tədeɪz ədʒɛndə

10/28/04

- Attendance (sign-in sheet)
- A few fun things (1 2 3)
- Summary so far
- Formants and Spectrograms
- Begin Vowel Acoustics

tədeɪz poʊm

ʌndəˠgɔn swɔmp tɪkɨt rɛlətɪv / wɪst nætʃɹ̩l swip ɪneɪt bɪkəˠ

flaɪt noʊʃn̩ ritʃaʊt tɪnsl̩ ɹɛkənɪŋ / bɪt stɹærl̩ ɪnɪkwətəs ɹæmbl̩ stʌŋ

feɪməs fɜˠnətʃəˠ ɪnstənt pæskl̩ / pæʃənɨt ɹʌnɪmid lɪkɹəʃ

fitʃəˠ dəpɑɹtʃəˠ fɹikwɨntsi næʃ / lænts swɛt lɔdʒ ɹæmpɑɹt kɹoʊ

Formants

In speech, the resonant frequencies of the vocal tract (that is the frequencies that resonate the loudest) are called **formants**. We can see them as the peaks in a spectrum.

With vowels, the frequencies of the formants determine which vowel you hear and, in general, are responsible for the differences in quality among different periodic sounds.

At any one point in time (as with spectra) there may be any number of formants, but for speech the most informative are the first three, appropriately referred to as F1, F2, and F3.

