**6.542J, 24.966J, HST.712J LABORATORY ON THE PHYSIOLOGY,
ACOUSTICS, AND PERCEPTION OF SPEECH
Fall 2001**

Lab 4   *09/18/01*

**Spectral Analysis of Stop and Fricative Consonants: Sound
Generation from Turbulence in the Vocal Tract**

References

Kewley-Port, D. (1982) *Measurement of formant transitions in naturally produced stop consonant-vowel syllables*, **J. Acoust. Soc. Am. 72**, 379-389.

Stevens, K.N. (1993) *Models for the production and acoustics of stop consonants*, **Speech Communication 13**, 367-375.

Stevens, K.N. Chapters 7 and 8.

See also the following notes and reprints (in Speech Group Library)

Manuel, S.Y. and K.N. Stevens (1995) *Formant transitions: Teasing apart consonant and vowel contributions*. **Proc. International Conference of Phonetic Sciences, Vol. 4**, Stockholm, 436-439.

Stevens, K.N., S.E. Blumstein, L. Glicksman, M. Burton and K. Kurowski (1992) *Acoustic and perceptual characteristics of voicing in fricatives and fricative clusters*, **J. Acoust. Soc. Am. 91**, 2979-3000.

Stevens, K.N. (2000) *Diverse acoustic cues at consonantal landmarks*, **Phonetica 57**, 139-151.

Procedure

Broadband spectrograms and waveforms are to be made of selected utterances containing various stop and fricative consonants. Spectra should be generated at selected points through the utterances in order to illustrate the properties of the sounds generated with turbulence noise at a supraglottal constriction (frication) and at the glottis (aspiration). The spectrum of the frication noise and of the

aspiration noise should be examined in relation to the spectrum near the onset of the adjacent vowel. Also examine the transitions in the adjacent vowels. All of this work is to be done on the computer, using the *lspecto* command for spectrograms, and *xkl* for spectra.

Each group will study the consonants in at least one of the following sets:

b d g p t k h   (voiced and voiceless stop consonants + /h/)
f θ s š v ð z ž   (voiced and voiceless fricative consonants)
č j t d š ž   (stops and affricates produced with the tongue blade)

The following questions might be considered as you study these consonants.

1. How do the spectra of the bursts differ for different places of articulation for stop consonants?
2. Can you tell when frication noise ends and aspiration noise begins in voiceless aspirated stop consonants?
3. Is there evidence of breathy voicing as voicing begins (or ends) in /p t k h/?
4. How does the spectrum of the frication noise differ for different places of articulation of fricative consonants?
5. How do voiced fricatives differ from voiceless fricatives? How does the amplitude of voicing in a voiced fricative differ from that in an adjacent vowel (as indicated by the amplitude of the first harmonic)? Are there differences in the spectrum amplitude of the noise for voiced and voiceless fricatives?
6. Compare the spectrum of the noise (in stops and fricatives) with spectra at vowel onset. For example, compare high-frequency amplitude in /s/ with high-frequency amplitude in adjacent vowel 20 ms after voice onset.
7. Characterize the time course of events in affricate consonants.

For examining most of the spectral characteristics, a 6.4 ms time window is suggested. To examine low-frequency characteristics (such as voicing amplitude), a 30-ms time window might be better. For female voices, you may wish to use a sampling rate of 16 kHz (low-pass filter of 7.5 kHz), whereas for a male voice, the default sampling rate of 10 kHz (filter at 4.8 kHz) is appropriate. To digitize at a sampling rate of 16 kHz, type *record - s16000* (instead of just record for 10 kHz). In estimating the spectrum of noise that is in a reasonably steady-state region (such as in a fricative), you may wish to calculate an *average* spectrum. You can do this in xkl by typing *A* and following instructions. You may also type *a* and follow instructions. In the case of spectra of bursts in stop consonants, be sure that the averaging interval does not extend into the voicing for the following vowel.

Your report should contain sample spectrograms and spectra, and should address some of the questions asked above.