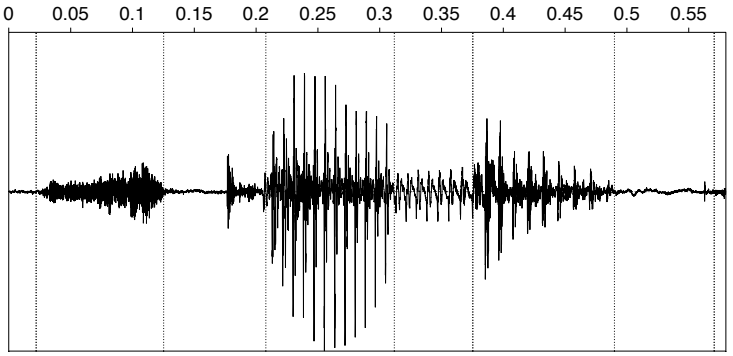
Spectral features of fricatives and stops

Cơ sở âm vị học và ngữ âm học

Lecture 14

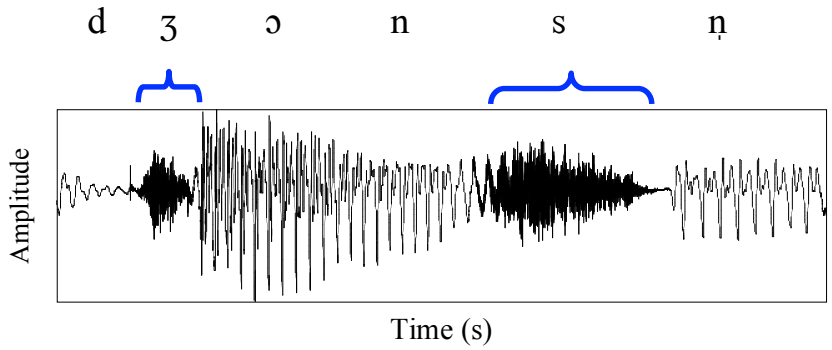
Recap

- In the first lecture we distinguished periodic sounds (same patterns repeats every cycle) from aperiodic sounds (no regularity in the pattern of air perturbations).



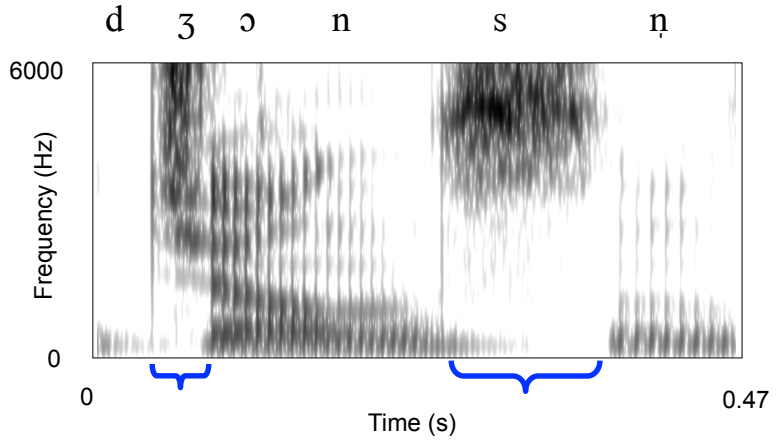
Fricatives

- Sound source: aperiodic noise → random pattern in the waveform. (*không theo mô hình*)



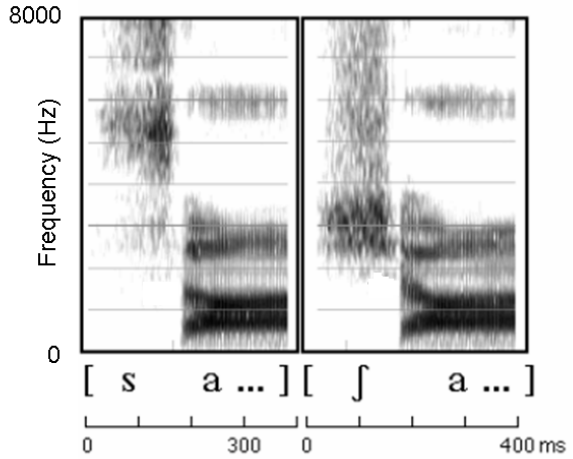
Fricatives

- In a spectrogram, fricatives feature energy over a wide frequency range.



