

# Phonetics, phonology, and spectrograms

"Sounds and Language" 🎵 Chelsea Voss (csvoss@mit.edu), Splash! 2013

**Part 1: Phonology.** Below is a chart of the International Phonetic Alphabet (IPA).  
Not all of these sounds are used by English! Which vowels and consonants are?

## the international phonetic alphabet (2005)

consonants (pulmonic)	LABIAL		CORONAL				DORSAL				RADICAL		LARYNGEAL
	Bilabial	Labio-dental	Dental	Alveolar	Palato-alveolar	Retroflex	Alveolo-palatal	Palatal	Velar	Uvular	Pharyngeal	Epi-glottal	Glottal
Nasal	m	ɱ	n			ɳ	ɲ		ŋ	ɴ			
Plosive	p b		t d			ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ	ʕ	
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ	ʕ	ħ ʕ	h ɦ
Approximant		ʋ	ɹ			ɻ	j	ɰ					
Tap, flap		ⱱ	ɾ			ɽ							
Trill	ʙ		r									ʀ	
Lateral fricative			ɬ ɮ		ɮ	ɬ	ɮ	ɮ					
Lateral approximant			ɭ		ɭ		ɭ	ɭ					
Lateral flap			ɺ		ɺ								

Where symbols appear in pairs, the one to the right represents a modally voiced consonant, except for murmured ɦ.  
Shaded areas denote articulations judged to be impossible. Light grey letters are unofficial extensions of the IPA.

### consonants (non-pulmonic)

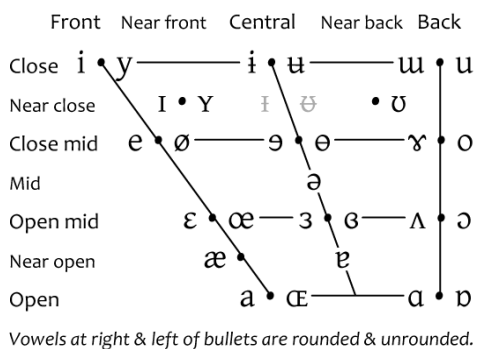
clicks	implosives	ejectives
⊙ Bilabial fricated	ɓ Bilabial	ʼ examples:
Laminar alveolar fricated ("dental")	ɗ Dental or alveolar	pʼ Bilabial
! Apical (post)alveolar abrupt ("retroflex")	ɖ Retroflex	tʼ Dental or alveolar
!! Subapical retroflex	ɟ Palatal	kʼ Velar
‡ Laminar postalveolar abrupt ("palatal")	ɠ Velar	tʃʼ Lateral affricate
Lateral alveolar fricated ("lateral")	ɡ Uvular	sʼ Alveolar fricative

### consonants (co-articulated)

- ɱ Voiceless labialized velar approximant //morphophonemic//
- ʋ Voiced labialized velar approximant /phonemic/
- ɰ Voiced labialized palatal approximant [phonetic]
- ħ Simultaneous x and f (existence disputed) <orthographic>
- ɬɰ Affricates and double articulations
- ɡ̊ may be joined by a tie bar

### brackets

### vowels



### suprasegmentals

- ˈ Primary stress
- ˌ Secondary stress [ˈfoʊnəˈtɪʃən]
- eː Long
- e Short
- Syllable break
- ˌ intonation
  - | Minor (foot) break
  - || Major (intonation) break
- ↗ Global rise
- ↘ Global fall

### (tone)

- level tones
  - é ˩ Top
  - é ˨ High
  - ē ˩ Mid
  - è ˩ Low
  - è ˩ Bottom
- contour tones (e.g.)
  - ě ˩ Rising
  - ê ˩ Falling
  - ě ˩ High rising
  - è ˩ Low rising
  - ē ˩ High falling
  - ê ˩ Low falling
  - ˩ Upstep
  - ˩ Downstep
  - ě ˩ Peaking
  - ě ˩ Dipping
- tone terracing
  - ˩ Upstep
  - ˩ Downstep

