Physiological effects on stop consonant voicing

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Citation: The Journal of the Acoustical Society of America **73**, S47 (1983); doi: 10.1121/1.2020405
View online: https://doi.org/10.1121/1.2020405
View Table of Contents: https://asa.scitation.org/toc/jas/73/S1
Published by the Acoustical Society of America

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V6. Evidence of consistent double and triple vocal fold vibratory patterns during pulse register phonation. Robert L. Whitehead, Dale E. Metz, and Brenda H. Whitehead (National Technical Institute for the Deaf, P.O. Box 9887, Rochester, NY 14623)

It has been suggested by Hollien *et al.* [Folia Phoniatr. **29**, 200–205 (1977)] that vocal fold vibratory patterns during pulse register phonation may consist of single and/or multiple pulses. These authors did admit, however, that quantifiable evidence for the existence of multiple pulsing was limited. In the present investigation, high-speed laryngeal films (4000 frames/s) were obtained during phonation of the vowel /ɑ/ in pulse register by a normally hearing and speaking adult female. Glottal area-time functions were calculated for 15 consecutive vibratory cycles from a frame-by-frame analysis. The results indicated that the vowel sample was phonated at an average fundamental vocal frequency of 34 Hz. In addition, it was found that each complete vibratory cycle was comprised of either a double or triple pulsing of the vocal folds prior to achieving total closure of the vocal folds, for a substantial period of time, at the completion of each vibratory cycle. These data are discussed with reference to previously reported findings on the physiologic and acoustic features of pulse register phonation. [Work supported by U.S. Department of Education.]

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V7. Physiological effects on stop consonant voicing. Patricia A. Keating (Linguistics, UCLA, Los Angeles, CA 90024)

Voiced and voiceless stops in initial position are known to differ in Voice Onset Time; they may also differ in closure duration and the duration of closure voicing. Besides the voicing distinction, such factors as the position of the stop in a word or utterance, the stop's place of articulation, and the stress of adjacent syllables will also affect these measures. Data from the literature have been extended with new acoustic measurements for English, Swedish, and other languages. While there is some variation across languages, general patterns, which might be attributable to vocal tract physiology, can be identified. In an attempt to account for these patterns, an electrical analog of vocal tract aerodynamics can be used to study the probable effects of place of articulation and syllable stress on closure voicing offset. The model allows variation of subglottal pressure, glottal area, supralaryngeal cavity volume, wall mechanics, and oral constriction geometry. The extent to which these variables determine universal, presumably inherent, patterns of variation will be considered.

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V8. An ultrasound demonstration of tongue anatomy and speech activity. Thomas H. Shawker and Maureen Stone (Diagnostic Radiology Department, Building 10, Room 6S211, National Institutes of Health, Bethesda, MD 20205)

Soft tissue detail, motion display, and subject safety are features of ultrasound imaging that make it ideal for viewing the tongue and floor of the mouth during speech. In addition to the tongue surface, much of the intrinsic anatomy can be identified including the genioglossus, geniohyoid, mylohyoid, and digastric muscles; fascial boundaries such as the median fibrous septum of the tongue, the floor of the mouth intermuscular septum, and paramedian septums; and the hyoid bone. This study correlates the clinical ultrasound image with the anatomy demonstrated by tongue dissection. In addition, tongue movement during production of the speech sounds /ɑ/, /i/, and /k/ was examined in ten normal speakers and three patients with dysarthria. Tongue movement was found to be consistent for the normal speakers of /i/ and /k/. The three patients with neurological disease showed varying but significant differences in articulation compared to normals including prolonged movement, decreased intrinsic tongue activity, and a tendency to move the tongue as a unit with increased utilization of the floor of the mouth muscles. It appears that real-time ultrasound imaging of the oral cavity is a potentially valuable technique for the investigation of normal and abnormal speech.

3:05

V9. Real-time ultrasound visualization of the tongue surface: Displacement and curvature. Maureen Stone, Barbara C. Sonies (Department of Rehabilitation Medicine, Building 10, Room 5D37, National Institutes of Health, Bethesda, MD 20205), and Kathleen A. Morrish (Department of Radiology, National Institutes of Health, Bethesda, MD 20205)

Real-time ultrasound was used to image the tongue surface during speech. Reliability measures were obtained for two judges. The tongue surface was examined during the production of steady state vowels (i, ɑ, u) and rest position, as well as vowels embedded in a carrier phrase (i, ɑ, æ, o, u). The steady state vowels were repeated five times each by five subjects and were examined with respect to radial displacement, curvature, and variability of tongue position. The embedded vowels were part of a carrier phrase which was repeated ten times by four subjects. A curvature equation was used to determine the first and second derivative (slope and concavity) of the tongue surface curvature. The resultant waveform provided amplification of subtle differences seen in the posterior 2/3 of the tongue for the vowels. Results will be discussed with regard to current models of vowel production.

3:20

V10. Analysis of tongue motion during swallowing using real-time ultrasound visualization. Barbara C. Sonies (Speech–Language Pathology, Department of Rehabilitation Medicine, Clinical Center, National Institutes of Health, Bethesda, MD 20205) and Thomas H. Shawker (Department of Diagnostic Radiology, National Institutes of Health, Bethesda, MD 20205)

Because real-time ultrasound provides an excellent method to visualize the soft tissue structures of the tongue during speech, this technique was applied to analyze the oral and pharyngeal stages of swallowing. Eight normal subjects (ages 19–26, $\bar{x} = 22.7$) and one patient with a neurologic disease were subjects. Sagittal ultrasound scans of the tongue were obtained while subjects swallowed 5 cc of water in single swallows. Measurements were made of mid-tongue thickness at rest and during swallow, tongue length, sequence and timing of bolus movement, and tongue activity during swallow. Comparison of data for the normal and impaired subjects will be presented along with a discussion of the stages of swallowing. The results will be discussed with respect to neuromuscular theory and standard radiologic techniques.

3:35

V11. Aerodynamic characteristics of the early stages of speech adaptation to a dental appliance. Sandra L. Hamlet (Department of Hearing and Speech Sciences, University of Maryland, College Park, MD 20742)

Sibilants, especially /s/, present the greatest difficulty in speech adaptation to a dental appliance. The flow profile for /s/ in an intervocalic context is double humped, reflecting the dynamic interplay between vocal fold opening and tongue gesture. Air-flow profiles for /s/ during the first few minutes of adaptation show a marked change (either much higher or much lower) compared to a compensated condition two weeks later. These flow profiles were also more variable than in the compensated condition—the greatest contribution stemming from the very first reading of the speech sample. Successive readings showed continued, but more gradual, adjustments. Consideration is given to alterations in timing of articulatory gestures as the mechanism producing these early adaptive changes. [Work supported by NIH.]