L105/205 – Phonetics Handout 3
Scarborough Oct. 4, 2005

reading: Lehiste chapter in Lass (1996) – p. 227-232 (today); Johnson Ch.2.1-2.2 (Thurs)
optional: Ladefoged Ch.9 (135-148); Johnson Quantitative Methods 1.6-1.8, 2.3, 3.1

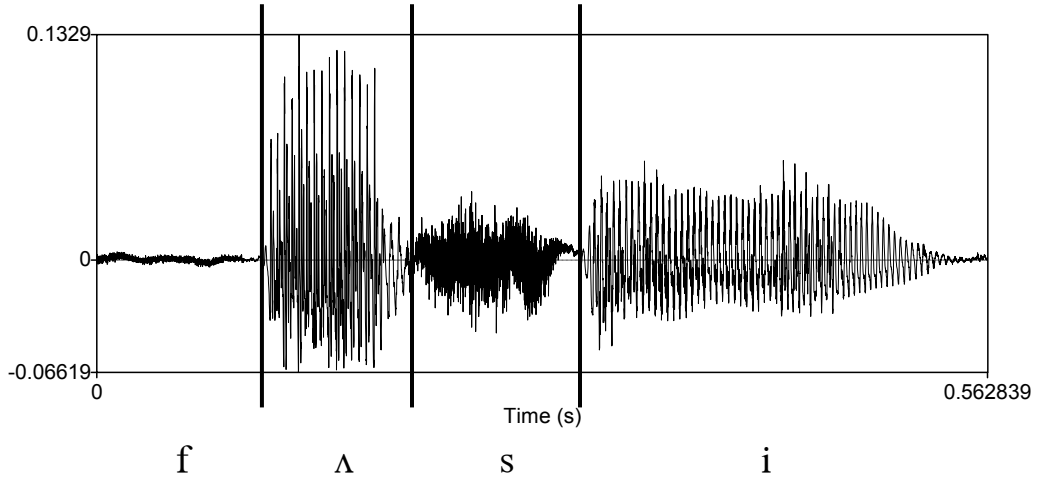
Segmentation and Segment Durations

1. Segmentation is locating individual segments, specifically their beginning and ending points, in a speech stream.

   It is typically assumed that a speech signal can be exhaustively parsed into segments (that is, every bit in the signal belongs to one and only one segment).

   However, in speech, successive segments overlap and influence one another, so there is generally no single right answer about where to divide them. Therefore, segmentation is always arbitrary. But we can decide upon motivated (though necessarily arbitrary) criteria and apply them consistently.

2. *Manner of articulation* is the usual first basis for segmentation. When successive segments have different manners, segmentation is usually relatively straightforward and can often be done just from a waveform.



3. Segmenting a sequence of segments that share manner (e.g., sonorants: vowels, glides, liquids, nasals) is more difficult, and a spectrogram may be very helpful.
   - Spectrograms show weak frication and aspiration more easily. They also show sudden changes in amplitude, either overall (due to the fact that sounds differ in degree of mouth opening) or in particular frequency regions (due to the positions of articulators).
   - When none of these other criteria work, certain frequency changes have to be used for segmentation.

4. A set of segmentation criteria

SEGMENT CLASS (SOURCE)	BEGINS AT	ENDS AT
Vowel (voice source with open mouth – look for strong voicing with lots of high frequency components; however we also count aspiration as part of the vowel – voiceless vowel)	preceding stop release, if there is one; else onset of complex voicing (with higher frequency components)	offset of higher-frequency components (NB. low-frequency voicing during a following C does not count in vowel)
Sonorant consonant (voice source, but weaker than vowel)	point of amplitude change, and/or frequency shifts	opposite of beginning
Fricative (frication noise source, possibly also voicing)	onset of clear frication noise (NB. preceding brief silence usually included in fricative)	opposite of beginning
Stop – voiceless (silence, transient source, sometimes some frication noise)	offset of all higher frequency components, showing mouth is closed	at release burst
Stop – aspirated (stop release followed by aspiration noise)	same as for voiceless	same as for voiceless (thus, aspiration counts as part of the next sound)
Stop – voiced (sometimes weak voicing, only at low frequencies, instead of silence)	same as for voiceless (don't use presence vs. absence of voicing as the criterion)	same as for voiceless
Affricate (stop plus fricative)	beginning of stop, as above	end of fricative, as above

- Transitions from consonant to vowel and vowel to consonant are generally counted as part of the vowel.
    - However, sometimes aspiration may be counted as part of the aspirated stop rather than as voiceless vowel.