### diacritics

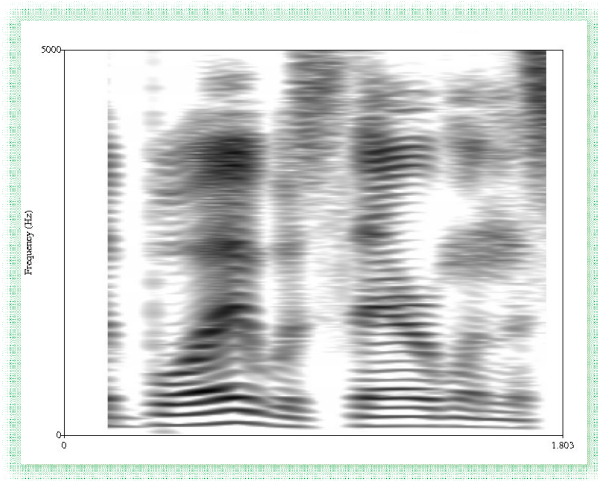
Diacritics may be moved to fit a letter, as ɲ̥ or ɻ̥. Other letters may be used as diacritics of phonetic detail: ʔʰ (fricative release), bʰ (breathy voice), mʷ (glottalized), ə̤ (epenthetic schwa), oʷ (off-glide), uʷ (compressed).

SYLLABICITY & RELEASES		PHONATION		PRIMARY ARTICULATION		SECONDARY ARTICULATION			
ɲ̥ ɲ̥	Syllabic	ɲ̥ ɲ̥	Voiceless or Slack voice	ɲ̥ ɲ̥	Dental	tʷ dʷ	Labialized	ɔ̞ ɔ̞	More rounded
e̞ ʊ̞	Non-syllabic	ɣ̞ ɣ̞	Modal voice or Stiff voice	ɲ̥ ɲ̥	Apical	tʲ dʲ	Palatalized	ɔ̞ ɔ̞ʷ	Less rounded
tʰ h̥	(Pre)aspirated	ɲ̥ ɲ̥	Breathy voice	ɲ̥ ɲ̥	Laminar	tʰ dʰ	Velarized	ẽ ẽ	Nasalized
d̥	Nasal release	ɲ̥ ɲ̥	Creaky voice	ɲ̥ ɲ̥	Advanced	tʰ dʰ	Pharyngealized	ɔ̞ ɔ̞	Rhoticity
d̥	Lateral release	ɲ̥ ɲ̥	Strident	ɲ̥ ɲ̥	Retracted	ɬ ɮ	Velarized or pharyngealized	ɔ̞ ɔ̞	Advanced tongue root
t̥	No audible release	ɲ̥ ɲ̥	Linguolabial	ä̞ j̞	Centralized	ũ̞	Mid-centralized	ɔ̞ ɔ̞	Retracted tongue root
e̞ β̞	Lowered (β̞ is a bilabial approximant)	e̞ ɹ̞	Raised (ɹ̞ is a voiced alveolar non-sibilant fricative, ɹ̞ a fricative trill)	e̞ ɹ̞					

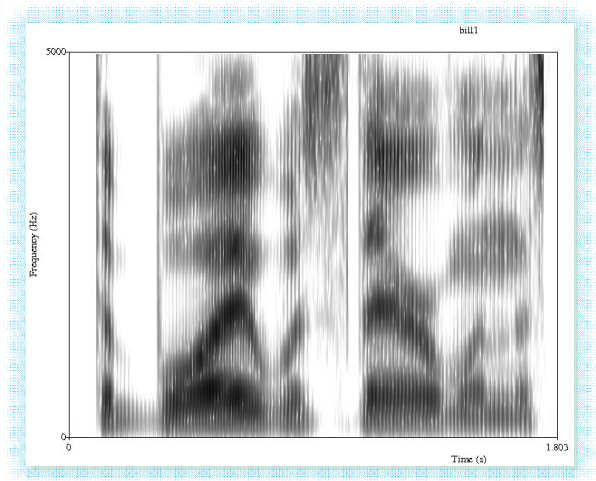
Part 2: How sound works.

Part 3: Spectrograms! A tool for looking at sounds.

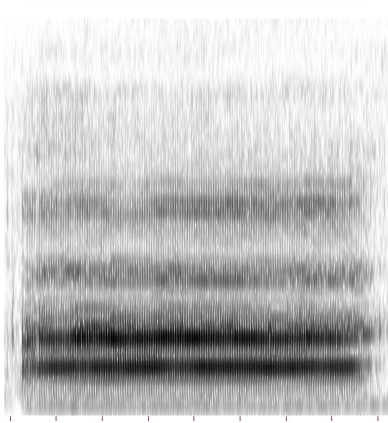
**Narrowband:** This is what we've seen so far.  
**Better frequency resolution.**  
**Worse time resolution.**