Characteristic Formants of American English Vowels

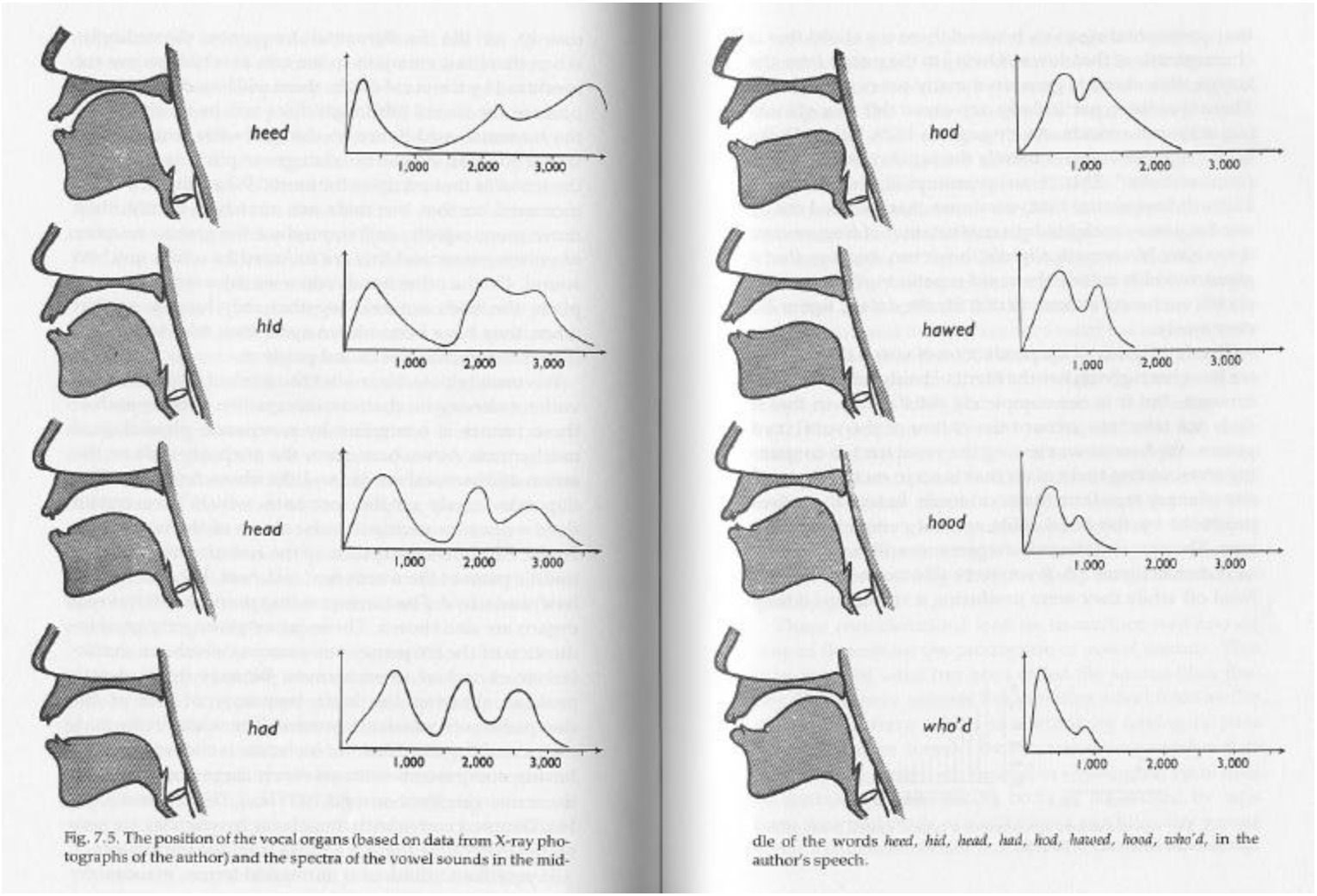
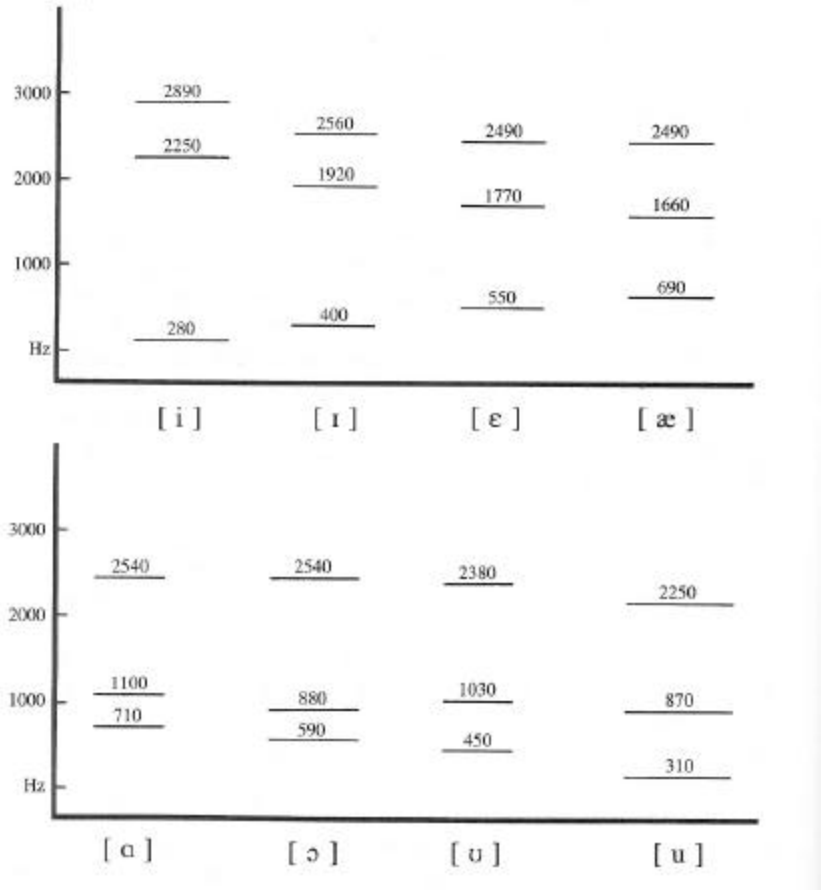


Fig. 7.5. The position of the vocal organs (based on data from X-ray photographs of the author) and the spectra of the vowel sounds in the middle of the words *heed, hid, head, had, hod, hawed, hood, who'd,* in the author's speech.

