# Phonetic analysis of vowels (*phân tích của nguyên âm*)

Cơ sở âm vị học và ngữ âm học

Lecture 12

## Recap

- Periodic speech waves are complex: they are made up of a simple waves with different frequencies.
- The various component frequencies (harmonics) in a complex wave can be displayed as a spectrum.

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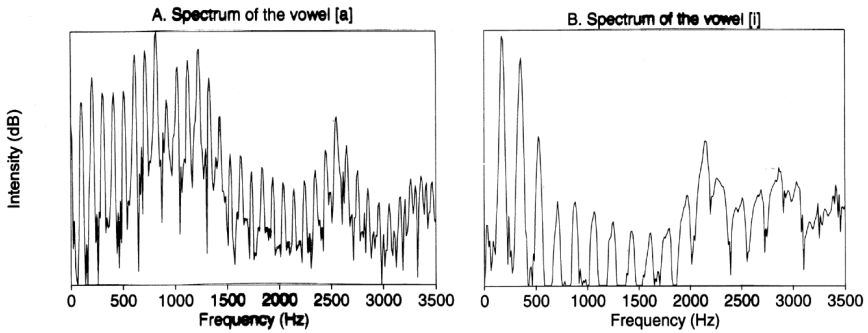
## Recap

- One way in which spectra of speech sounds differ is in the relative intensity of their harmonics.



## Formants

- These relative maxima in the spectra of vowels are called **formants** and reflect the shape of the vocal tract (*hình dáng của đường dẫn âm*).
- Different shapes of the vocal tract, which cause the air to vibrate at different natural frequencies, or **resonances** (*cộng hưởng*)

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## Resonance (*cộng hưởng*)

- When vibration hits a surface, it resonates at a frequency determined by the size of the cavity
  - small cavities resonate at high frequencies (filled bottle)
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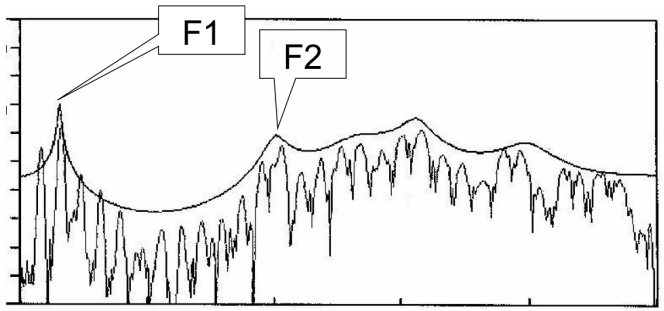
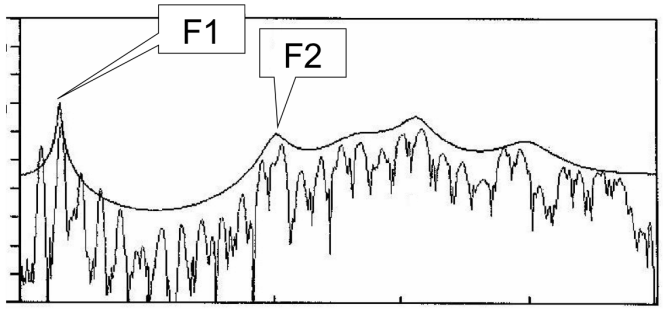



Fourier spectrum of [i], with an LPC spectrum overlaid.

*From Kent & Read (1992) The Acoustic Analysis of Speech.*

- The first formant is **F1** (about 300Hz in [i] and 800Hz in [a]); the second formant is **F2** (about 2100Hz in [i] and 1250Hz in [a]); etc.