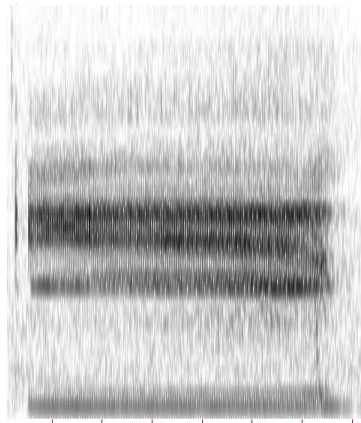
**Broadband:** Almost everything else for the rest of the class.  
**Better time resolution.**  
**Worse frequency resolution.**



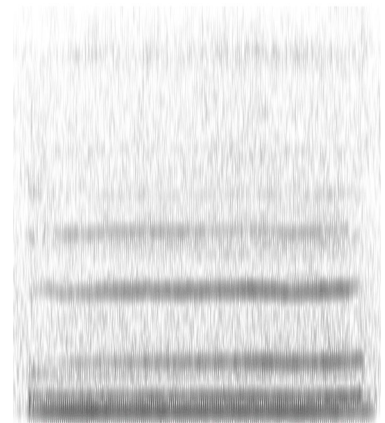
Part 4: Phonetics – vowels and consonants



/a/ "ahh"



/i/ "eeh"

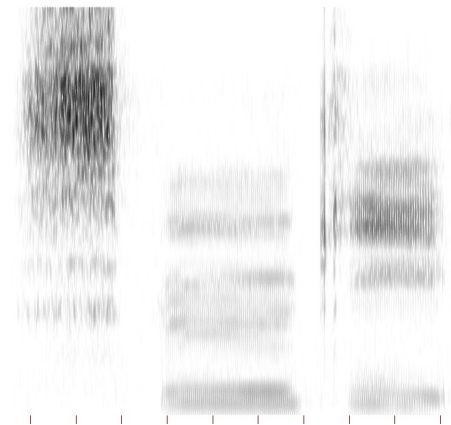
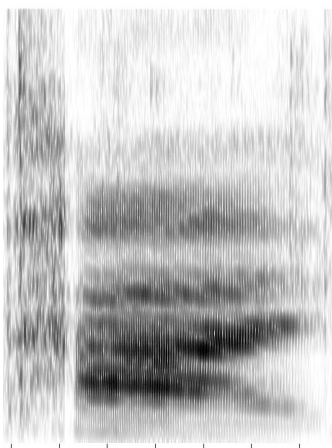
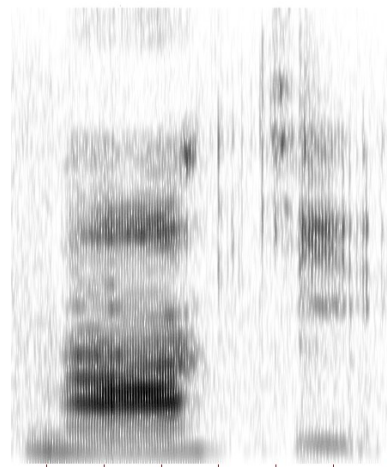
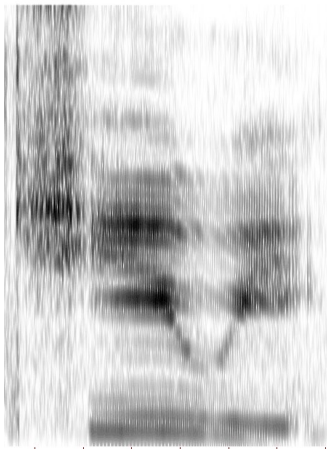


/u/ "ooh"

Spectrograms for five words are given in scrambled order here. Match them!

spooky, maki, kiwi, pie

*Useful note: I pronounced the 'k' in 'maki' a bit too quietly*



[Problem adapted from "The Whole Spectrum," NACLO 2008]

# *Spectrograms: a puzzle*

## Background

The sounds of human speech (and indeed all sounds) travel through the air in waves, some of which your ear detects as sounds. These waves can be analyzed (by a mathematical technique called "Fourier analysis") into combinations of basic ("sinusoidal") waves whose most important properties are "frequency" and "amplitude". One sound may comprise many such basic waves, and a basic wave of the same frequency or amplitude may appear in many sounds. Linguists sometimes display this analysis on a diagram called a spectrogram: the resulting sine waves' frequencies are plotted vertically (with greater amplitude indicated by darker points) and the time horizontally.