Characteristic Formants of American English Vowels

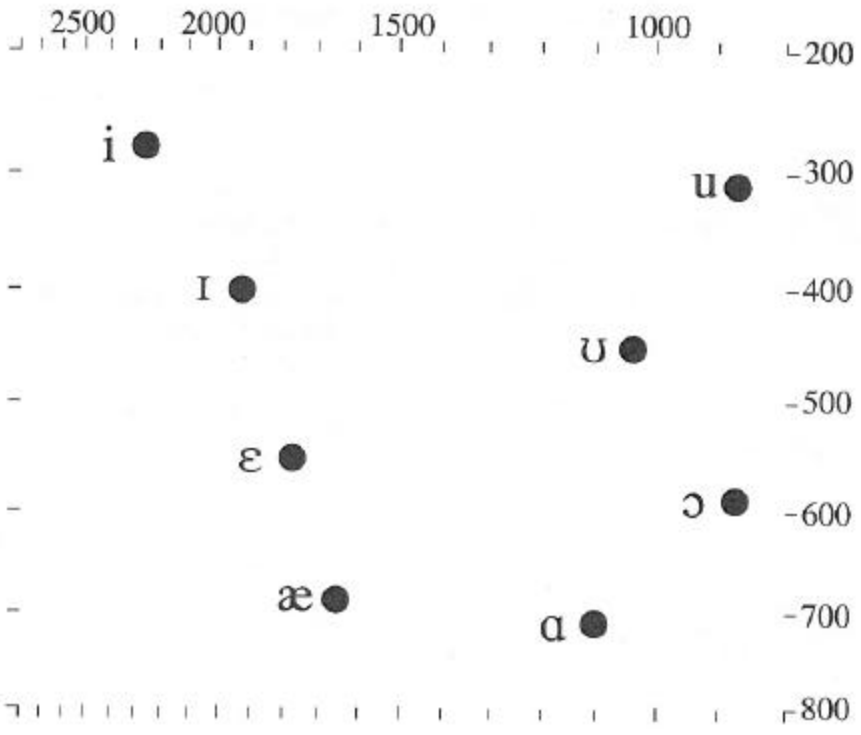
FIGURE 8.6 The frequencies of the first three formants in eight American English vowels.



Listen to speech with only F1, etc.

Characteristic Formants of American English Vowels

FIGURE 8.9 A formant chart showing the frequency of the first formant on the ordinate (the vertical axis) plotted against the second formant on the abscissa (the horizontal axis) for eight American English vowels. The scales are marked in Hz, arranged at Bark scale intervals.