5. Measuring duration – simply find the beginning and end of the segment or subsegment you want to measure and calculate (or record) the duration

6. Voice Onset Time (VOT)
   - time from release of stop to onset of voicing
        - for aspirated stops, this is roughly equivalent to aspiration, but the presence or absence of aspiration is actually ignored in determining VOT—only voice source information is used
    - VO = voice onset, or the beginning of visible voicing
        - this is either stop voicing or the following vowel

<u>Lag VOT</u>: VO lags (follows) stop release
- positive number (time from burst forwards)

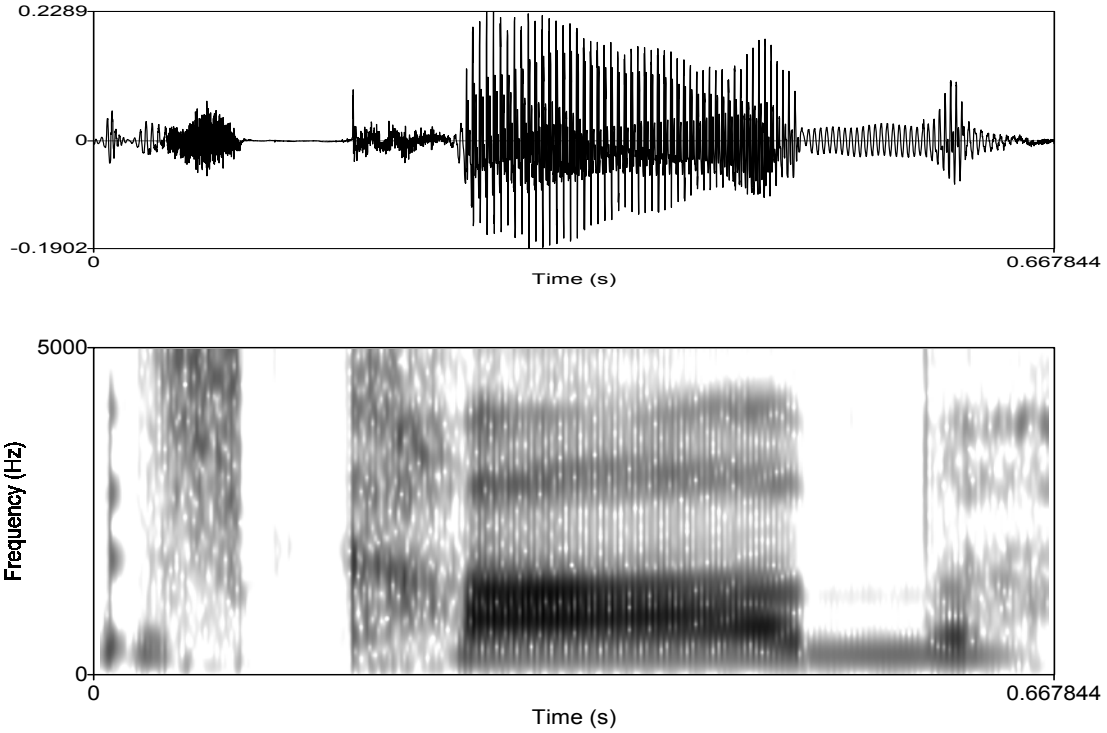
begins	at beginning of release burst for stop (1st burst, if 2 or more)
ends	VO = onset of voiced vowel alternative: VO = beginning of first periodic cycle

<u>Lead VOT</u>: VO leads (precedes) stop release
- negative number (time from burst backwards)

