

A phonetic analysis of voicing assimilation in Russian stops and fricatives across preposition boundaries

Martha W. Burton, Karen E. Robblee and Ann Wislowski

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measured from LPC spectra. Preliminary results confirm expectations: /r/ engenders lower formant frequencies than /z/ in less-stressed, all-b contexts, even in nonadjacent syllables. Vowel stress and /d/ contexts tend to block the spread of differences due to /z/ or /r/, presumably because the tongue is more constrained. Many of these differences are audible; their contribution to robustness and naturalness of synthetic speech will be described. [Work partly supported by Telia Promotor Infovox AB.]

2pSP29. Phonetic variants of Taiwanese "voiced" stops. Ho-hsien Pan (Div. of Speech and Hear. Sci., Ohio State Univ., 110 Pressey, 1070 Carmack Rd., Columbus, OH 43210)

Taiwanese (Amoy) is one of only a handful of Chinese languages that have a third "voiced" stop type contrasting with aspirated and unaspirated voiceless stops at same place of articulation. As in other languages with "voiced" stops, the phonetic realization of Taiwanese /b/ and /g/ is highly variable from one context to another. For example, in utterance initial position, they are said to be "prenasalized" as well as prevoiced and Zhang [1981, *Tai Wan Min Nan Fang Yen Gi Yau*] even claims that they are replaced by homorganic nasals [m] and [ŋ] when the syllable is closed by a nasal. The positional variants were examined using oral and nasal airflow recordings from seven male native speakers. Three types of syllable structures were chosen with initial voiced stops in CV, CVN, and CVC. The target syllables are placed in utterance initial position and in medial positions after nasals, vowels, and voiceless stops. Initially, there is clear voicing during the closure, while the presence of prenasalization is speaker dependent. When the target syllables are medially, the voiced stops become nasals when preceded by nasals, and otherwise are plain voiced stops with no prenasalization.

2pSP30. Attributes of lateral consonants. Kenneth N. Stevens (Res. Lab. of Electron. and Dept. of Elec. Eng. and Comput. Sci., MIT, Cambridge, MA 02139) and Sheila E. Blumstein (Brown Univ., Providence, RI 02912)

This paper attempts to define acoustic properties of laterals in English that are adjacent to vowels and in syllabic nuclei. When the tongue is in the lateral configuration, there is an increased bandwidth and decreased prominence of the second formant (due to increased losses) and some irregularities in the $F3$ - $F4$ region (divided acoustic path). When a lateral consonant is produced adjacent to a vowel, there is a rapid change in the acoustic spectrum as these attributes appear or disappear. A series of acoustic analyses has investigated the nature of this discontinuity, particularly the change in amplitude and frequency of the first two spectral prominences. An abrupt change in $F2$ amplitude of about 10 dB at consonant release (less at closure) is a salient attribute. The attributes that distinguish a syllabic lateral and a nonlow back vowel /o/ have been examined through acoustic analyses and through perceptual experiments in which $F2$ bandwidth and other properties are manipulated in synthetic utterances. $F2$ bandwidth again appears to play a significant role in signalling this distinction. The common acoustic attributes associated with the lateral configuration appear to be used in different ways by listeners depending on the context. [Research supported in part by NIDCD.]

2pSP31. Acoustic characteristics of American English vowels. James Hillenbrand, Laura A. Getty, Kimberlee Wheeler, and Michael J. Clark (Speech Pathol. and Audiol., Western Michigan Univ., Kalamazoo, MI 49008)

This study was designed as a replication and extension of the classic study of vowel acoustics by Peterson and Barney (PB) [*J. Acoust. Soc. Am.* 24, 175-184 (1952)]. Recordings were made of 50 men, 50 women, and 50 children producing the vowels /i, ɪ, e, æ, ɜ, ʌ, a, ɔ, u, u/ in h-V-d syllables. Formant contours for $F1$ - $F4$ were measured from LPC spectra using a custom interactive editing tool. For comparison with the PB data, formant patterns were sampled at a time that was judged by visual inspection to be maximally steady. Preliminary analysis shows numerous differences between the present data and those of PB, both in terms of average formant frequencies for vowels, and the degree of overlap among adjacent vowels. As with the original study, listening

tests showed that the signals were nearly always identified as the vowel intended by the talker.

