

Sonority, Syllables and Stress

An Interesting Fact

- Some vowels are louder than others
- dB of different vowels relative to [ɑ] (Fonagy, 1966):

[ɑ] : 0.0

[e] : -3.6

[o] : -7.2

[i] : -9.7

[u] : -12.3

- Why?

Another Interesting Fact

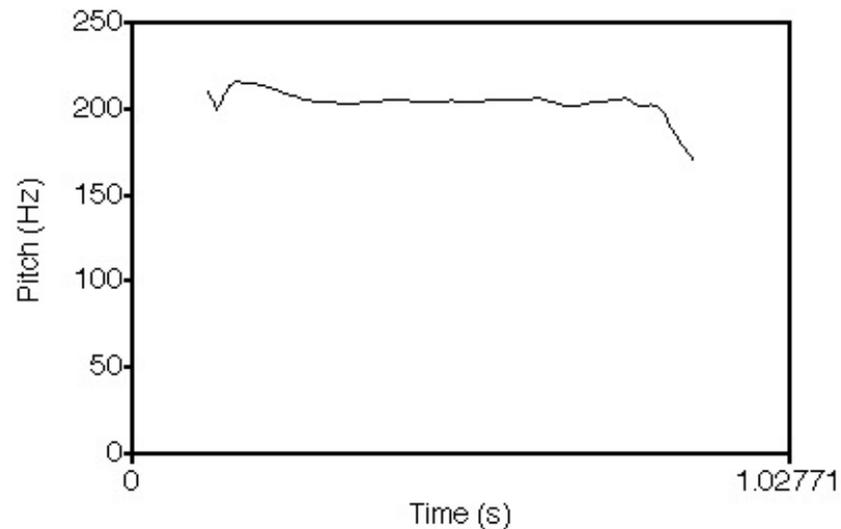
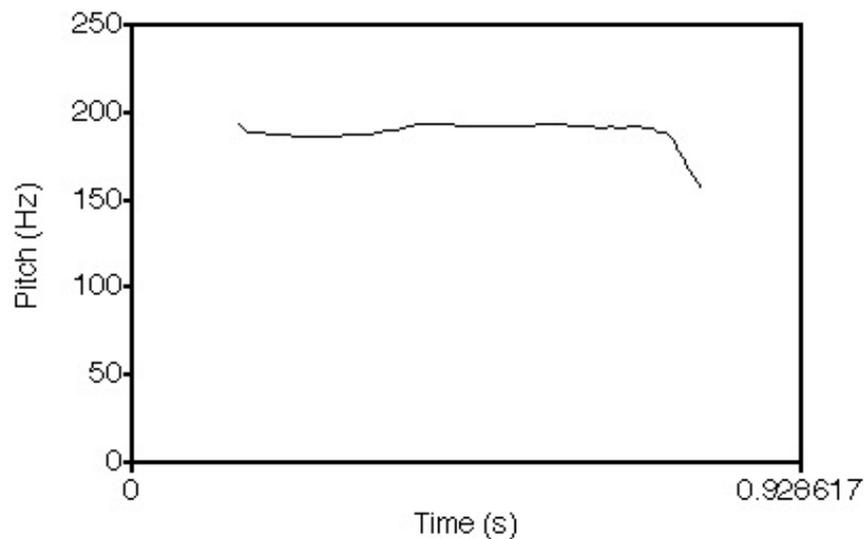
- Some vowels are inherently longer than others.
- Data from Swedish (Elert, 1964):

		long	short
high	[i y u]	140 msec	95
mid	[e ɛ ɔ]	155	103
low	[æ œ ɑ]	164	111

- Why?

Frequency and Vowels

- Had you done the old mystery tone language exercise, you may have noticed that the fundamental frequency of [i] was slightly higher than that of [ɑ], for the same tones



“Intrinsic” Pitch

- It's been observed that F0 is usually higher for high vowels than for low vowels

[i] 183 Hz

[e] 169

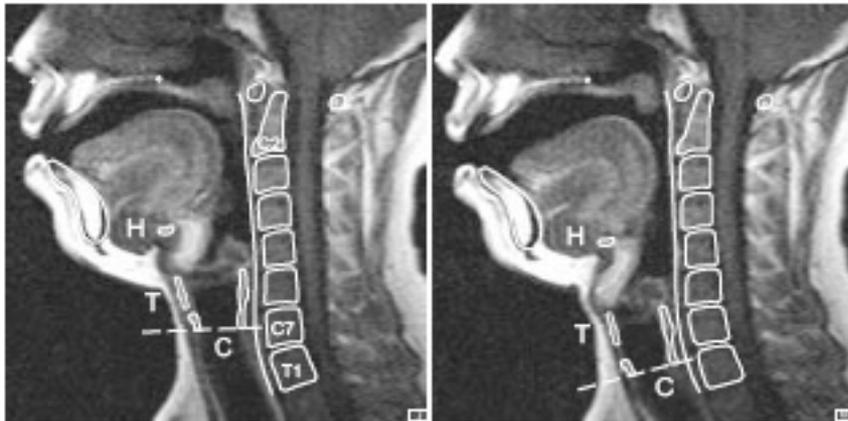
[æ] 162

[a] 163

[o] 170

[u] 182

- Data from Lehiste & Peterson (1961) for American English



(a) 262Hz

(b) 87Hz

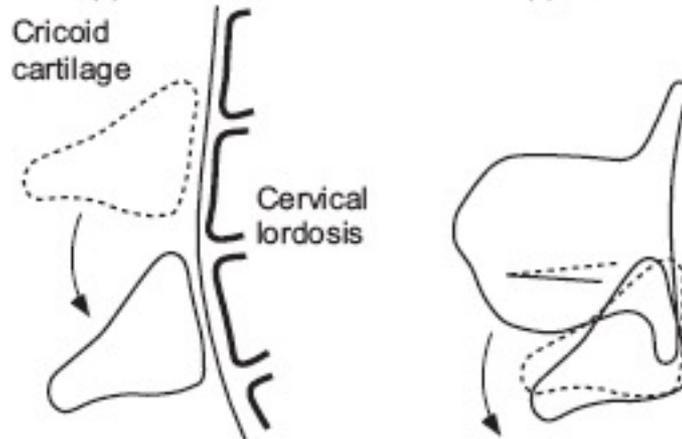


Figure 6: Vertical larynx movement and its effect on F_0 . As the larynx is lowered, the cricoid cartilage moves downward keeping its posterior plate parallel to the curvature of the cervical spine, and thus rotates to shorten the vocal folds.