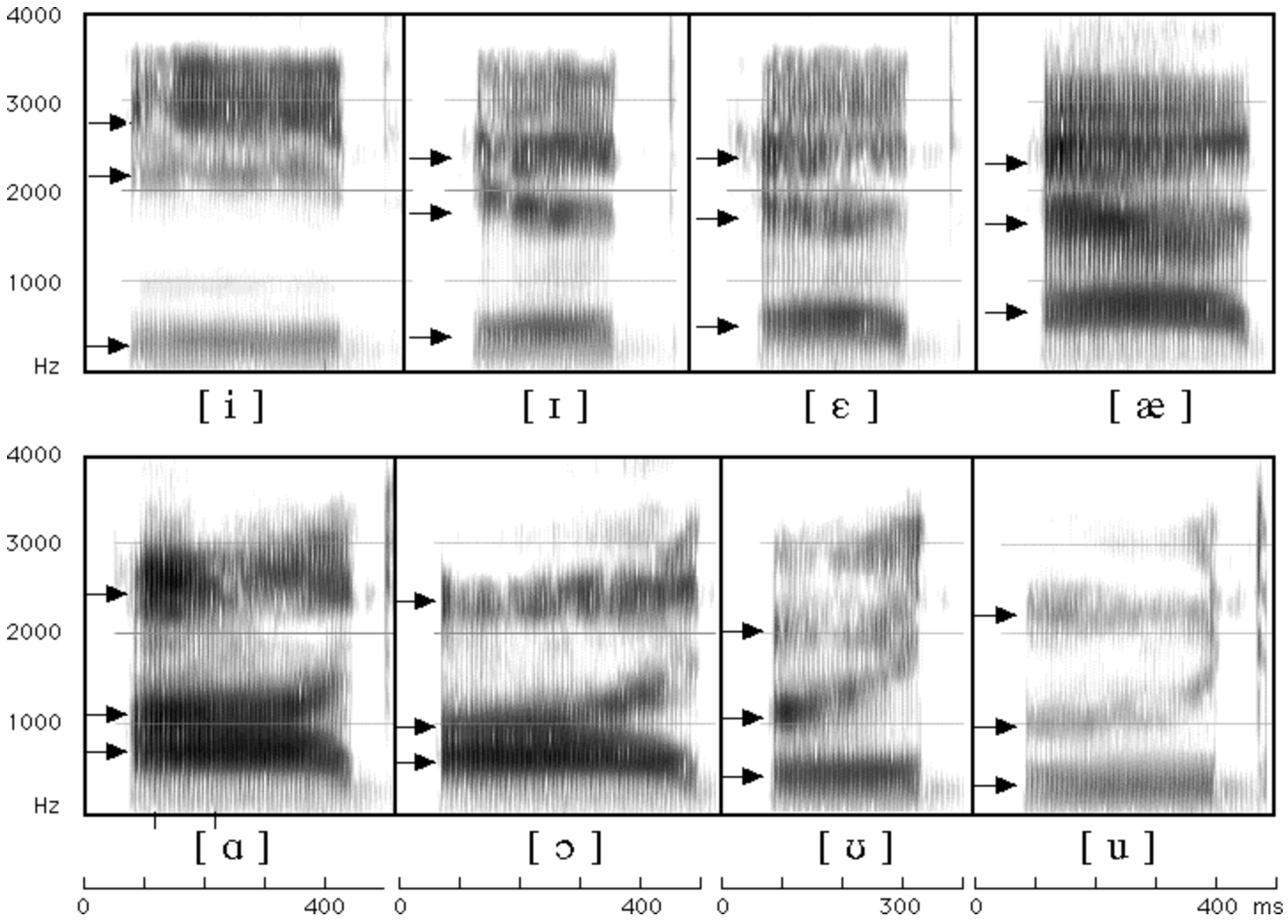
Spectrograms

As we've noted, spectra just show one point in time but speech is a continuous process; sounds change over time (e.g., in diphthongs) and we need to have a way to represent that.

A graphic representation of three dimensions of sounds in terms of their component frequencies is called a **spectrogram**.

In a spectrogram, time is always represented on the x-axis and frequency on the y-axis. Intensity is depicted by the relative darkness of the frequencies shown. The formants (resonant frequencies; the loudest) are the darker bands that correspond to the peaks in the spectra.

Spectrograms of American English Vowels



Source-Filter Theory

Listen to glottal pulse

The **source** of sound for speech is the glottis - air passing through and on the other side of the vibrating vocal folds is excited by the opening and closing movements.

Before it can exit the mouth the air must pass through the vocal tract, which acts as a **filter** (or resonator) that suppresses or damps some frequencies while intensifying others.Which frequencies get damped and which intensified depends on the shape of the vocal tract at a given point in time.

The frequencies that are intensified are the formants that we see on a spectrogram and represent the sounds that resonate the loudest in the particular filter formed by the vocal tract.

The Shape of the Filter

The vocal tract essentially forms a tube that is closed at one end (the glottis) and open at the other (the lips).

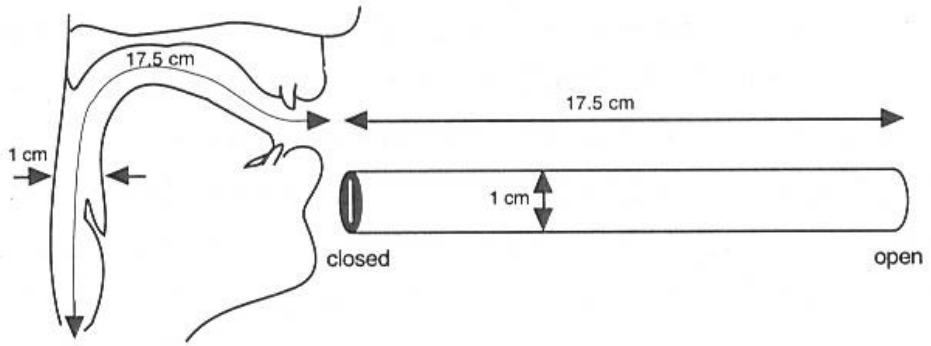


Fig. 8.2. A schematic diagram of a neutral vocal tract in the position for the vowel [ə] on the left, and a simplified version of that shape as a tube closed at one end on the right.