Voiceless fricatives

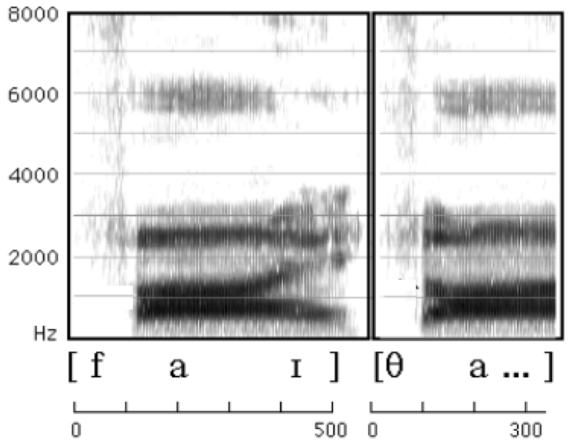
- The further back the constriction, the longer the front cavity, and the lower the peak in spectral energy.



From Ladefoged (2006), A Course in Phonetics

Voiceless fricatives

- For [f θ] there is less filter → weaker energy



From Ladefoged (2006), A Course in Phonetics

Voiceless fricatives: overview

- [s] and [ʃ] have stronger energy because they are sibilants (*âm xuýt*) – the air encounters a sharp obstacle (e.g., edge of teeth)

	Location of energy maximum	độ năng lượng
[f]	between 3 and 4 kHz	weak
[θ]	above 8 kHz	weak
[s]	between 5 and 10 kHz	strong
[ʃ]	between 3 and 5 kHz	strong

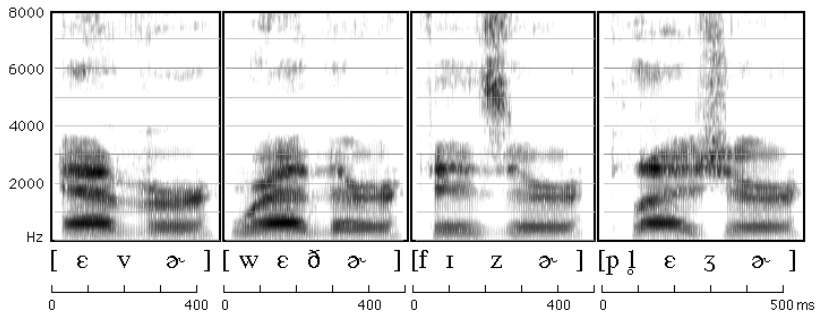
Voiceless fricatives: overview

- For [f θ] the constriction is in the front of the oral cavity, so there is hardly any vocal tract in front of the constriction to filter the sound!

	Location of energy maximum	Energy strength
[f]	between 3 and 4 kHz	weak
[θ]	above 8 kHz	weak
[s]	between 5 and 10 kHz	strong
[ʃ]	between 3 and 5 kHz	strong

Voiced fricatives

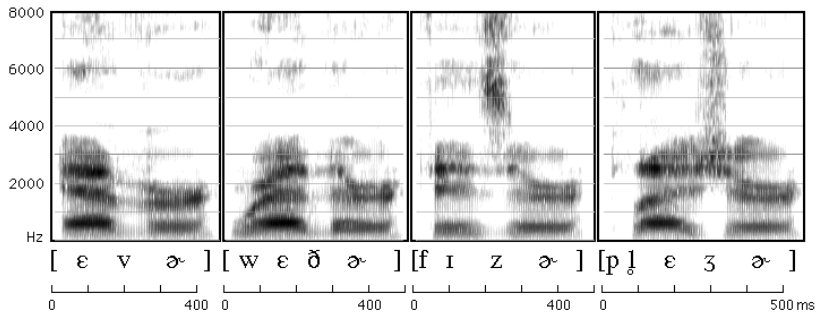
- [v ð z ʒ] are spectrally similar to [f θ s ʃ], but with striations/voicing bar and weaker frication.