- The “Tongue Pull” Hypothesis (Honda, 2004):
- Raising the tongue for high vowels also raises the larynx
- The cricoid cartilage rises up and around the spine...
- Thus stretching the vocal folds
- and increasing longitudinal tension.

An Intrinsic Summary

	High Vowels	Low Vowels
Intensity	Less	More
Duration	Shorter	Longer
F0	Higher	Lower

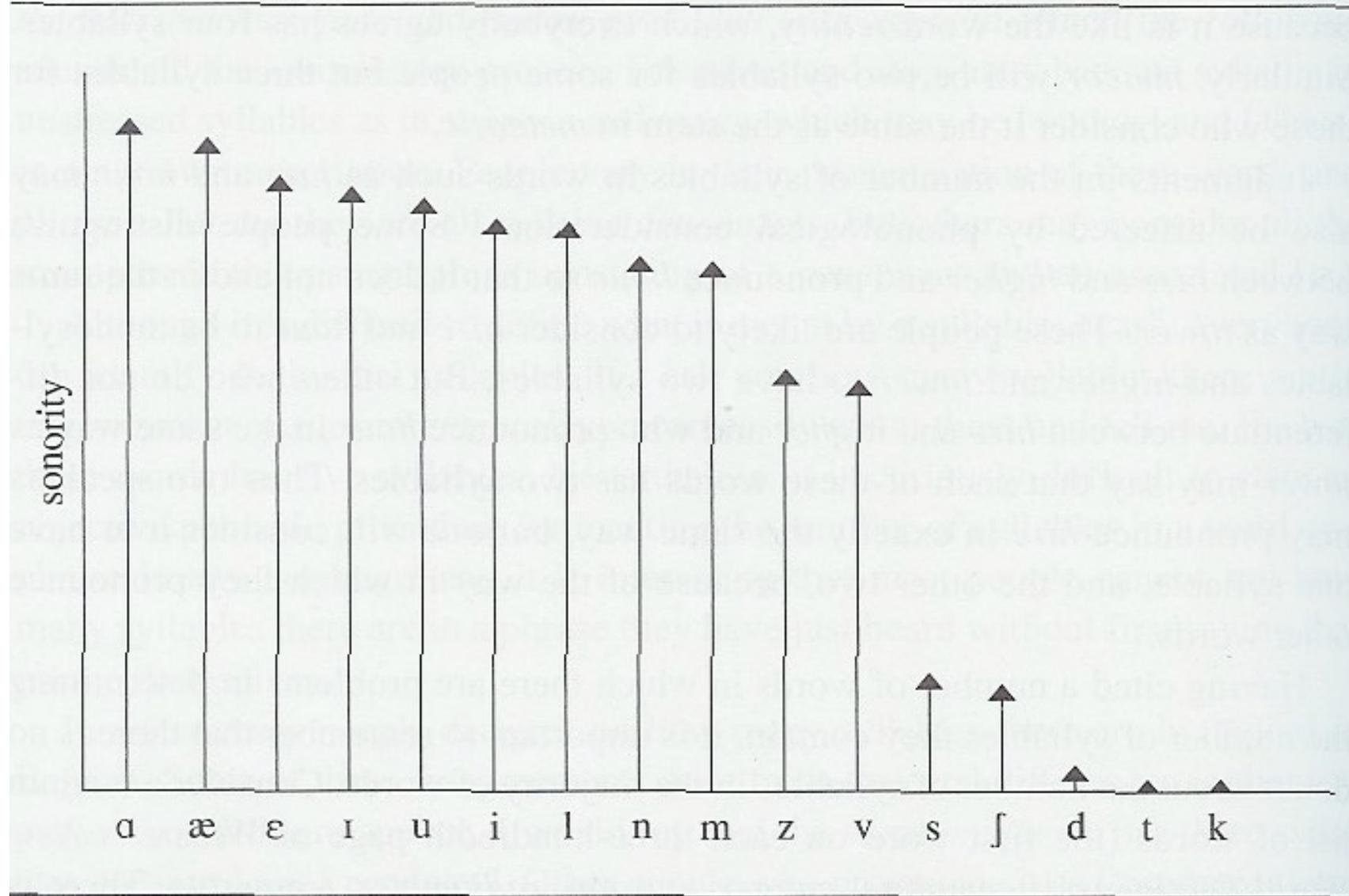
- A word of caution:
 - **All** of these factors (intensity, duration, F0) factor into perceived prominence and stress.

Sonority

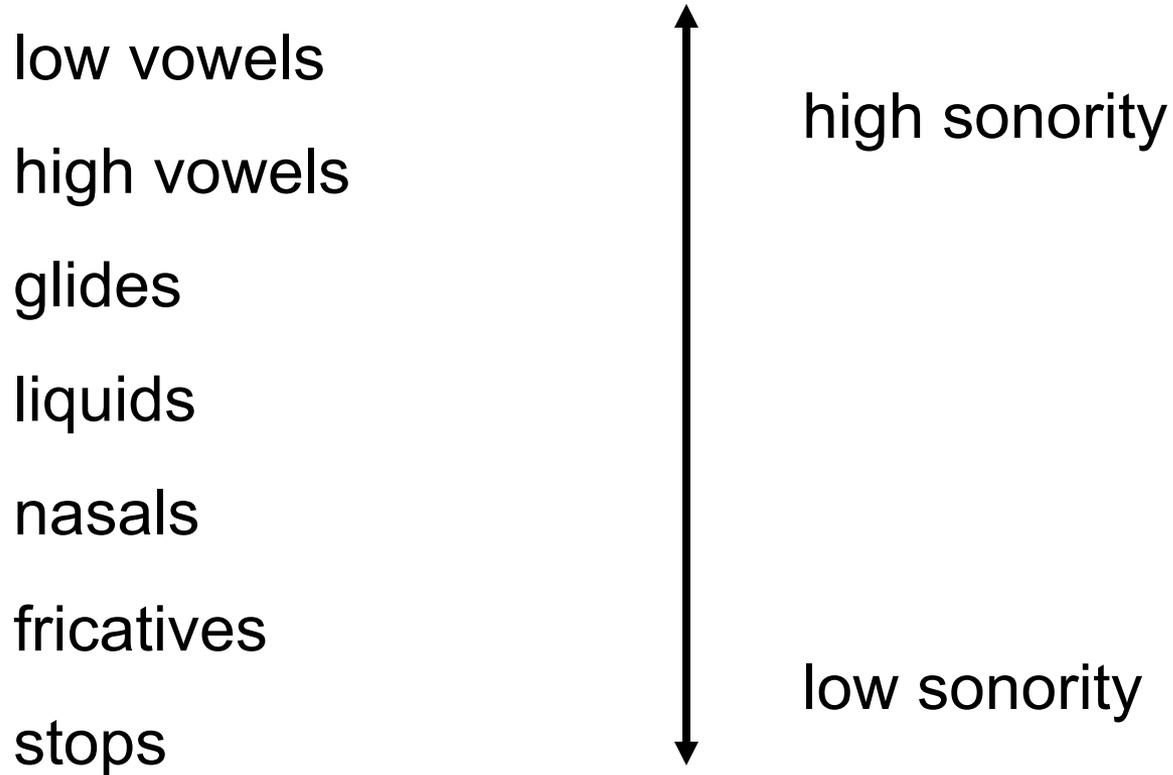
- Loudness is also a highly context-dependent measure.
 - Can vary wildly within speaker, from speaker to speaker, from room to room, and across speaking contexts.
- However, all things being equal, some speech sounds are louder than others.
- Course in Phonetics:
 - “The **sonority** of a sound is its loudness relative to that of other sounds with the same length, stress and pitch.”