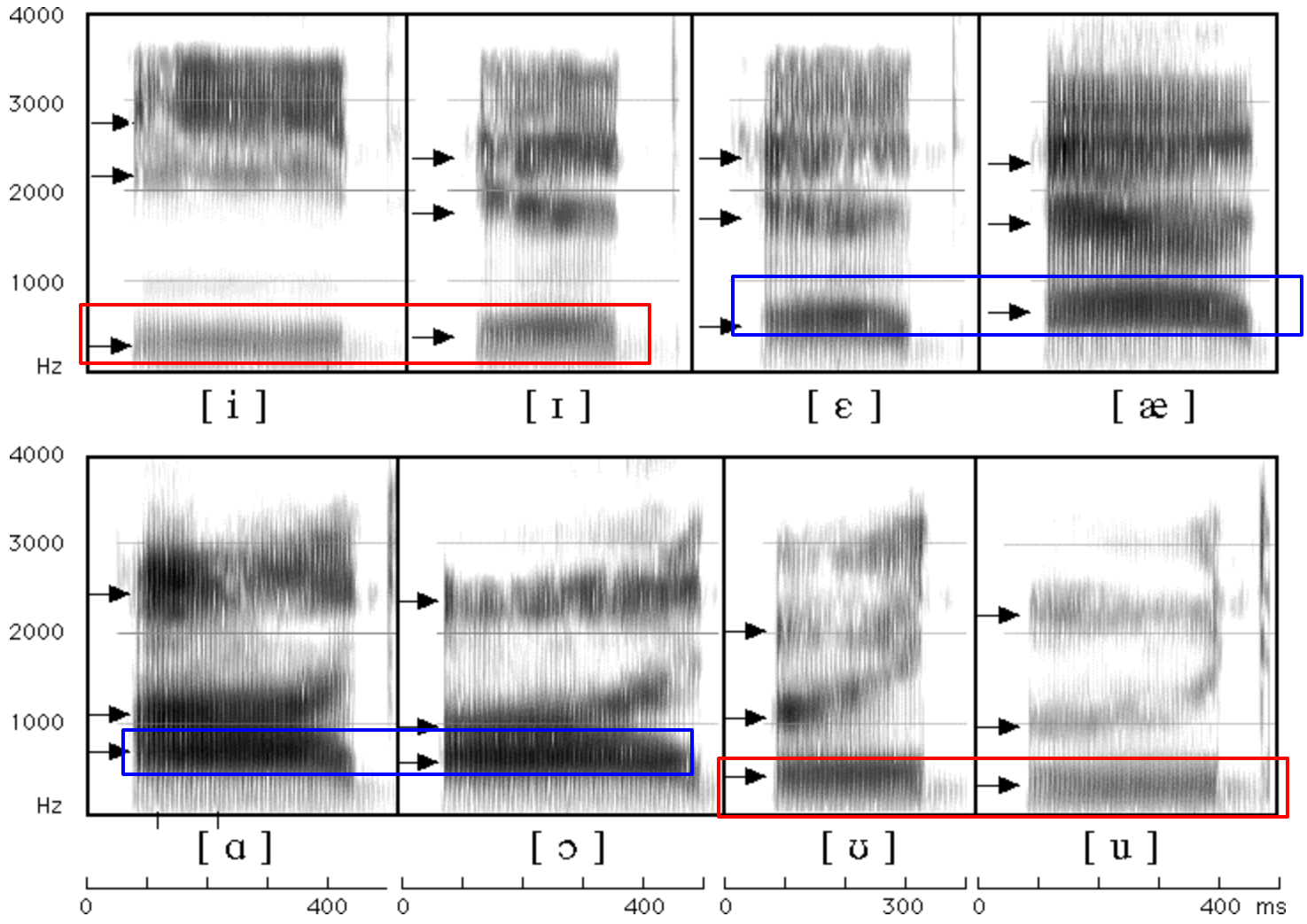
This shape constrains the air in the vocal tract so that it only moves with maximal freedom at one end (the open end) - and is restricted at the other (the closed end,the glottis). See this

Vowel Acoustics

The first formant (F1) in vowels is inversely related to vowel height:

The higher the vowel, the lower the first formant (and vice versa).

High	[i]~[u] ⇨ F1 ≈ 280~310
Mid-high	[ɪ]~[ʊ] ⇨ F1 ≈ 400~450
Mid-low	[ɛ]~[ɔ] ⇨ F1 ≈ 550~590
Low	[æ]~[ɑ] ⇨ F1 ≈ 690~710