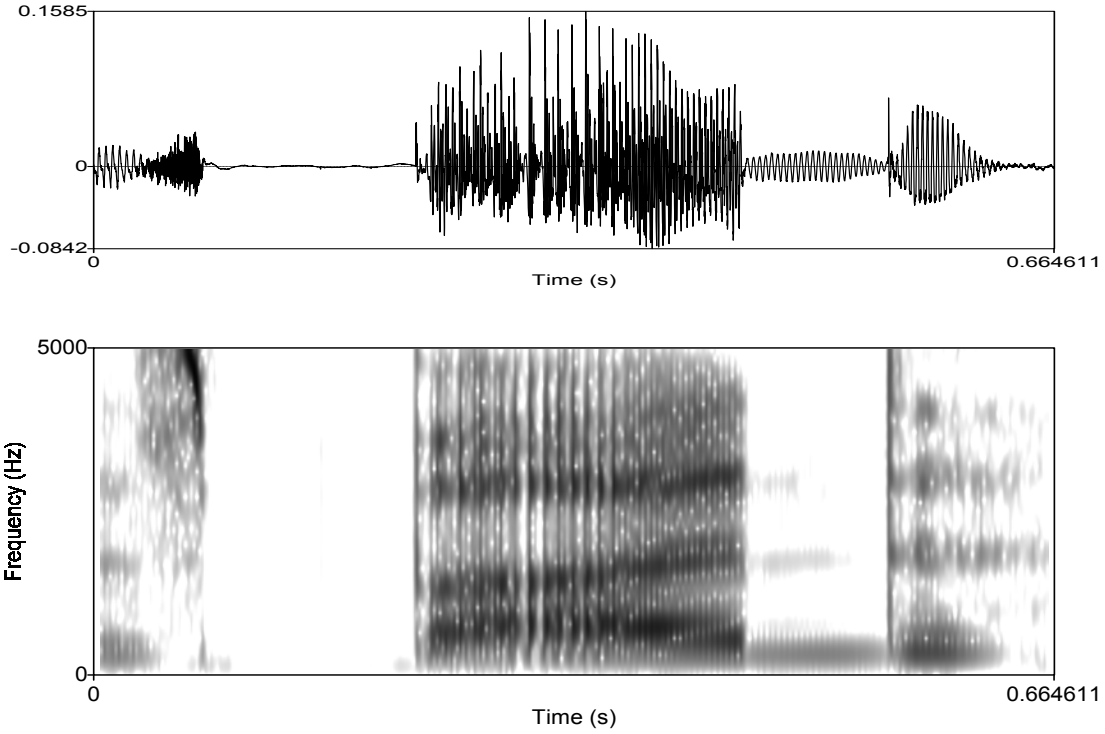
begins	at beginning of voiced closure
ends	at beginning of (first) release burst for stop

NB. If lead VOT is measured in voiced stops after vowels, where the closure is all or partly voiced, the onset of closure is taken as the onset of voicing and the whole closure duration is the VOT, even if closure has a voicing break.

lag VOT (*cob*)



lead VOT (*bud*)



7. Other stop consonant duration measures
   - closure voicing: duration of voicing in closure
   - voiceless closure: duration of silent part of closure
   - closure duration: sum of voiced plus voiceless closure durations
     (compare with *stop duration*, which can include release or even VOT)
   - glottal opening: sum of voiceless closure plus lag VOT

8. Some linguistic phonetic generalizations involving segment durations
   - Phonemic length – Consonants and/or vowels may contrast as phonemically short or long. (Long segments tend to be about 1.5-2.5 times the duration of short ones.)
   - Feature-dependent segment durations
     - Low vowels are longer than high vowels; tense vowels are longer than lax vowels.
     - Vowels are longer before voiced than before voiceless consonants.
     - Vowels are longer before fricatives than before stops.
     - Voiceless (unaspirated) consonants are longer than voiced consonants.
     - Bursts and VOT are longer for velar or palatal stops than for labial or anterior stops.
     - An affricate (or a doubly-articulated segment like a labial-velar) will have about the same duration as a single simple segment.
     - Sources differ as to the effects of place of articulation on stop closure duration and duration of a preceding vowel.
   - Prosodic duration effects
     - Stressed vowels are longer than stressless vowels; primary stress is longer than secondary; nuclear stress is longest of all.
     - Vowels are shorter in closed syllables than in open ones (Maddieson, 1985).
     - Consonants are shortened in clusters.
     - Segments that are final in the word or any larger prosodic domain are lengthened—the larger the domain, the more the lengthening.