From Ladefoged

FIGURE 10.1 The relative sonority of a number of the sounds of English.

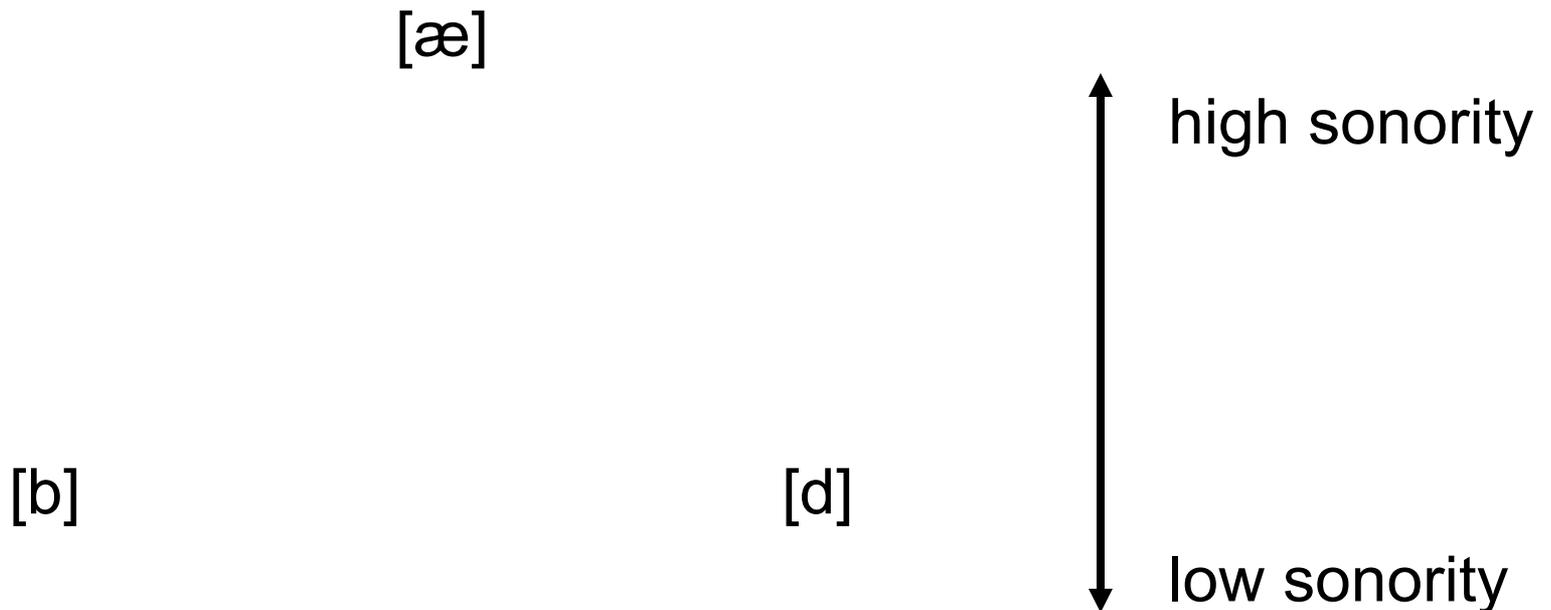


A Sonority Scale



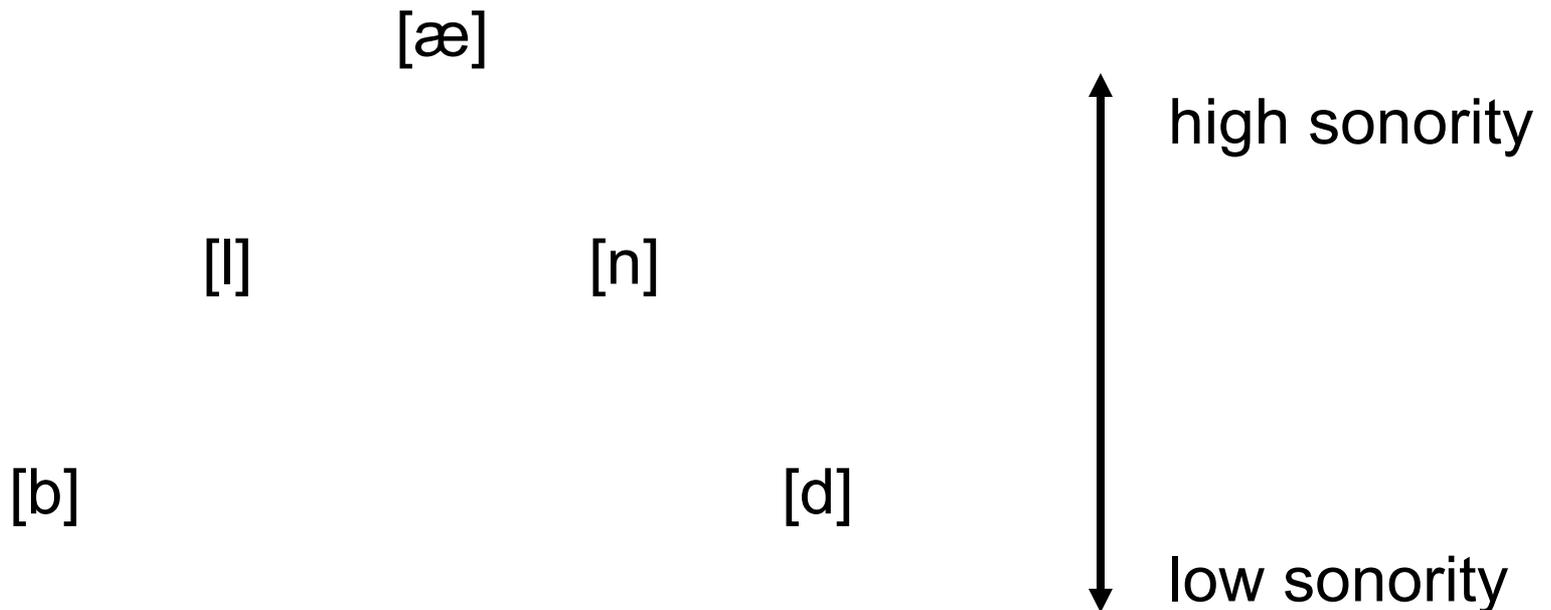
Sonority and Syllables

- An old idea (e.g., Pike, 1943): syllables are organized around peaks in sonority.
