non-invasive clinical indicator of laryngeal function. Recordings were made of 20 adults between the ages of 20-48 with normal laryngeal function, each using a normal (Group 1) and breathy voice (Group 2). The participants' productions were designed and collected in such a manner to control for speaking rate, vowel context, pitch, and loudness; all of which have been shown to influence VOT. A mixed analyses of variance showed that hypofunctional productions demonstrated longer VOTs across all stop consonants when compared to normal productions. Within the stops, a significant difference between the voiced and voiceless stops was noted, although no gender differences were found. It was concluded that VOT can be used as an indirect clinical indicator of laryngeal function.

Background

Voice onset time (VOT), the time between the release of an oral constriction and the start of vocal fold vibration, is an important temporal-acoustic measure for distinguishing stop consonant voicing. (Lisker & Abramson, 1964).

VOT has traditionally been used to measure articulatory function in both normal and disordered populations (McCrea & Morris, 2004; 2005).
Voice disordered subjects had significantly longer VOTs for voice stops as compared to normal voice speakers, whereas there was no difference in VOTs for voiceless stops (Tyler & Watterson, 1991).
Thus, VOT may reflect the timing differences between supralaryngeal articulation and phonatory gestures, thus VOT can also be used to assess laryngeal function.

Purpose

The purpose of this study was to measure and compare the VOTs of healthy individuals using a normal and breathy voice in an effort to determine if VOT can be used as a non-invasive clinical indicator of laryngeal function

Methods: Participants

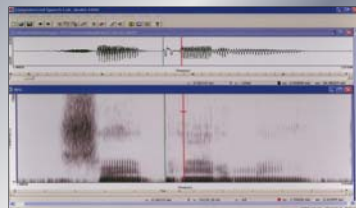
- 10 adult males with normal laryngeal function
- 10 adult females with normal laryngeal function
- All participants were between the ages of 20-48
- Mean age of participants: 25 years old

Methods: Instrumentation

- Head mounted AKG C420 condenser microphone
- Kay Pentax CSL Model 4400
- Acoustic Speech Analysis Software (TF-32)
- Dell Latitude D610 laptop computer

Methods: Procedure

- Participants provided one normal voice sample and one hypofunctional voice sample.
- Participants were recorded while repeating the phrase "Say (blank) to me." The CV syllables /pi/ /bi/ /ti/ /di/ /ki/ /gi/ were randomly inserted into each phrase.
- Oscillographic trace waveforms and spectrograms were obtained for each utterance and analyzed to collect VOT measurements in milliseconds.



Methods: Analysis

A 2X2X6 mixed analyses of variance (ANOVAs) was used to compare the participants' average VOTs across the between-subject factor of voice quality and the within-subject factors of phoneme and gender.

Methods: Reliability

Ten percent of the total data was selected at random and remeasured by the same investigator to determine intra-rater reliability. Intra-class correlation indicated strong reliability for both investigators.

$$\rho_1 = .997 (F(70,71) = 9.29; p < .003)$$

$$\rho_1 = .997 (F(70,71) = 0.29; p < .59)$$

Another 10% of the total data was remeasured by a different investigator to examine inter-rater reliability based on intra-class correlation.

$$\rho_1 = .998 (F(71,72) = 1.8; p = .18)$$

Results: Normal and hypofunctional main effect

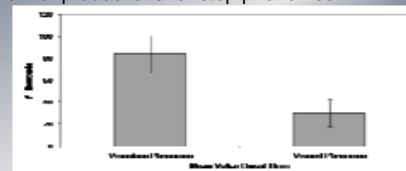
A significant difference was found between hypofunctional and normal voice productions:
 $F(1, 18)=15.28; p =.001, \eta^2 =.46; \beta =.96$

Hypofunctional and normal voice groups mean VOT and standard deviation (SD) in milliseconds across all voiced and voiceless stops:

Voice Type	Mean VOT	SD
Hypofunctional	63.03	32.79
Normal	51.23	31.82

Results: Phoneme differences

Voiceless phonemes displayed significantly longer mean VOTs than voiced phonemes.
 $F(5,90)=298.08; p <.001; \eta^2 =.94; \beta =1$
Mean VOT values across both hypofunctional and normal productions for stop phonemes:



Results: Gender

No significant differences were found between genders across all stop phonemes:
 $F(1,18)=.06; p =.82; \eta^2 =.003; \beta =.06$

Female and Male Mean VOTs in milliseconds:

Gender	Mean VOT	SD
Female	57.49	31.1
Male	56.77	33.62

Results: Interactions

- Voice X Gender:
 $F(1,18)=.01; p =.92; \eta^2 =.001; \beta =.05$
- Voice X Phoneme:
 $F(5,90)=.1; p =.99; \eta^2 =.006; \beta =.07$
- Voice X Gender X Phoneme:
 $F(5,90)=.69; p =.64; \eta^2 =.037; \beta =.24$

No significant interactions were found.

Discussion

- Hypofunctional VOTs were longer than normal VOTs regardless of phoneme or gender.
- Hypofunctional voice results in a longer time to initiate steady-state vocal fold vibration for the vowel following the burst release.
- Thus, the participants in this study prolonged the burst release during a hypofunctional production which resulted in the longer VOTs, as compared to normal productions.
- The minimal adductive tension and weak medial compression characteristic of hypofunctional voice results in a longer time to build positive subglottal air pressure (Laver, 1980).
- No significant differences were found between genders; however aerodynamic differences associated with the hypofunctional voice may have overcome any gender based differences related to VOT.
- Voiceless phonemes demonstrated consistently longer VOT values than their voiced cognate regardless of gender or voice quality.
- Possible influences include
 - Stress
 - Lung Volume
 - Rate Change
 - Vocal History

Conclusion

- These results indicate that VOT is an indirect clinical indicator of hypofunctional voice disorders.
- Hypofunctional and normal productions were within standardized VOT phoneme ranges.
- Hypofunctional voice productions were consistently longer when compared to normal productions.
- No significant differences were found between male and female VOTs.
- Voiceless phonemes' VOT were consistently longer than their voiced cognate.
- Limitations of the present study include:
 - Small sample size
 - Use of single CV structure
 - Unnatural speech sample
 - Variability in the emphasis of stops
 - Imitation of hypofunctional voices
- Future research is needed on the role of VOT in hypofunctional voices.