From Ladefoged (2006), A Course in Phonetics

Voiced fricatives

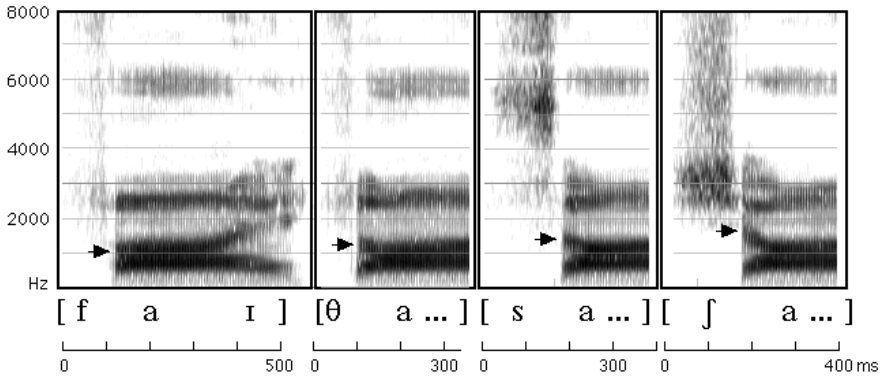
- Voiced fricatives (x-linguistically rare) are difficult to produce, and are frequently voiceless or 'partially voiced'



From Ladefoged (2006), A Course in Phonetics

Other clues

- What (else) distinguishes these fricatives?



From Ladefoged (2006), A Course in Phonetics

[h]

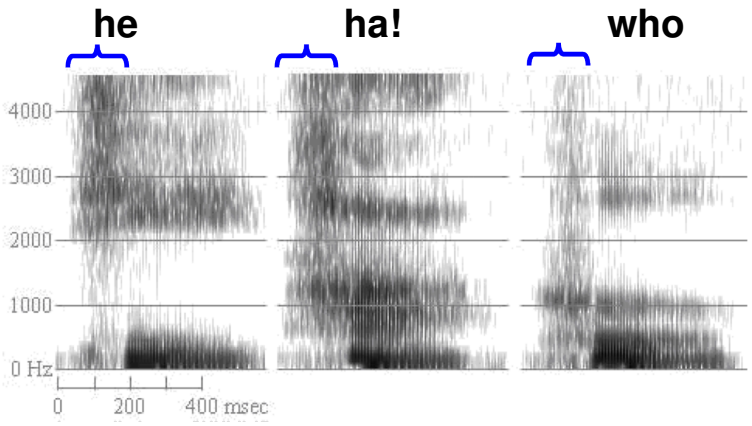
- Listed as a fricative in the IPA chart, but actually...
- The source of sound is not air being forced through a narrow opening, but instead caused by air rushing through the open vocal folds and vocal tract
- This is the same sound source as whispered speech

[h]

- Listed as a fricative in the IPA chart, but actually...
- The source of sound is not air being forced through a narrow opening, but instead caused by air rushing through the open vocal folds and vocal tract
- This is the same sound source as whispered speech

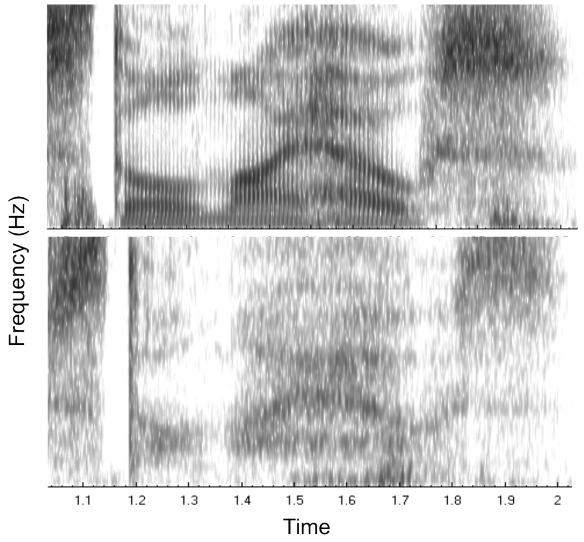
[h]

- Listed as a fricative in the IPA chart, but actually...
- The source of sound is not air being forced through a narrow opening, but instead caused by air rushing through the open vocal folds and vocal tract
- This is the same sound source as whispered speech



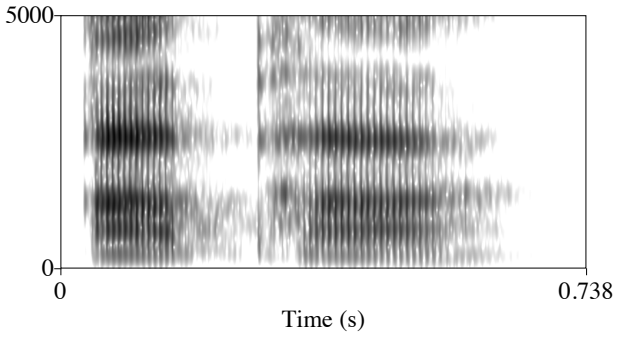
From http://home.cc.umanitoba.ca/$\sim$robh/howto.html#intro