- This is the **Sonority Sequencing Principle (SSP)**.
- Example: [bæd] is a well-formed syllable in English.

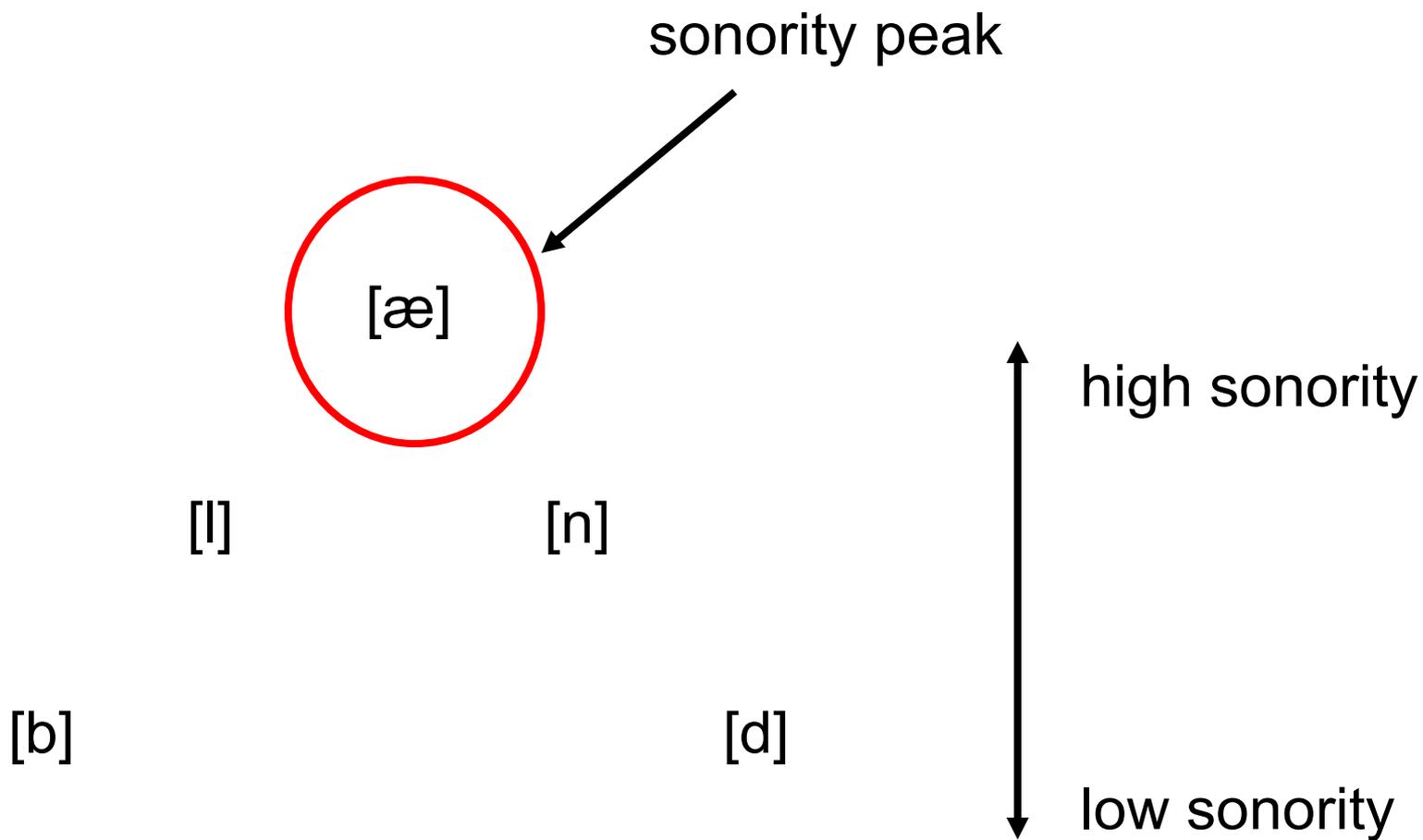


Sonority and Syllables

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- Example: [blænd] works well, too.