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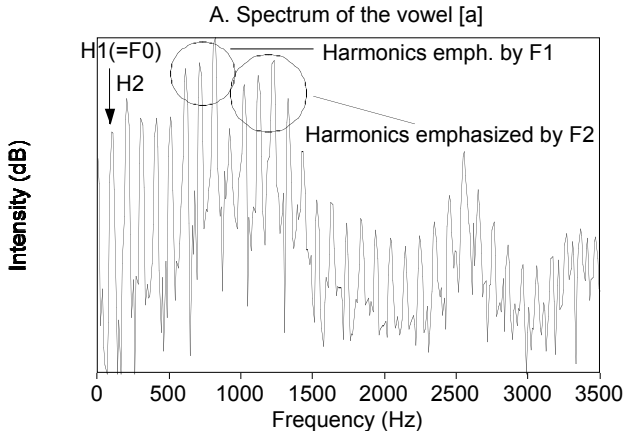
- F1 and F2 play a crucial role in distinguishing vowels; the higher formants are of less importance.

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## Formants ≠ harmonics

- **Harmonics** are whole-number multiples of F0
  – i.e., a function of pitch (F0)
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## How?

- The **source** (*nguồn*) and **filter** (*bộ lọc*) are independent!
- The vocal fold vibrations are the **source** (F0)
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Fant (1960), *Acoustic Theory of Speech Production*

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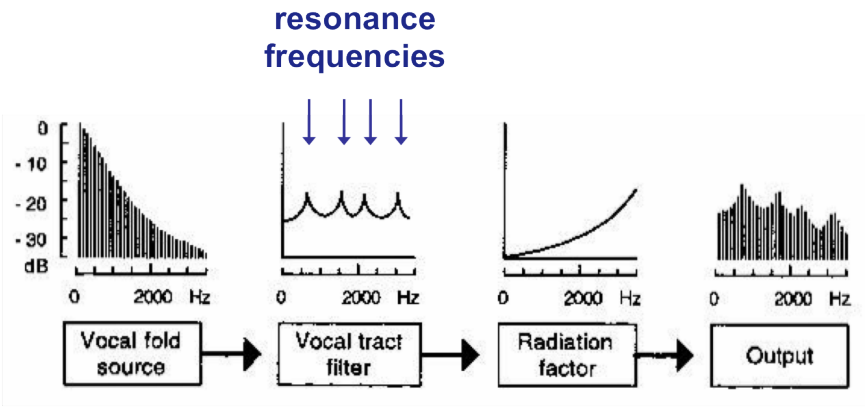
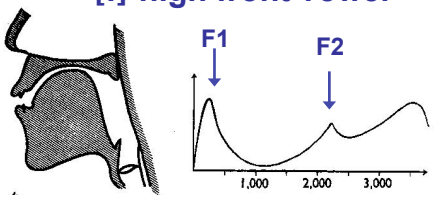
# The source-filter model



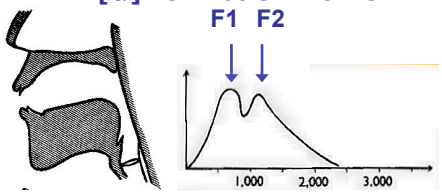

*From Ladefoged (1996) Elements of Acoustic Phonetics.*

# Resonances of the vocal tract

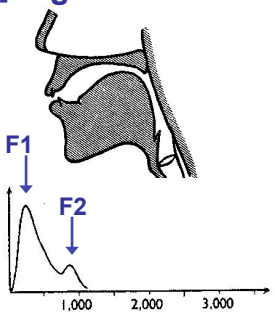
**[i] high front vowel**




**[ɑ] low back vowel**




**[u] high back vowel**

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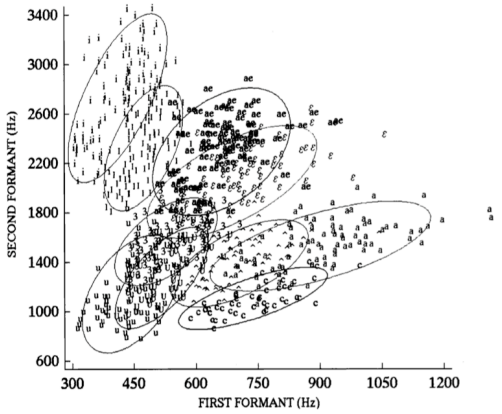
# Visualising the vowel space

- F1 reflects vowel height;
- F2 reflects vowel backness.
- Plotting F1 against F2 for each vowel of a given language provides a detailed representation of the vowel system.