‘Stole my house’



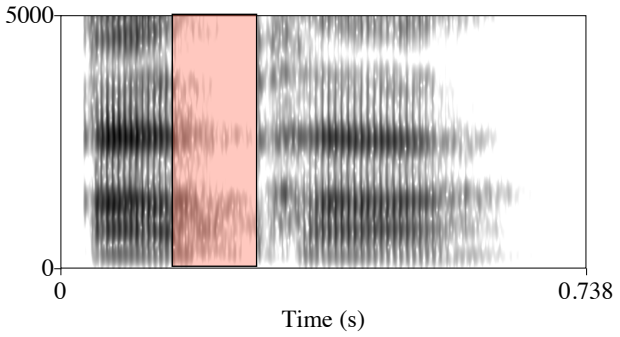
Stops

- Stops consist of **two** parts: a closure and a noise burst.



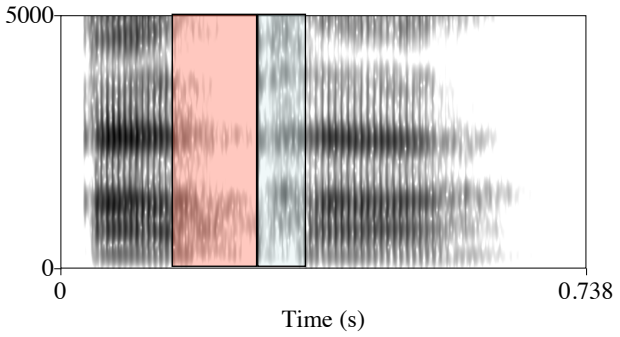
Stops

- Stops consist of **two** parts: a closure and a noise burst.



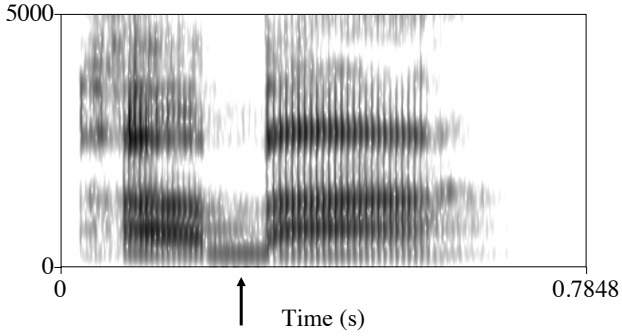
Stops

- Stops consist of **two** parts: a closure and a noise burst.



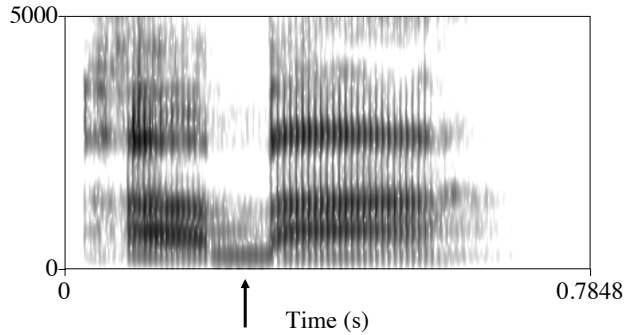
Voiced stops

- In voiced stops, we see a 'voice bar' during the closure
- these are weak striations at the low end of the frequency scale (because the mouth is still closed).



Voiced stops

- In voiced stops, we see a 'voice bar' during the closure
- these are weak striations at the low end of the frequency scale (because the mouth is still closed).



Voiced stops [b d g]

- The **burst** of voiced stops often does not appear clearly in a spectrogram
- If closure and burst are similar for all voiced stops, how do we distinguish e.g. [b] from [d]?

Voiced stops [b d g]

- The **burst** of voiced stops often does not appear clearly in a spectrogram
- If closure and burst are similar for all voiced stops, how do we distinguish e.g. [b] from [d]?

Formant transitions

- At the moment the stop constriction is released, the resonances of the vocal tract filter change very rapidly.
- These changes are called **formant transitions**.
- Formant transitions are extremely important perceptual cues to phonetic contrasts.