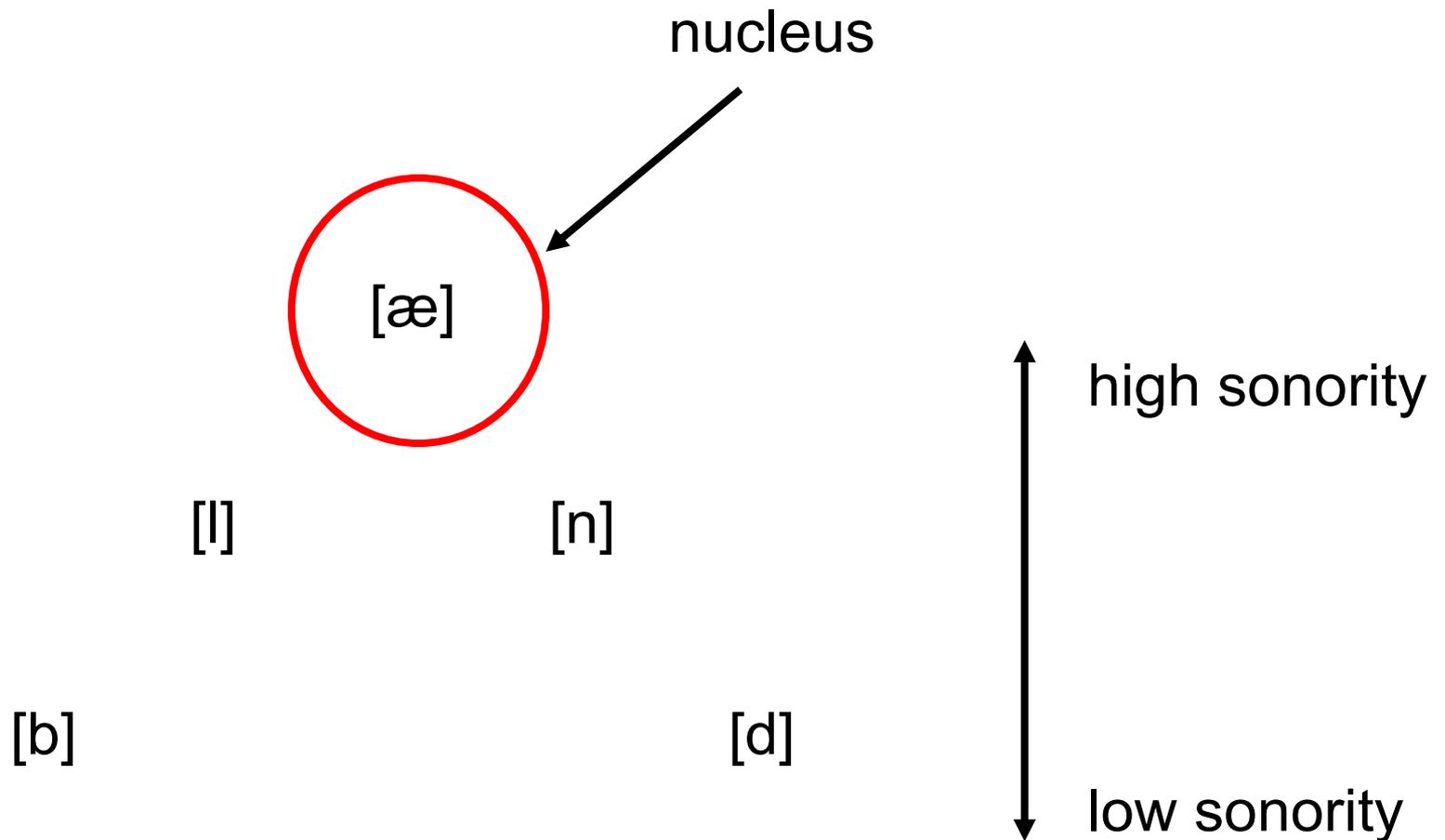


Technical Terms



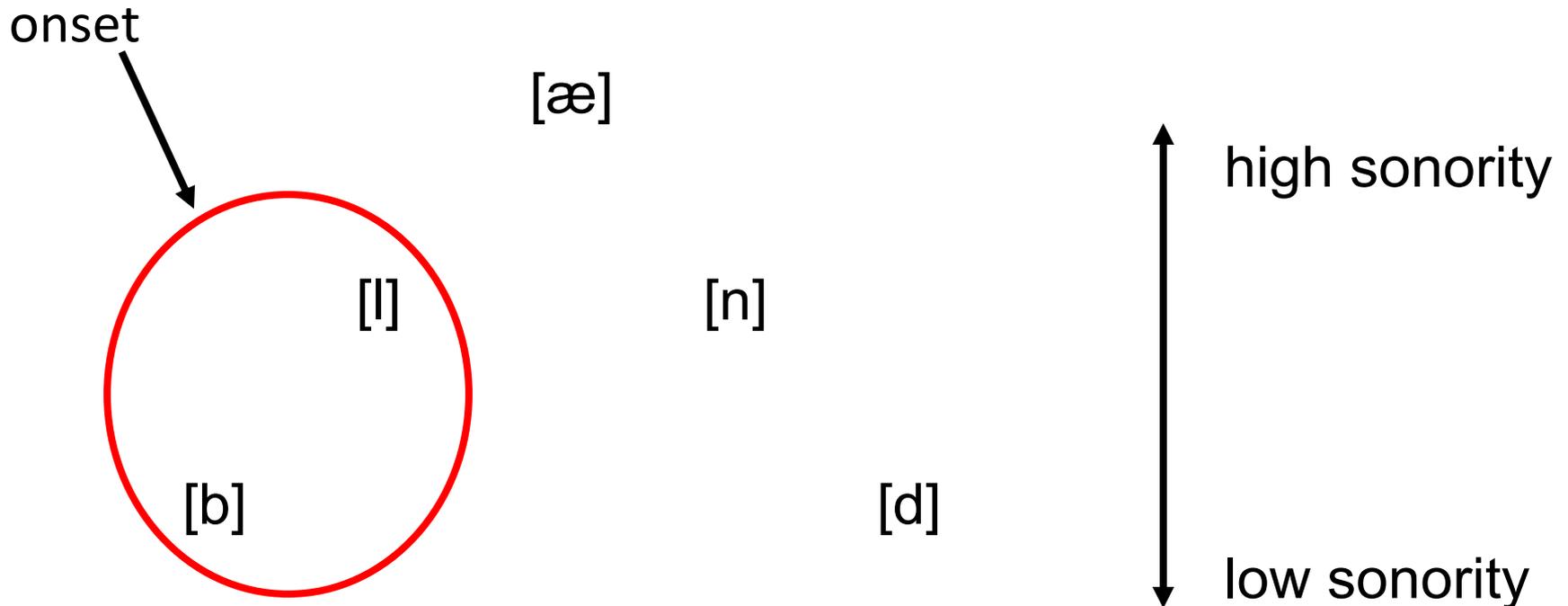
Technical Terms

- The sonority peak forms the **nucleus** of the syllable.