2pSP32. VC and CV transitions and the recognition of Canadian French syllables containing /l/. Benoît Jacques (Lab. de Investigaciones Sensoriales, CONICET, Buenos Aires and Dept. de Linguistique, Univ. du Québec à Montréal, P. O. Box 8888, sub. Centre-Ville, Montréal, PQ H3C 3P8, Canada) and Lise Cloutier (Univ. du Québec à Montréal)

According to recent works, the formant structure of consonant /l/ is influenced by the adjoining vowels, so that the liquid appears as a modulation of these ones in frequency and intensity. The aim of this paper was to find out to what extent the VC and CV transitions are still needed in order that a syllable containing /l/ be recognizable. To that end, nonsense /VlV/ utterances in which both V's correspond to the same vowel were recorded by a Canadian French speaking informant and digitalized. In addition, vowels /i, e, ε, a, o, u, y/, recorded in isolation, were also digitalized. Through the splicing and editing of the acoustic signal, the first vowel of each utterance, then the second one, was replaced successively by each of the vowels previously recorded in isolation, thus giving 112 stimuli. Listening tests through a panel comprising of 16 French Canadian subjects were performed. Results showed that a syllable containing /l/ is recognized most when the replacing vowel in the utterance is /i/ or /y/. In most other cases, the syllable is not recognized and the consonant itself might be perceived as a vowel.

2pSP33. A phonetic analysis of voicing assimilation in Russian stops and fricatives across preposition boundaries. Martha W. Burton (415 Moore Bldg., Dept. of Psychol., Penn State Univ., University Park, PA 16802), Karen E. Robblee, and Ann Wislowski (Penn State Univ., University Park, PA 16802)

In Russian, voicing assimilation is usually regressive with the voicing of obstruent clusters conditioned by the final obstruent. However, there is conflicting phonetic evidence from other languages such as Polish on whether neutralization of voicing is complete [cf. W. Jassem and L. Richter, *J. Phon.* 17, 317-325 (1989); L. Slowiczek and D. Dinnsen, *J. Phon.* 13, 325-341 (1985)]. This study investigated the effects of voicing assimilation across prepositional boundaries, an environment where voicing assimilation is believed to occur in Russian. Three native speakers of Russian produced sentences containing prepositions ending in a voiceless stop or fricative. These prepositions were followed by word tokens with initial obstruents that were voiced or voiceless. Thus there were four stop-fricative combinations [ts,dx,tz,dz] and four fricative-stop combinations [st,sd,zt,zd]. Acoustic analyses of these tokens included duration measurements and spectral analyses. Preliminary results indicate that a pattern generally consistent with voicing assimilation emerges. However, for some speakers there was variation depending on the particular combination of fricative and stop. The findings of the study will be considered in terms of phonetic and phonological theories of speech.

2pSP34. Multi-channel acoustical modeling of the vocal tract for /l/ production. Vladimir M. Barsukov (Res. Lab. of Electron., MIT, Cambridge, MA 02139)

Acoustic analysis of the lateral consonant /l/ shows some extra, unexplained poles and zeros above the second formant. A vocal tract model with a bifurcation in the acoustic path from the glottis to the lips was analyzed to explain these acoustic characteristics. The mathematical model consists of a tube that contains an additional parallel acoustic path or a side branch with dimensions roughly consistent with the shape of the airways for /l/. A one-dimensional approximation was used to set up differential equations for sound pressure P and volume velocity U , appropriate boundary conditions were applied, and an analytical solution for the problem was found for various geometrical parameters. The analysis of this solution shows existence of the extra poles and zeros above the second formant for a reasonable set of parameters. [Research supported in part by a grant from NIDCD.]

2pSP35. Phonetic structures of an endangered language: Khonoma Angami. Barbara Blankenship (Phon. Lab., Linguist. Dept., UCLA, Los Angeles, CA 90024-1543)