## Data

A sequence of spectrograms produced using the computer software Praat is shown in the following pages. The first 12 are each labeled with an English word for you, which is shown in the spectrograms. These 12 words are given:

**sash, lamb, knee, sheesh, soup, pang, loose, (the letter) e, mice, ice, coo, shine**

The last four spectrograms each show one of the following eight words:

**louse, lass, lease, lice, pass, ash, sheep, lack**

## Problems.

1. Which words are shown in the last four spectrograms?

Spectrogram 13:

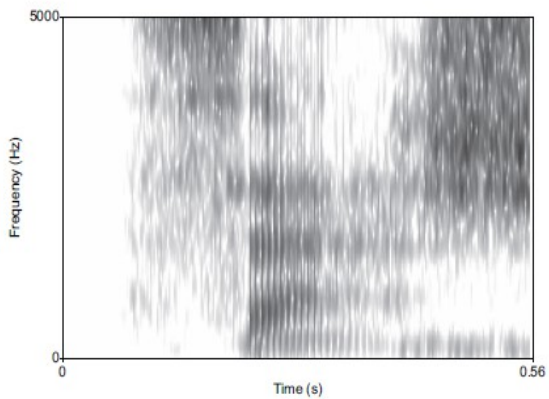
Spectrogram 14:

Spectrogram 15:

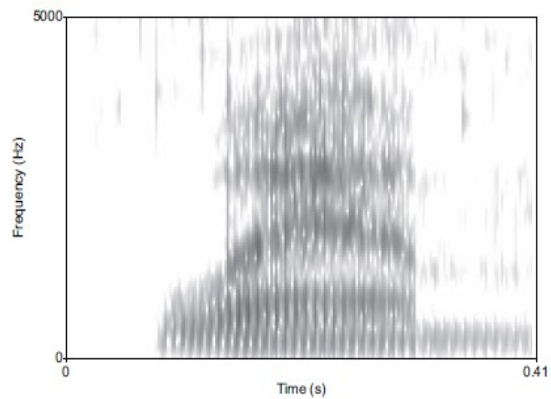
Spectrogram 16:

2. Mark the time intervals of the three sounds which comprise the word "sash" in its spectrogram.

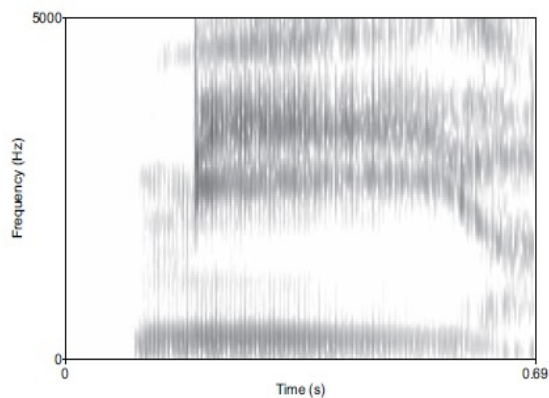
3. Do the same for "lamb".



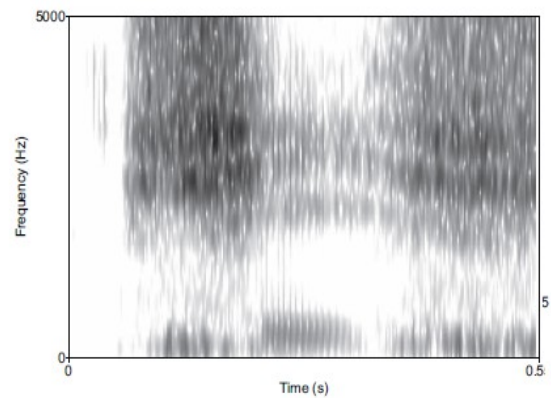
Spectrogram 1: "Sash"



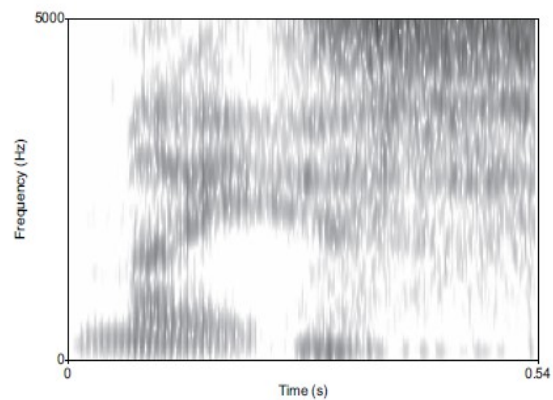
Spectrogram 2: "Lamb"