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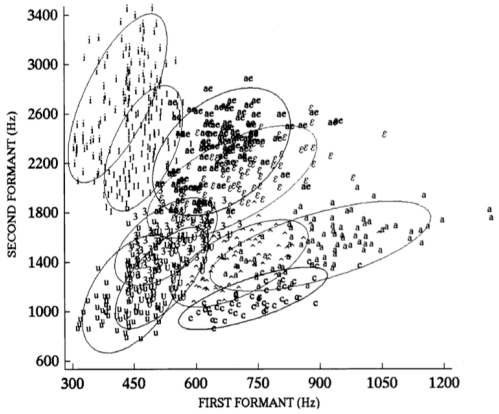


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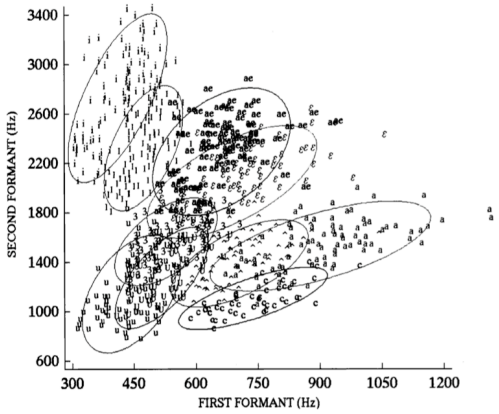


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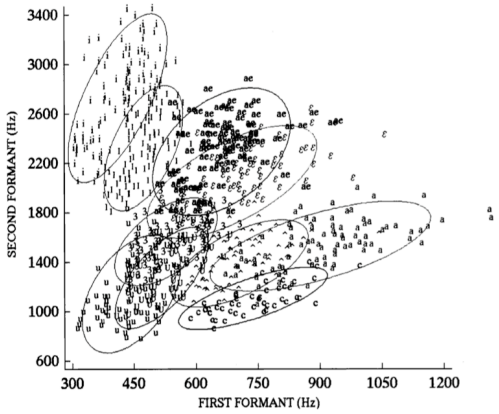


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# "Rules of thumb"

- Tongue **height** is inversely related to F1: the higher the tongue/vowel, the lower the F1 *note: this is actually a lie*
- The more **back** the vowel, the lower the F2 (but other things can lower F2 as well)
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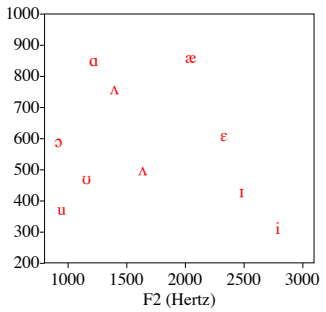
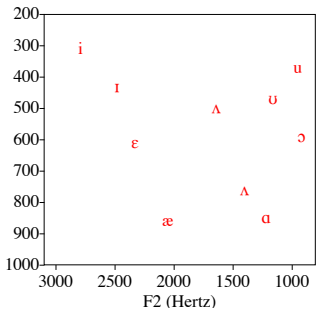
Vowel charts tend to be plotted with inverted axes – why?

