Interaction of speaking rate and postvocalic consonantal voicing on vowel duration in American English

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air strikes relatively rigid boundaries. The angle of the boundary with respect to the flow of air is the significant factor in this case. For /s, ʃ /, the obstacle is at right angles, for /ç, x/, the "obstacle," the tract wall, is nearly parallel to the flow. Implications for vocal tract models will be discussed. [Work supported by a Hunt Fellowship awarded by the Acoustical Society, and a grant awarded by the North Atlantic Treaty Organization in 1984.]

H4. A twisting one-mass glottal model. Lloyd Rice (Phonetics Laboratory, UCLA, Los Angeles, CA 90024-1543)

A new model of vocal cord vibration will be presented that represents the cord body by a single mass exhibiting oscillatory behavior on a horizontal axis together with a rotational component. The model is adequate to describe the diverging and converging configurations of the glottal opening as observed at different phases of the glottal cycle. Characteristics of the model are explored under various glottal vibratory modes and are compared with those of existing models such as the popular two-mass configuration.

H5. Bending-beam model of vocal-fold vibration. Corine Bickley (Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics, Room 36-521, Massachusetts Institute of Technology, Cambridge, MA 02139) and Kevin Brown (Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA 02139)

Recent theoretical developments have shown that a model based on the theory of bending beams is the best predictor of the fundamental frequencies of young children's speech [Bickley, Proc. 11th Int. Congr. Phon. Sci. (1987)]. For children of age 3 years and younger, the values predicted by a spring-mass model are too low, and the values of a vibrating-string model are too high. In the current study, the effect of growth of the vocal-fold structure on fundamental frequency is analyzed. The vocal-fold structure grows nonuniformly; for example, a 1-year-old's vocal folds are approximately one-fifth as long as an adult's folds but only 10% thinner. The bending-beam model is an improvement over other models because it reflects the structure of the vocal folds and the attachments of the vocal-fold tissue to the arytenoid and thyroid cartilages, characteristics previously ignored. The fundamental frequency of the new model depends on both the beamlike characteristics of the vocal folds and the springiness of the structure. Changes in fundamental frequency are predicted from the model as a function of age.

H6. Estimating vocal tract shapes from x-ray microbeam data. Peter Ladefoged and Mona Lindau-Webb (Phonetics Laboratory, UCLA, Los Angeles, CA 90024-1543)

X-ray microbeam techniques provide data on a few points on the tongue. The possibility of an algorithm that will turn these data into a full specification of the whole tongue shape is tested. A weakness of the system is that it is difficult to place pellets on the posterior half of the tongue. The first goal is thus to investigate what is the minimum number of pellets necessary to predict the shape of the anterior part of the tongue. Data were recorded from seven points, four of which were on the front of the tongue, approximately 15 mm apart. The subject produced short utterances illustrating English vowels. This procedure was then repeated with the four tongue pellets moved approximately 5 mm forward. Image scans of sustained English vowels in which the subject had a chain on the tongue midline consisting of 17 pellets 5 mm apart were also recorded. The results allowed determination of the extent to which tongue shapes can be determined from x-ray microbeam pellets. [Work supported by NIH.]

H7. Voicing distinction for fricatives: Acoustic theory and measurements. Kenneth N. Stevens (Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics, Speech Communication, Massachusetts Institute of Technology, Cambridge, MA 02139), Sheila E. Blumstein (Department of Cognitive and Linguistic Sciences, Brown University, Providence, RI 02912), and Laura B. Glicksman (Research Laboratory of Electronics, Speech Communication, Massachusetts Institute of Technology, Cambridge, MA 02139)

Theoretical analysis suggests that simultaneous generation of vocal-fold vibration and turbulence noise at a supraglottal constriction requires rather precise adjustment of the structures controlling the glottis, the intraoral volume, and the supraglottal constriction. The theory shows that there tends to be a reciprocal relation between voicing amplitude and the amplitude of the turbulence noise. It is not surprising, therefore, that vocal-fold vibration does not always occur throughout the constricted interval when a "voiced" fricative is produced, and that variation in the noise amplitude is often observed. Measurements of the amplitude of voicing (expressed as the spectrum amplitude in the region of the first harmonic) and of frication noise have been made for several fricative consonants spoken by several speakers in a number of phonetic environments, including utterance final and intervocalic position, and in clusters with other voiced and voiceless fricatives. Evidence for voicing can usually be found over some portion of the constricted interval, particularly in the vicinity of fricative onset or release. However, voicing may be weak or absent when the voiced fricative is followed in a cluster by a voiceless fricative. [Work supported in part by Grants NS-04332 and NS-15123 from the National Institutes of Health.]

H8. Stress effects on stop consonant closure and release gestures. Mark K. Tiede (Haskins Laboratories, 270 Crown Street, New Haven, CT 06510)

This study seeks to characterize the articulatory kinematics of stop consonant gestures in contrasting environments, with the aim of incorporating the results into the gesture-based approach to synthesis under development at Haskins. The CVCVC tokens drawn from the Bell x-ray microbeam corpus have been examined, representing combinations of stress, vowel, and consonant type spoken in isolation by a female speaker of English. Measurements were taken from peaks of the vertical component of pellet displacement and velocity corresponding to consonant closure and release gestures, using the lower lip pellet for labials and the tongue root pellet for velars. The ANOVA results show that stress affects consonant gesture duration independently of coproduced vowel type, but interacts significantly with consonant type, possibly because velars compete with coproduced vowels for control of the tongue. Results also showed different results for consonant duration depending on whether the gesture occurred in the first or final syllable, which is consistent with previous studies of prepausal lengthening [D. H. Klatt, J. Phonet. **3**, 129–140 (1975)]. [Work supported by NSF Grant BNS-8520709.]

H9. Interaction of speaking rate and postvocalic consonantal voicing on vowel duration in American English. H. S. Gopal (Callier Center, University of Texas at Dallas, 1966 Inwood Road, Dallas, TX 75235) and Ann K. Syrdal (AT&T Bell Labs, IH6C-320, Naperville–Wheaton Road, Naperville, IL 60566)

Vowel duration is influenced both by speaking rate and by voicing of the postvocalic consonant. Our study systematically investigates how these two factors interact. Syllable and segment durations were measured for /pVC/ target syllables containing one of eight vowels and voiced or voiceless stops or fricatives. Target syllables were produced in sentence contexts at three speaking rates by four female and three male native American English speakers. Our findings replicate and extend Klatt's incompressibility model of vowel duration [D. H. Klatt, J. Acoust. Soc. Am. **54**, 1102–1104 (1973)]. The two factors influencing vowel duration do not combine independently in a multiplicative or additive fashion. Instead, they interact such that vowels manifest a resistance to further shortening.