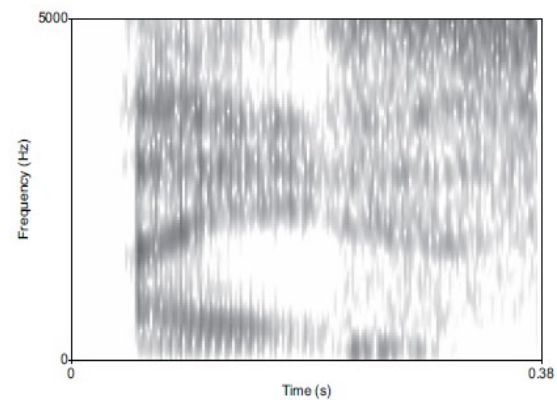
Spectrogram 3: "Knee"



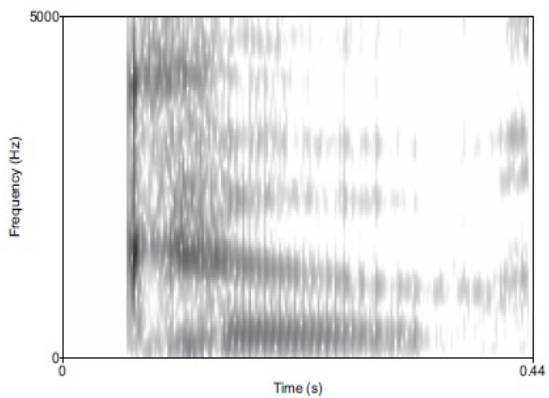
Spectrogram 4: "Sheesh"



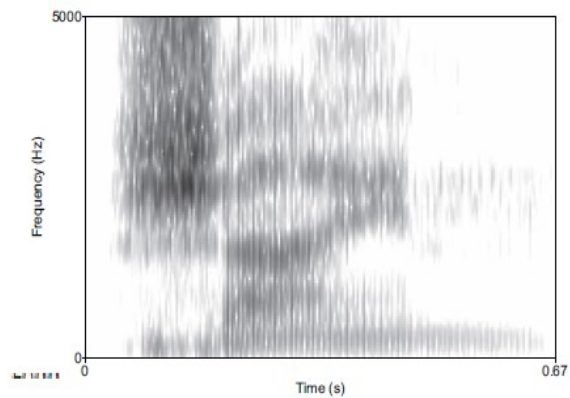
Spectrogram 9: "Mice"



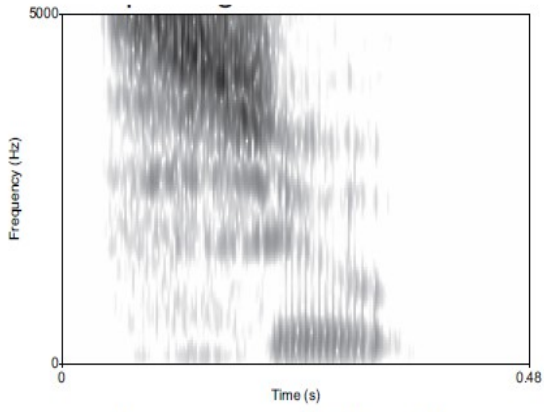
Spectrogram 10: "Ice"



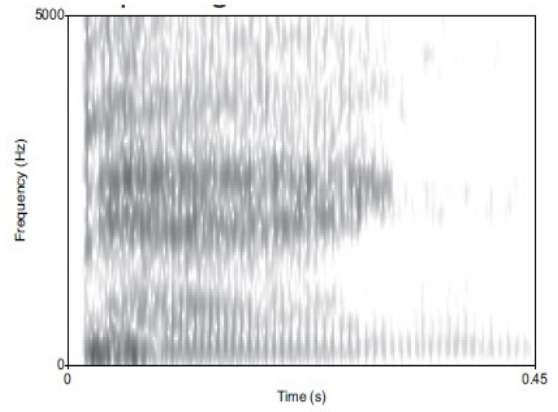
Spectrogram 11: "Coo"



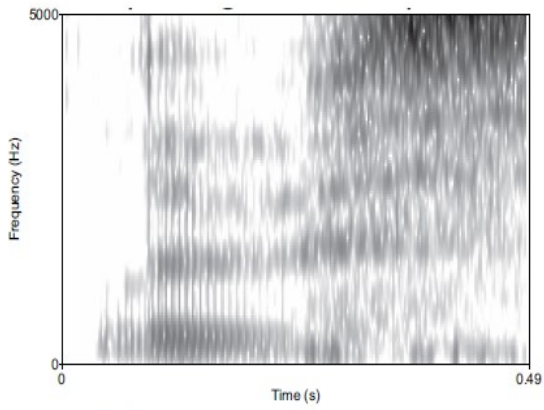
Spectrogram 12: "Shine"