Formant transitions

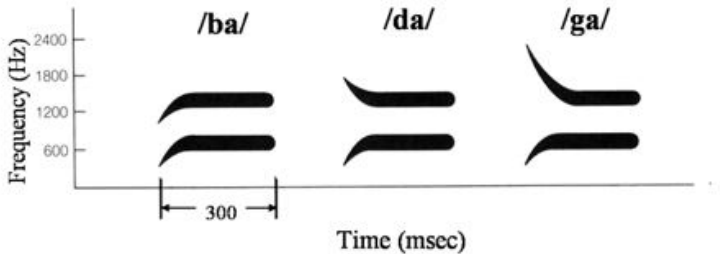
- In fact, work from speech synthesis shows you can't understand speech without the formant transitions – even though they only average about 50ms in duration.
- What does this mean for the conception of words as strings of phone[mes]?

Formant transitions

- In fact, work from speech synthesis shows you can't understand speech without the formant transitions – even though they only average about 50ms in duration.
- What does this mean for the conception of words as strings of phone[mes]?

Formant transitions

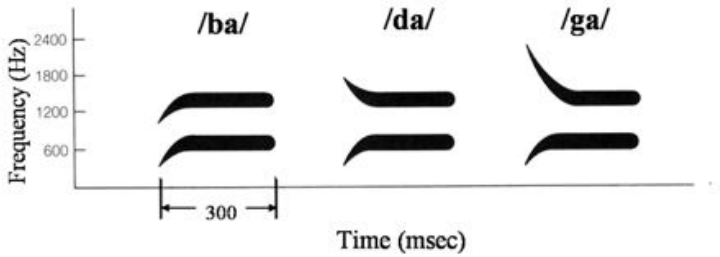
- F1 always rises after a stop.



http://www.cns.nyu.edu/ david/courses/perception/lecturenotes/speech/speech.html

Formant transitions

- The direction of F2 and F3 formant transitions depend on the particular constriction producing the stop (lips, tongue tip, tongue body).



http://www.cns.nyu.edu/ david/courses/perception/lecturenotes/speech/speech.html

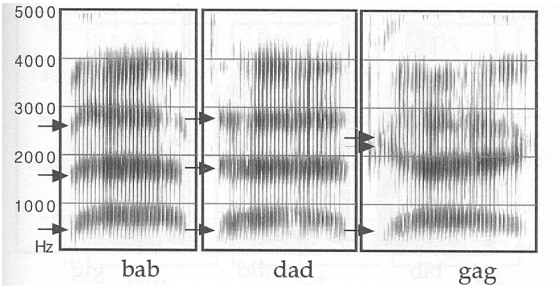
Formant transitions

- Formant transitions at the start of the vowel following a voiced stop (reverse for vowels preceding voiced stop):

	F2	F3
[b]	rises	rises
[d]	~level	falls
[g]	falls	rises

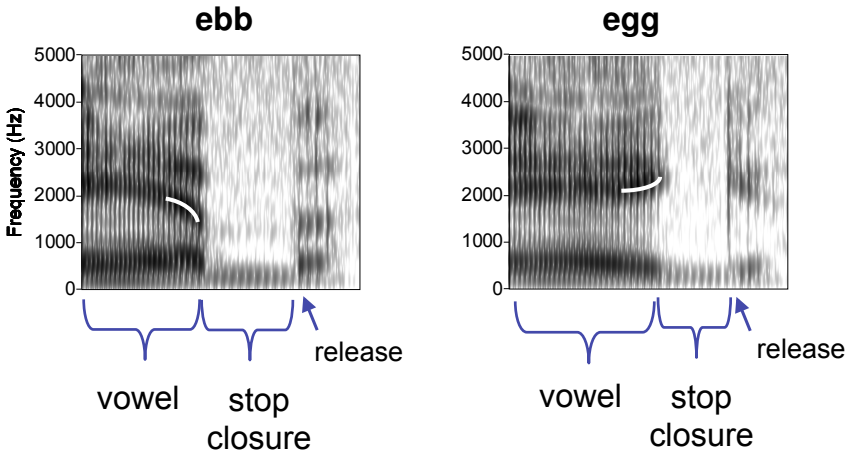
Formant transitions

- Formant transitions at the start of the vowel following a voiced stop (reverse for vowels preceding voiced stop):