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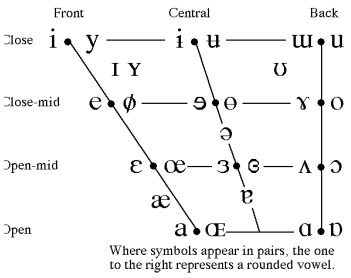
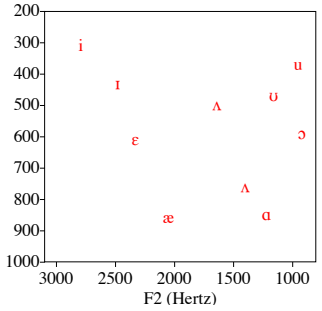
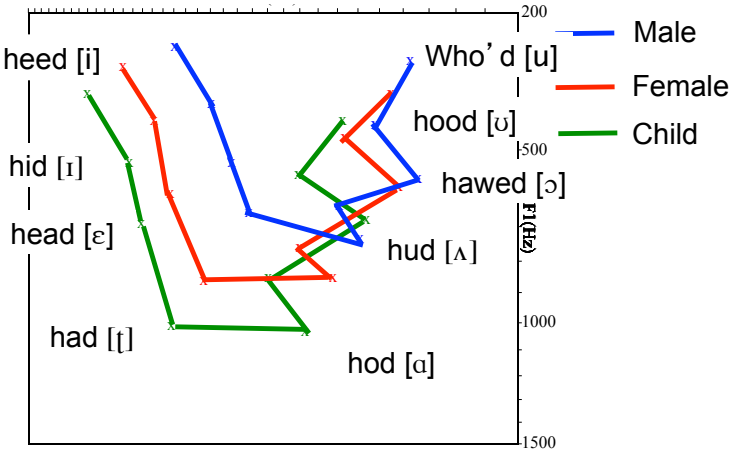



# Men, women, and children

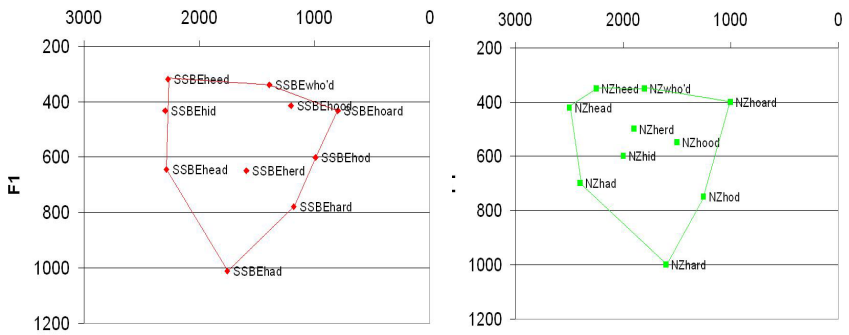
Women tend to produced higher vowels than men – why?




*Vowels of General American English (based on Peterson & Barney, 1952).*

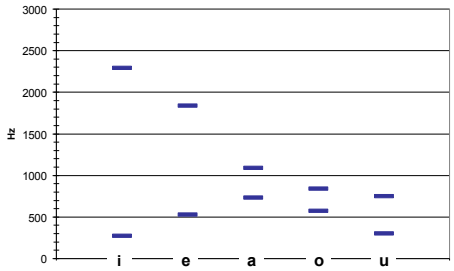
# Dialect variation

Formants can be useful for distinguishing between dialects.

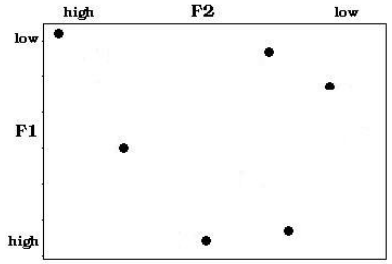



(from Deterding 1997 and Watson et al. 1998)

# Interpreting formants




- Formant frequencies of /i e a o u/




- Can you locate the vowels /i ɛ æ u o ɑ/ ?

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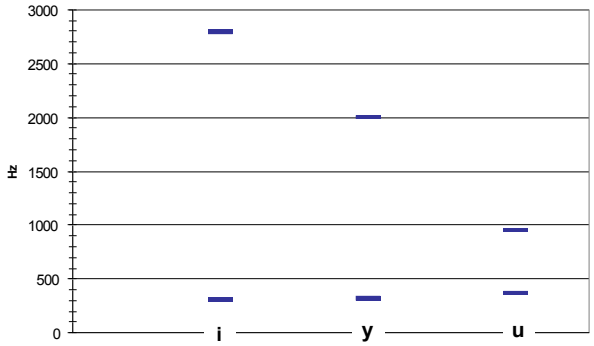


- Where does /ɯ/ fit into this chart?