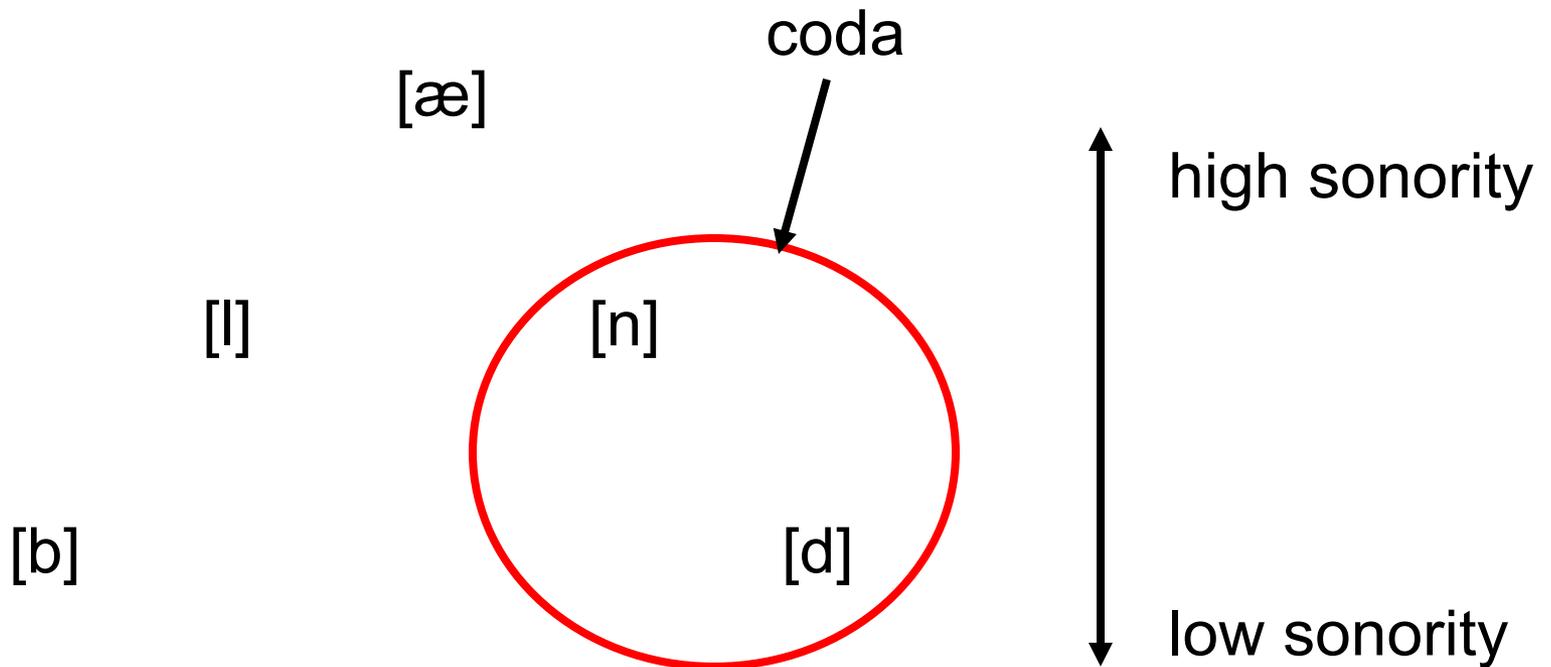
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- The sounds that precede the nucleus form the syllable **onset**.



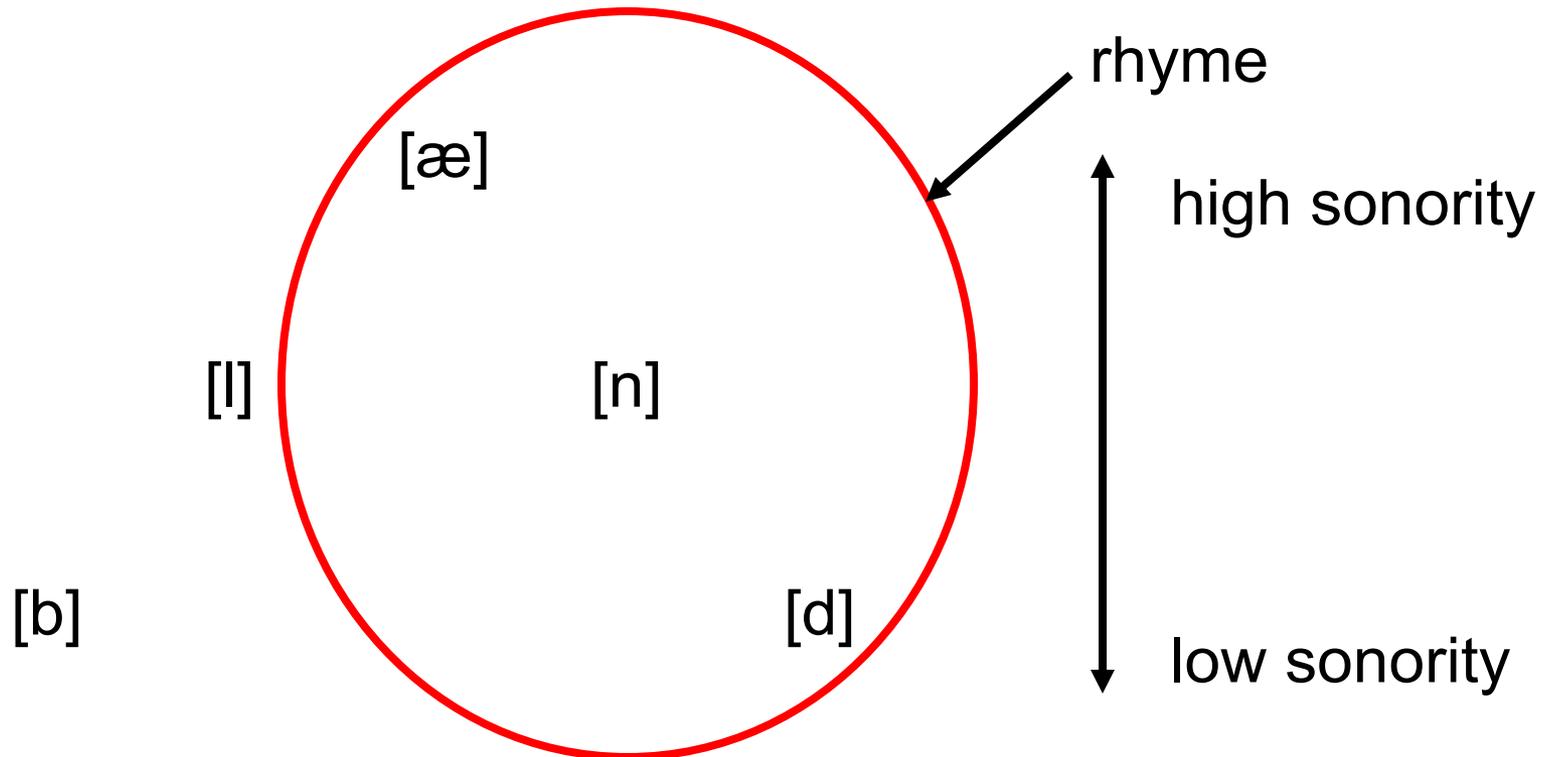
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Technical Terms

- The sonority peak forms the **nucleus** of the syllable.
- The sounds that precede the nucleus form the syllable **onset**.
- The sounds that follow the nucleus form the syllable **coda**.
- Together, the nucleus and coda form the syllable **rhyme**.