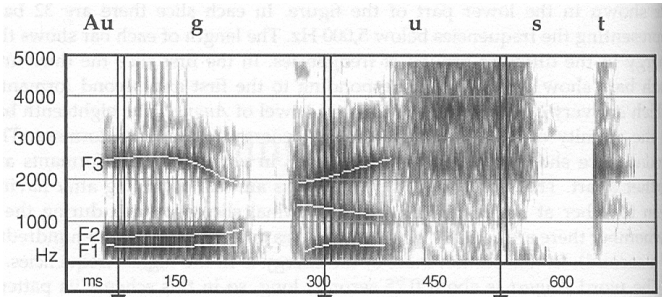
From Ladefoged (2001)

ebb vs. egg



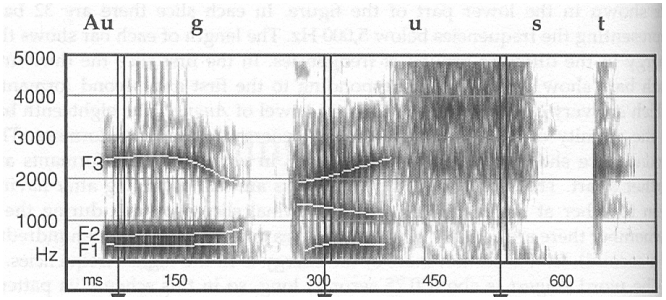
Velar stops [k] [g]

- Velars are relatively easy to spot due to the 'velar pinch' of F2 and F3.



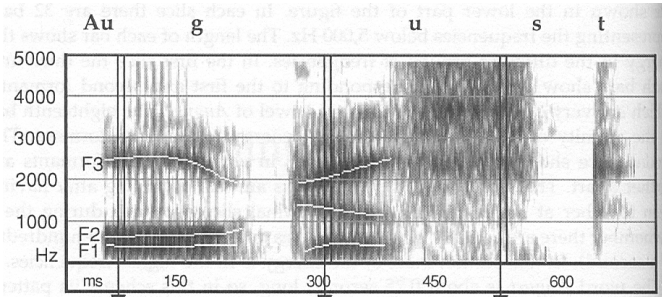
Velar stops [k] [g]

- Formant transitions for [g] tend to be longer for other stops – tongue body is also involved in vowel formation.



Velar stops [k] [g]

- The place of constriction for velar stops can vary – why?



Voiceless stops [p] [t] [k]

- In voiceless stops, the movement of lips and tongue take place *during* the burst, prior to the onset of voicing.
- Therefore these movements are not as clearly reflected in formant transitions/spectrograms
- A more reliable cue to the place feature for voiceless stops is the noise burst.

Voiceless stops [p] [t] [k]

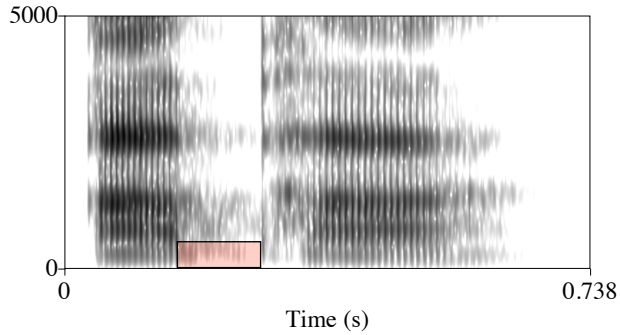
- In voiceless stops, the movement of lips and tongue take place *during* the burst, prior to the onset of voicing.
- Therefore these movements are not as clearly reflected in formant transitions/spectrograms
- A more reliable cue to the place feature for voiceless stops is the noise burst.

Voiceless stops [p] [t] [k]

- In voiceless stops, the movement of lips and tongue take place *during* the burst, prior to the onset of voicing.
- Therefore these movements are not as clearly reflected in formant transitions/spectrograms
- A more reliable cue to the place feature for voiceless stops is the noise burst.

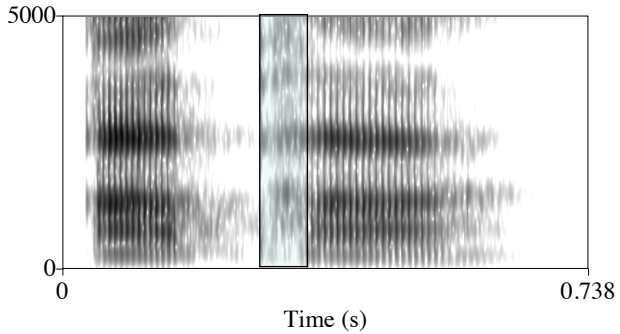
Voiceless stops [p] [t] [k]

- The closure is devoid of voicing bar activity...