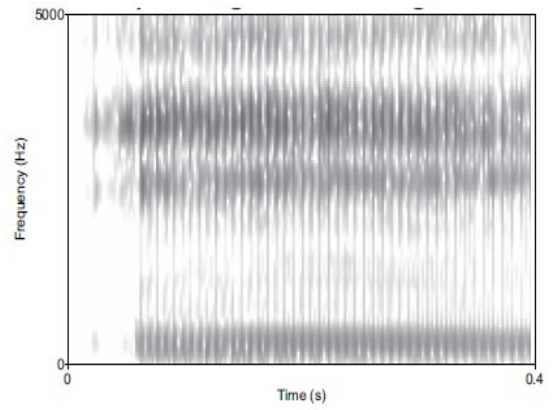
Spectrogram 5: "Soup"



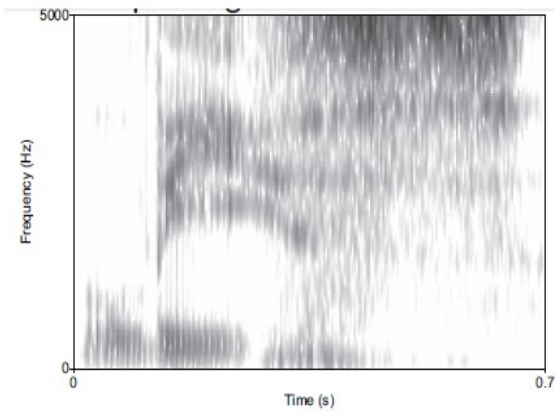
Spectrogram 6: "Pang"



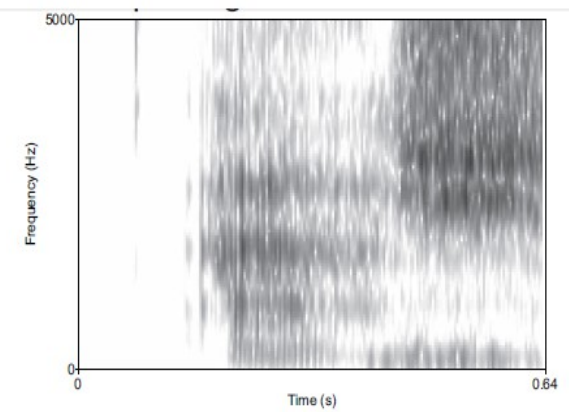
Spectrogram 7: "Loose"



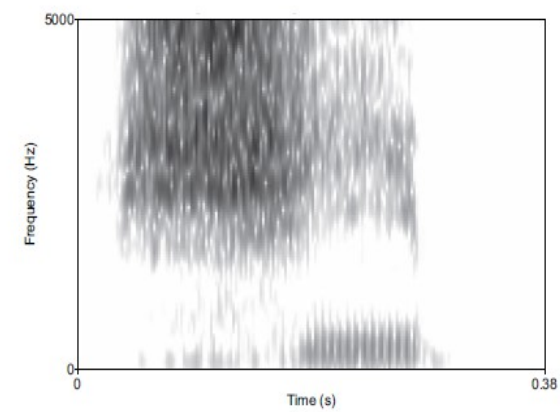
Spectrogram 8: (the letter) 'e'



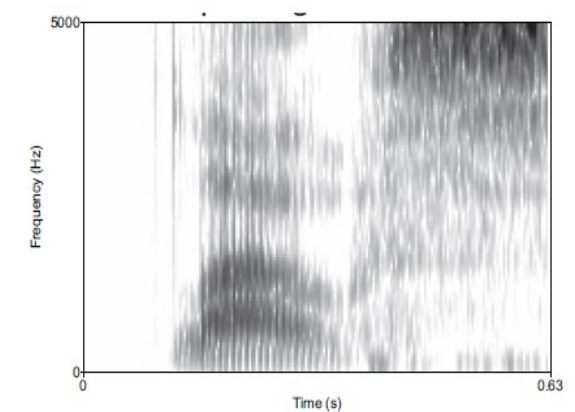
Spectrogram 13



Spectrogram 14



Spectrogram 15



Spectrogram 16