Some basic principles

- Onsets must rise in sonority towards the syllable peak.

Examples:

stop - {liquid/glide} **'play'** **'quick'**

fricative - {liquid/glide} **'fling'** **'thwack'**

[s] - {liquid/nasal/glide} **'slide'** **'snow'** **'sweet'**

- What onset clusters should be ruled out?
- Can you think of any English examples where this principle might not work?

Some basic principles

- Codas must drop in sonority away from the syllable peak.

Examples:

nasal - {fricative/stop}

'tenth' **'hand'**

liquid - {fricative/nasal/stop}

'help' **'helm'** **'heart'**

fricative - stop

'test'

- What coda clusters should be ruled out?
- Can you think of any English examples where this principle might not work?

Other Problems

- The Sonority Sequencing Principle doesn't always work.
- How can we define a “syllable”?
- An alternative idea: each syllable is a “chest pulse” (Stetson, 1951)
- It turns out this doesn't work, either.
 - Chest muscles don't necessarily contract for each syllable (Ladefoged, 1967)
- Any better ideas?

Interesting Patterns

- Check out the following words:

Atlantic atrocious

America arcade

Astronomy arthritic

When is the first vowel a [ə]?

- Is there a difference between the /t/ in ‘atrocious’ and the /t/ in ‘Atlantic’?
- Why?

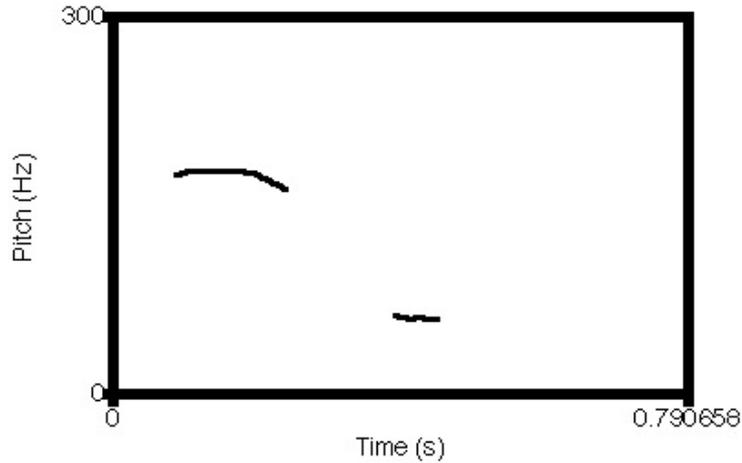
Syllables “defined”

- “Syllables are necessary units in the organization and production of utterances.” (Ladefoged, 1982)
- The construct of a “syllable” can account for a variety of interesting phonological patterns:
 1. Vowel reduction in unstressed syllables in English.
 2. Fricatives and stops devoiced at the end of syllables in German, Russian (and many other languages)
 3. Place contrasts disappear in coda position in Japanese (and many other languages)
 4. Voiceless stops are aspirated at the onset of stressed syllables in many Germanic languages.

Back to Stress

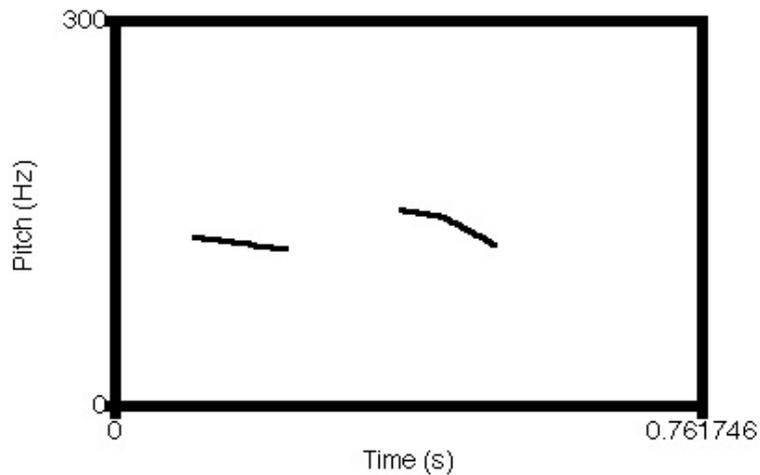
- Stress is a suprasegmental property that applies to whole syllables.
- Stressed syllables are higher in pitch (usually)
- Stressed syllables are longer (usually)
- Stressed syllables are louder (usually)
- Stressed syllables reflect more phonetic effort.
- The combination of these factors give stressed syllables more **prominence** than unstressed syllables.

Stress: Pitch



['ɪnsəʔt]

(N)

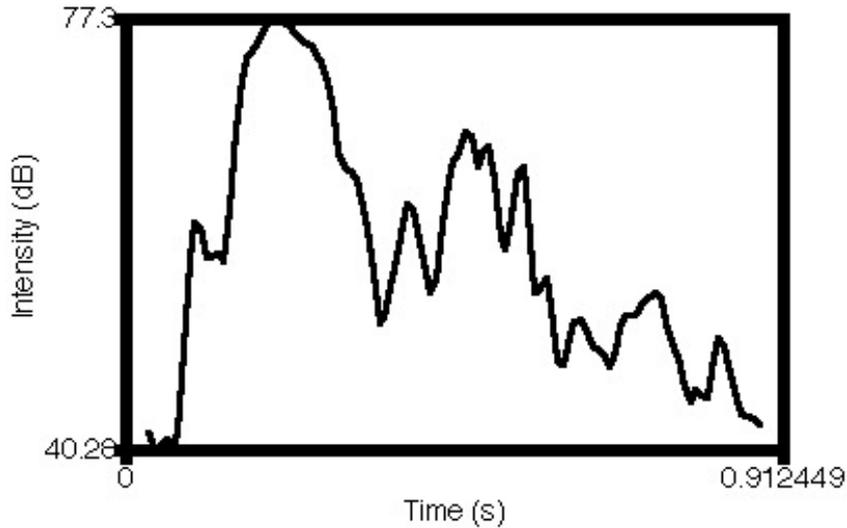


[ɪn'sɪʔt]