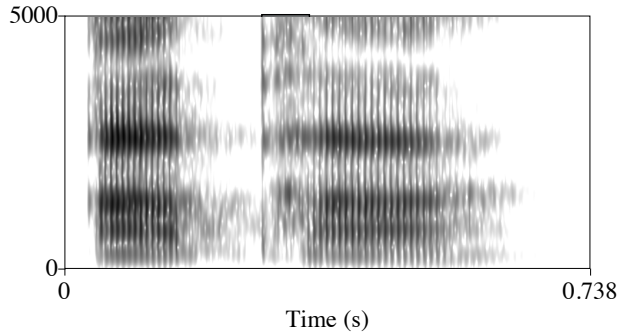
Voiceless stops [p] [t] [k]

- ...and the burst can be clearly seen in the spectrogram.

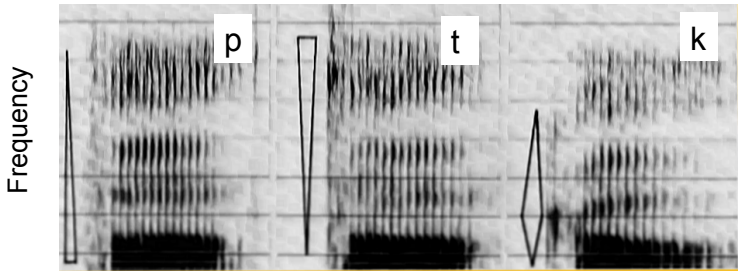


Voiceless stops [p] [t] [k]

- However, not all bursts are created equal.



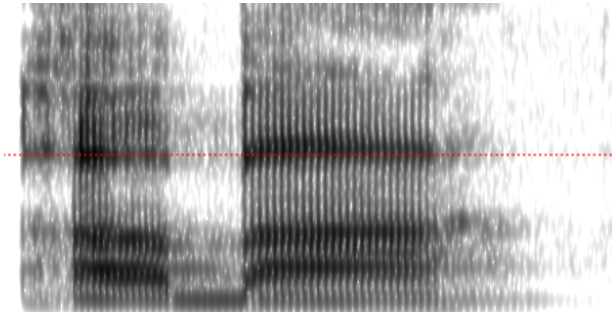
	Energy location	Energy strength	Length of burst
[p]	wide range	faint	short
[t]	mostly $>$ 4 kHz	strong	long
[k]	mostly $<$ 4 kHz	strong	longest



