24.963 Linguistic Phonetics
Fall 2005

Acoustics Assignment 3: Due 10/21

1. (a) What is the size of an analysis window (in ms) if the sampling rate is 22 kHz and the window contains 512 samples?

    (b) What is the interval between spectral points (analysis components) in an FFT spectrum if the sampling rate is 11 kHz and the analysis window is 512 samples long?

2. As mentioned in class, velars stops are often described as being characterized by a convergence of F2 and F3 in the formant transitions at closure and release.
    (i) F2 and F3 will only converge on exactly the same frequency under very specific conditions – what are these conditions?
    (ii) Under what broader set of circumstances would we expect F2 to fall and F3 to rise in the release transitions of a velar? (Assume that the following vowel is produced with a vocal tract with uniform cross-sectional area).

3. (This is an open-ended question:)
    Analyze the form of locus equations for F2 in stop-vowel sequences using simple tube models of the vocal tract. Labials and velars are probably easier to analyze than alveolars, but try to say something about alveolars also.
    The figure shows locus equations from Fowler (1994). Similar patterns have been found across languages:
    *   labials and velars have steep slopes (>0.7), alveolars and dentals have less steep slopes (0.4-0.5).
    *   The intercept (where the line crosses the y-axis) in labials is much lower than in velars, and is highest in alveolars/dentals.
    *   Locus plots for velars often look less linear than for labials or alveolars – the slope appears to flatten out at higher vowel F2 frequencies (as in Fowler's plot)

    Try to account for these observations in terms of models of the articulations involved in producing stop-vowel sequences. Some suggestions for models you might try and questions you might address:

    Bilabial stops
    A simple approach to modeling labial stops is to assume that they involve the same vocal tract shape as the following vowel, but with a constriction at the lips. The effect of this constriction can be modeled as equivalent to lengthening the front cavity. How well does this model account for the observed locus equation? Does it predict a precisely linear relationship between F2 onset and vowel F2? Does it account for the observed slope and intercept? Explore explanations for any gaps between predictions and observations.

    Velar stops
    For vowels produced with constrictions in the oral cavity rather than the pharynx (basically non-low vowels), a simple assumption is that the velar is formed with the constriction at the same location as the vowel. How well does this account for the form of the relevant portion of the observed locus equation?
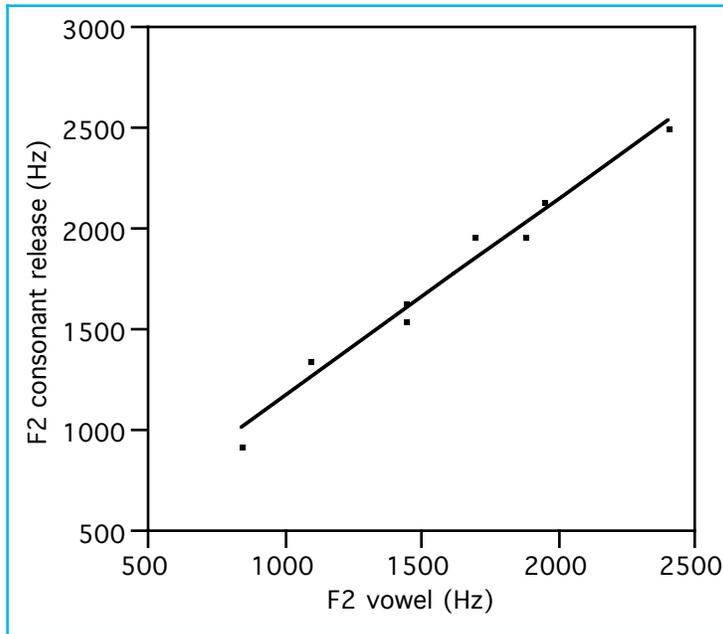   Where must the velar constriction be located when the velar precedes a low vowel to account for the rest of the locus equation?
    When the constriction is far forward, as in a high front vowel, F2 might be a resonance of the back cavity, whereas it is a resonance of the front cavity in less front vowels. Ladefoged (2003) suggests that this observation might explain the non-linearity often observed in velar locus plots. Does this explanation work?

Below is a locus equation plotted from my own speech. It is highly linear. What might explain the difference between my velar locus equation and the non-linear pattern observed by Fowler?

Alveolar stops
Bear in mind Manuel and Stevens' (1995) argument that alveolar formant transitions are due to a tongue body constriction rather than the tongue tip constriction (the latter is opened too quickly to have any effect on F2 at voice onset). What might give rise to the shallower slope of alveolar locus equations compared to labials and velars?

Edward's velar locus equation