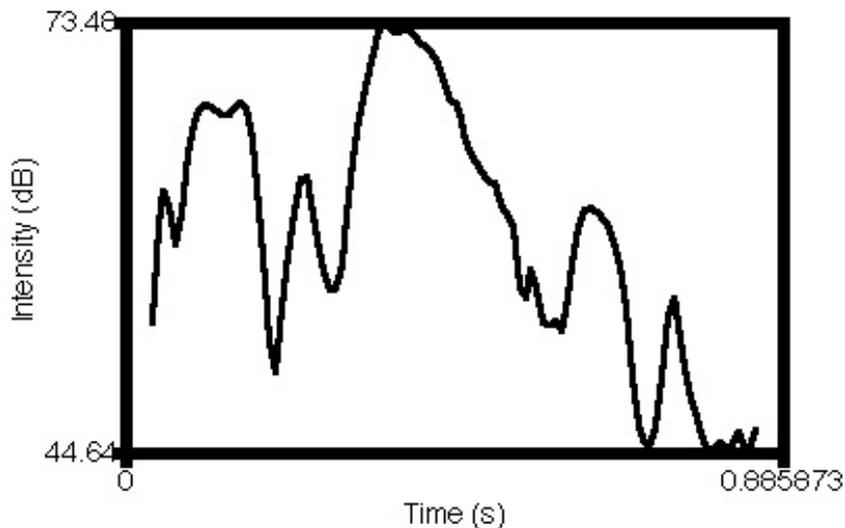
(V)

Complicating factor: pitch tends to drift downwards at the end of utterances

Stress: Intensity



['k^hant_ɹæst] (N)



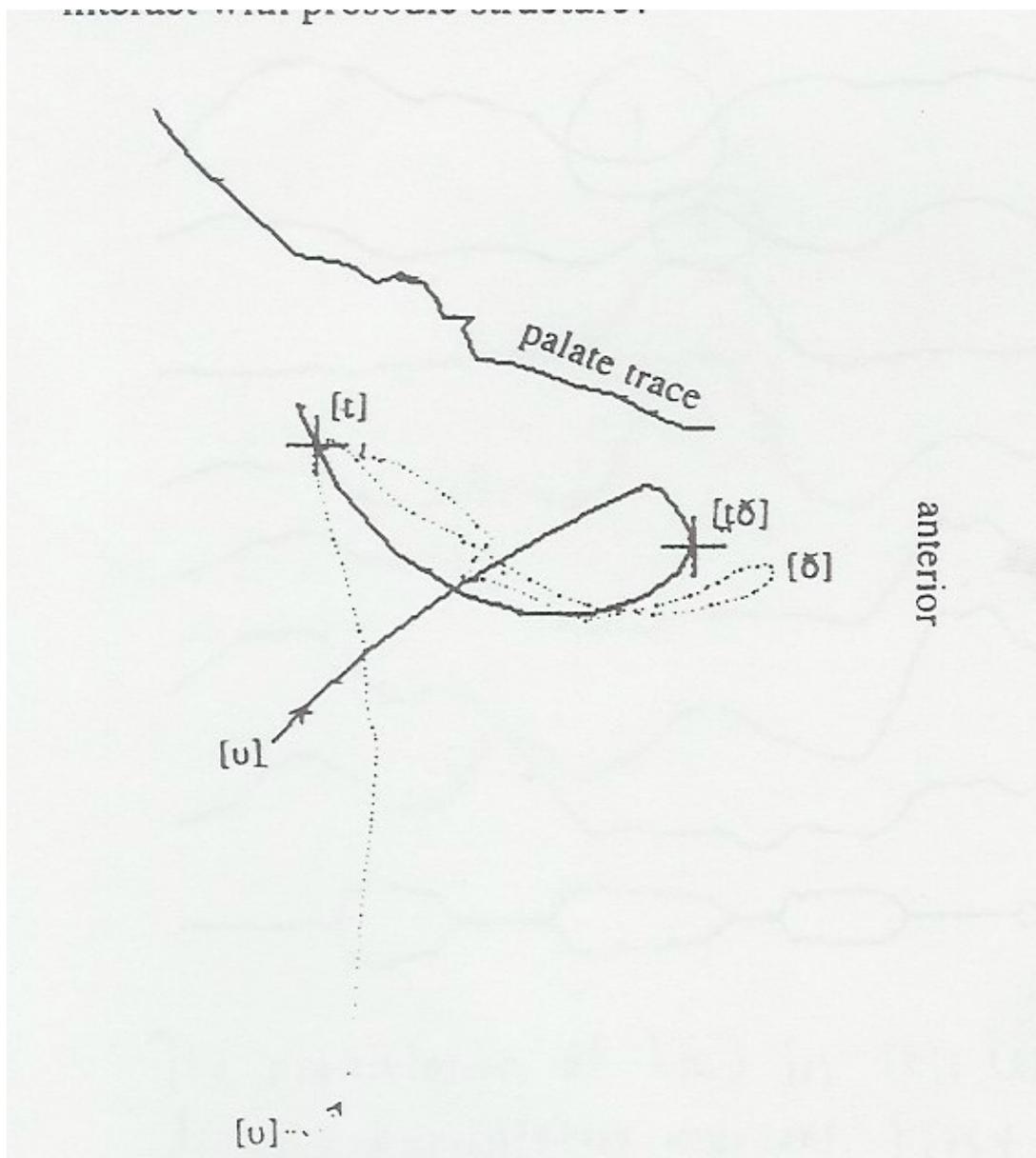
[kæn't^hɹæst] (V)

Perception of stress is highly correlated with the area under the intensity curve

“Phonetic Effort”

- Voiceless stops are more aspirated at the onset of stressed syllables in English
- Vowels are often reduced to [ə] in unstressed syllables in English.
- X-Ray microbeam study (deJong et al., 1993); two utterances:
 1. I said put the TOAST on the table, not the napkins!
 2. I said PUT the toast on the table, don't throw it!

X-ray microbeam data



Varying Levels of Stress/Prominence

- English has both primary and secondary stress.
- Example: [,ɛk.sploɪ. 'tʰeɪ.jən] “exploitation”

	[,ɛk.	sploɪ.	'tʰeɪ.	jən]	
vowel	X	X	X	X	↓ more prominence
full vowel	X	X	X		
stress	X		X		
tonic accent			X		