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

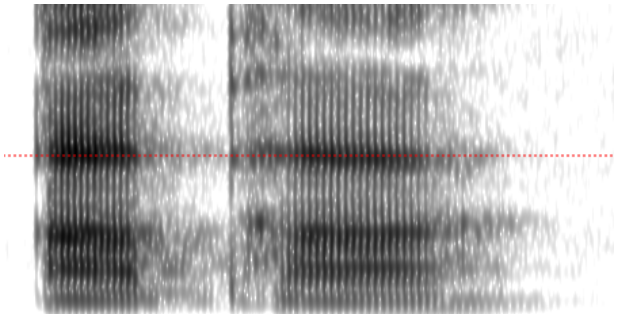
Voiced vs. voiceless stops

aba



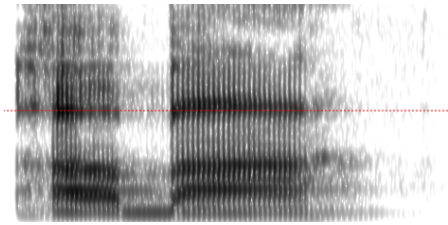
Voiced vs. voiceless stops

ap^{h}a

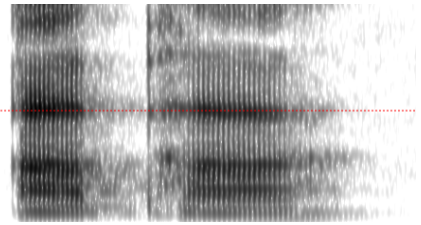


Voiced vs. voiceless stops

aba

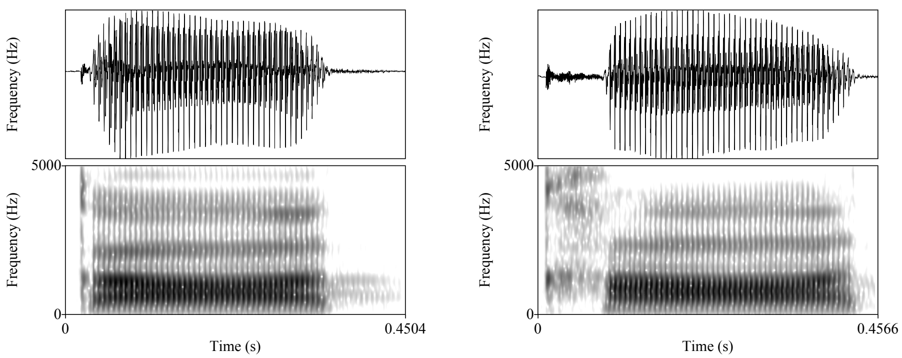


ap^{h}a

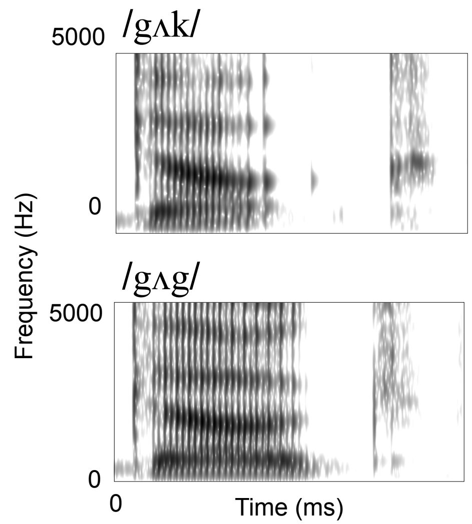


Voiced vs. voiceless stops

[kɑɑ] ‘neck’ **[kʰɑɑ]** ‘donkey’

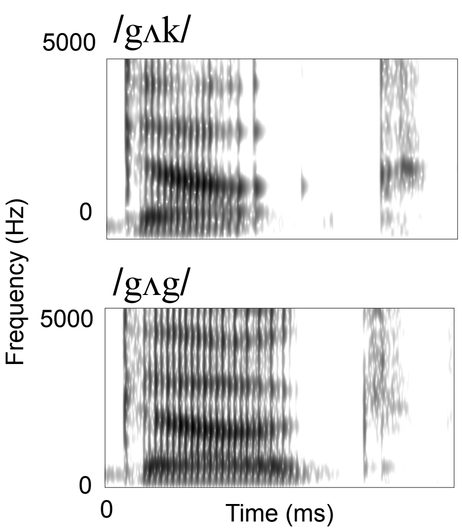


Other cues



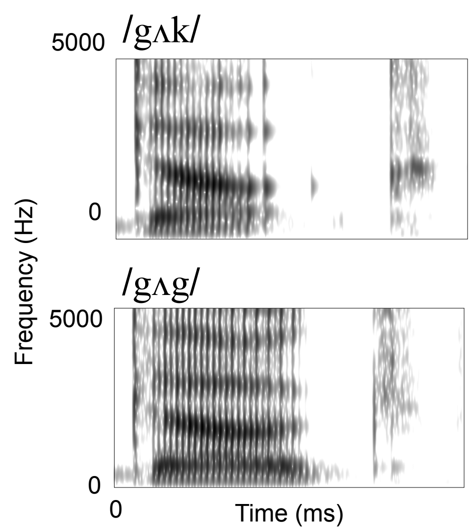
- closure duration
- voicing during closure
- duration of preceding vowel

Other cues



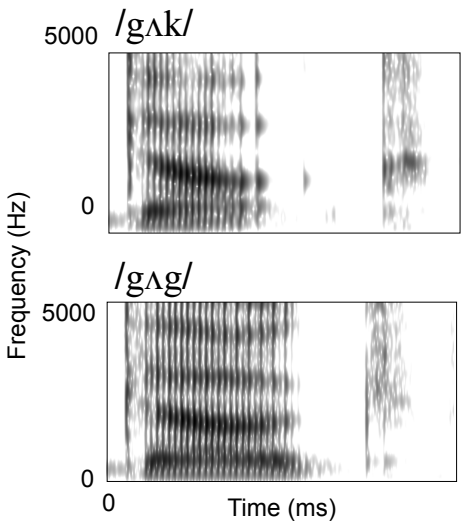
- closure duration
- voicing during closure
- duration of preceding vowel

Other cues



- closure duration
- voicing during closure
- duration of preceding vowel

Other cues



- closure duration
- voicing during closure
- duration of preceding vowel

Spectrogram practice

- Ladefoged course website:
  http:
  //www.phonetics.ucla.edu/course/chapter8/figure8.html
- More spectrograms:
  http://home.cc.umanitoba.ca/~robh/howto.html

Spectrogram practice

- Ladefoged course website:
  http:
  //www.phonetics.ucla.edu/course/chapter8/figure8.html
- More spectrograms:
  http://home.cc.umanitoba.ca/~robh/howto.html