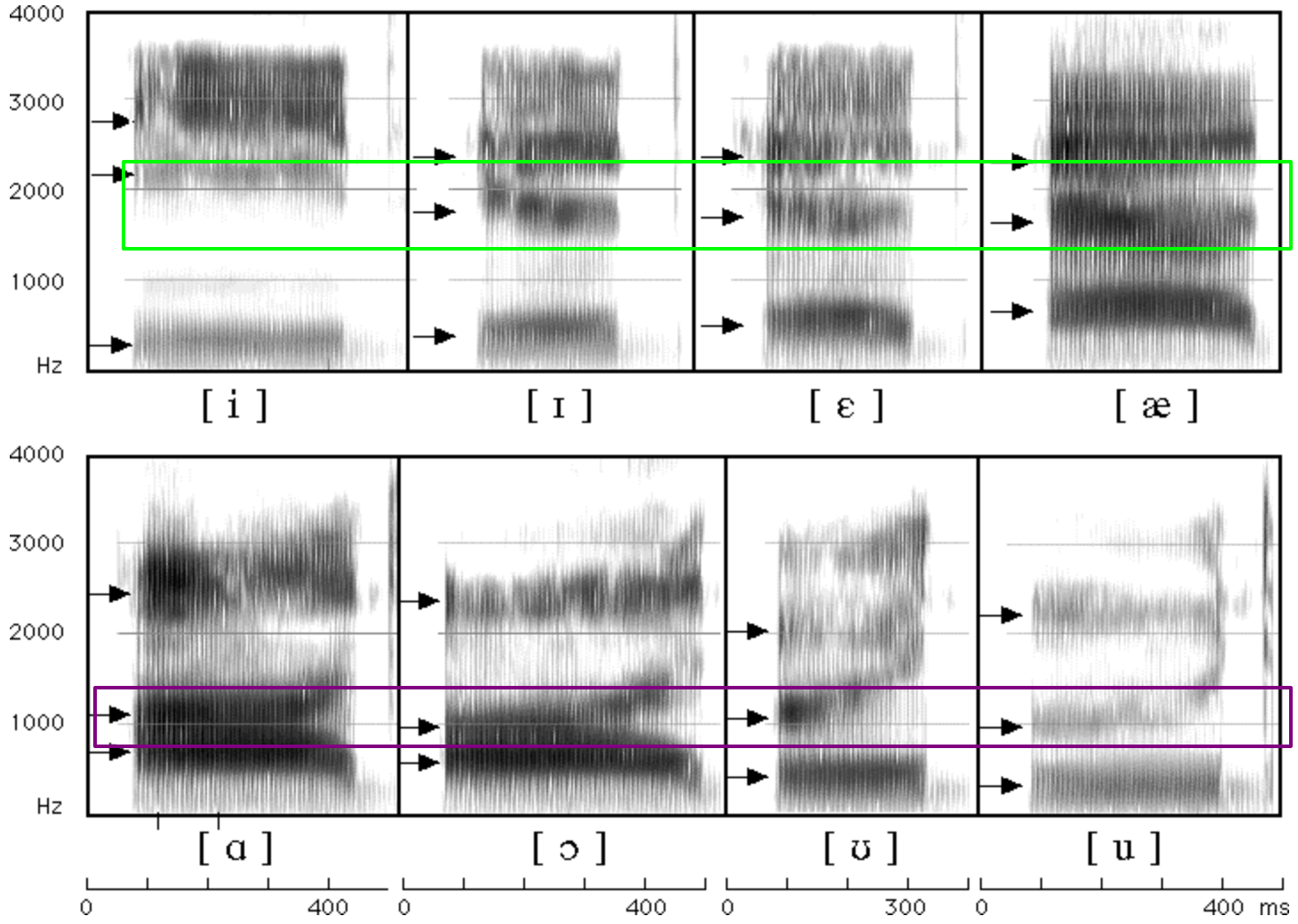
Red = high vowels, low F1 Blue = mid/low vowels, higher F1

Vowel Acoustics

The second formant (F2) in vowels is somewhat related to degree of backness.

The more front the vowel, the higher the second formant (but affected by lip-rounding).

Front		Back	
[i]	~	[u]	⇨ F2 ≈ 2250~ 870
[ɪ]	~	[ʊ]	⇨ F2 ≈ 1920~ 1030
[ɛ]	~	[ɔ]	⇨ F2 ≈ 1770~ 880
[æ]	~	[ɑ]	⇨ F2 ≈ 1660~ 1100



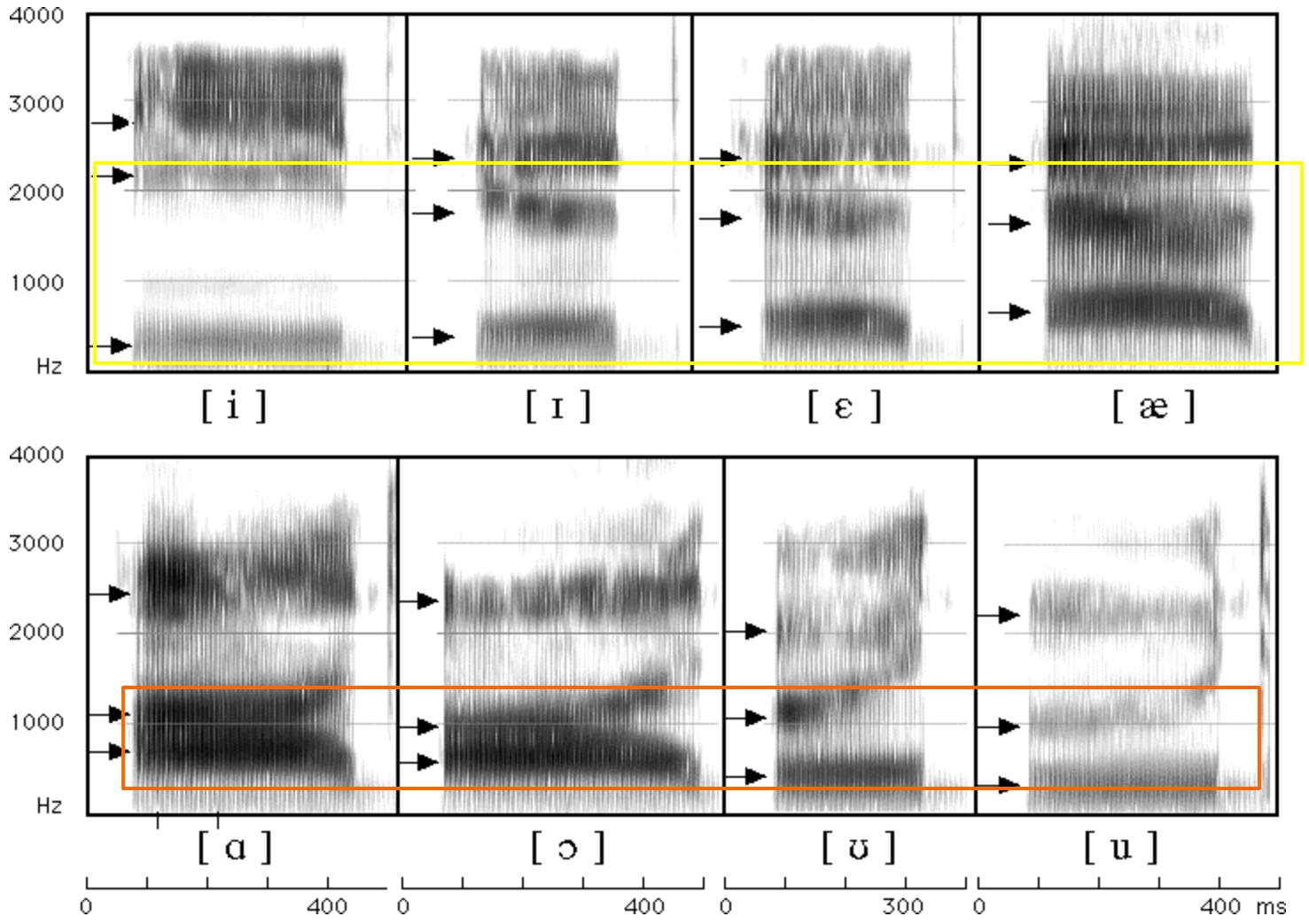
Green = front vowels, higher F2 Purple = back vowels, lower F2

Vowel Acoustics

The distance between F1 and F2 is a better predictor of degree of backness in vowels.

The closer F1 and F2 are to each other, the more back a vowel is.

	F1	F2		F1	F2
[i]	280	2250	[u]	310	870
[ɪ]	400	1920	[ʊ]	450	1030
[ɛ]	550	1770	[ɔ]	590	880
[æ]	690	1660	[ɑ]	710	1100



Yellow = front vowels, further apart F1-F2

Orange = back vowels, closer F1-F2

What's the Vowel?