

# Frequency, Tone and Length

Thanks to Chilin Shih for making some of these lecture materials available.

# Suprasegmentals

- **Suprasegmentals** are phonetic features of speech which are “above the segment”
  - Tone/Accent/Intonation
  - Quantity
  - Stress
- “Suprasegmental features are established by a comparison of items in a sequence.” --Ilse Lehiste (1970)
  - ⇒ Suprasegmental features are always defined in a **relative** manner.

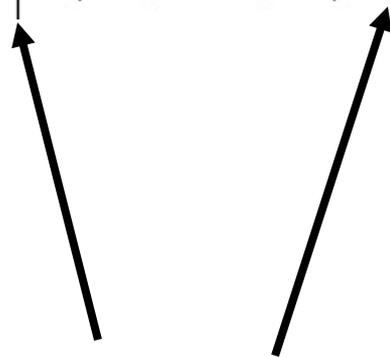
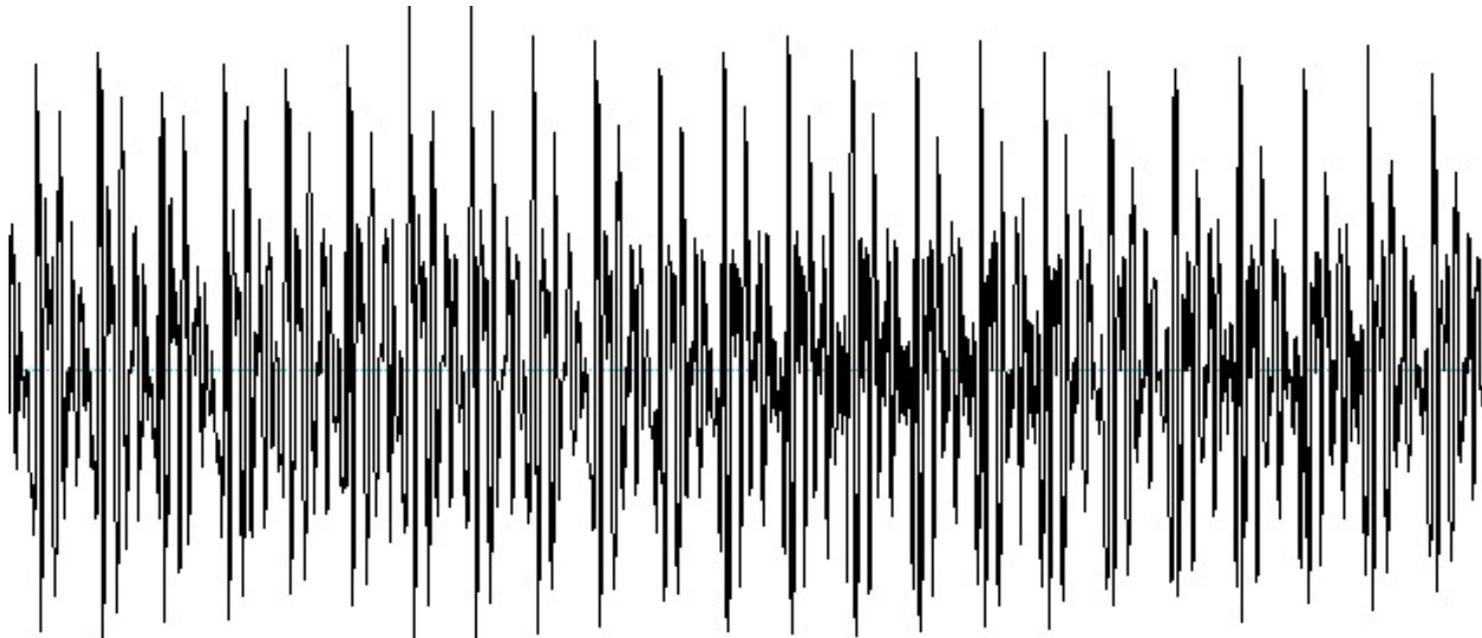
# Where Tone Comes From

Here's a waveform for my vowel [a]:



- The acoustic shockwave of each opening of the vocal folds shows up as a vertical bar in the waveform.
  - A “voicing bar”

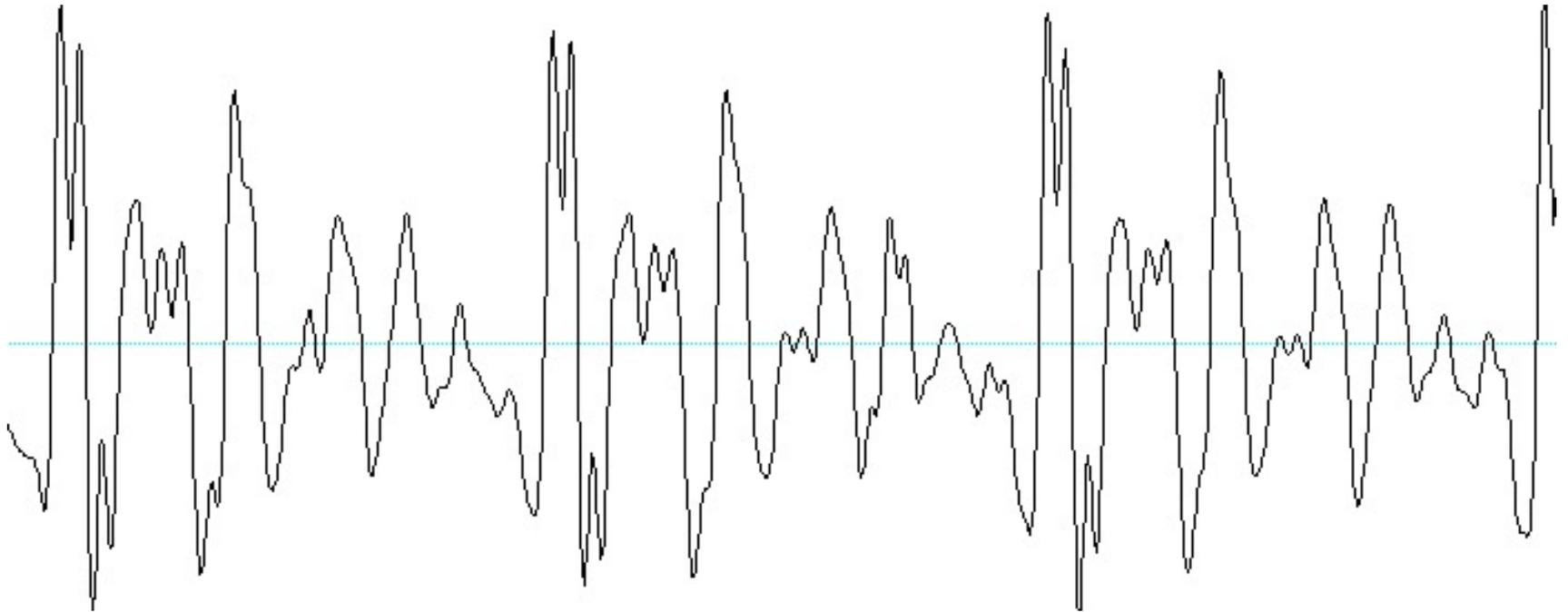
# Voicing Bar Close-up



Individual glottal pulses

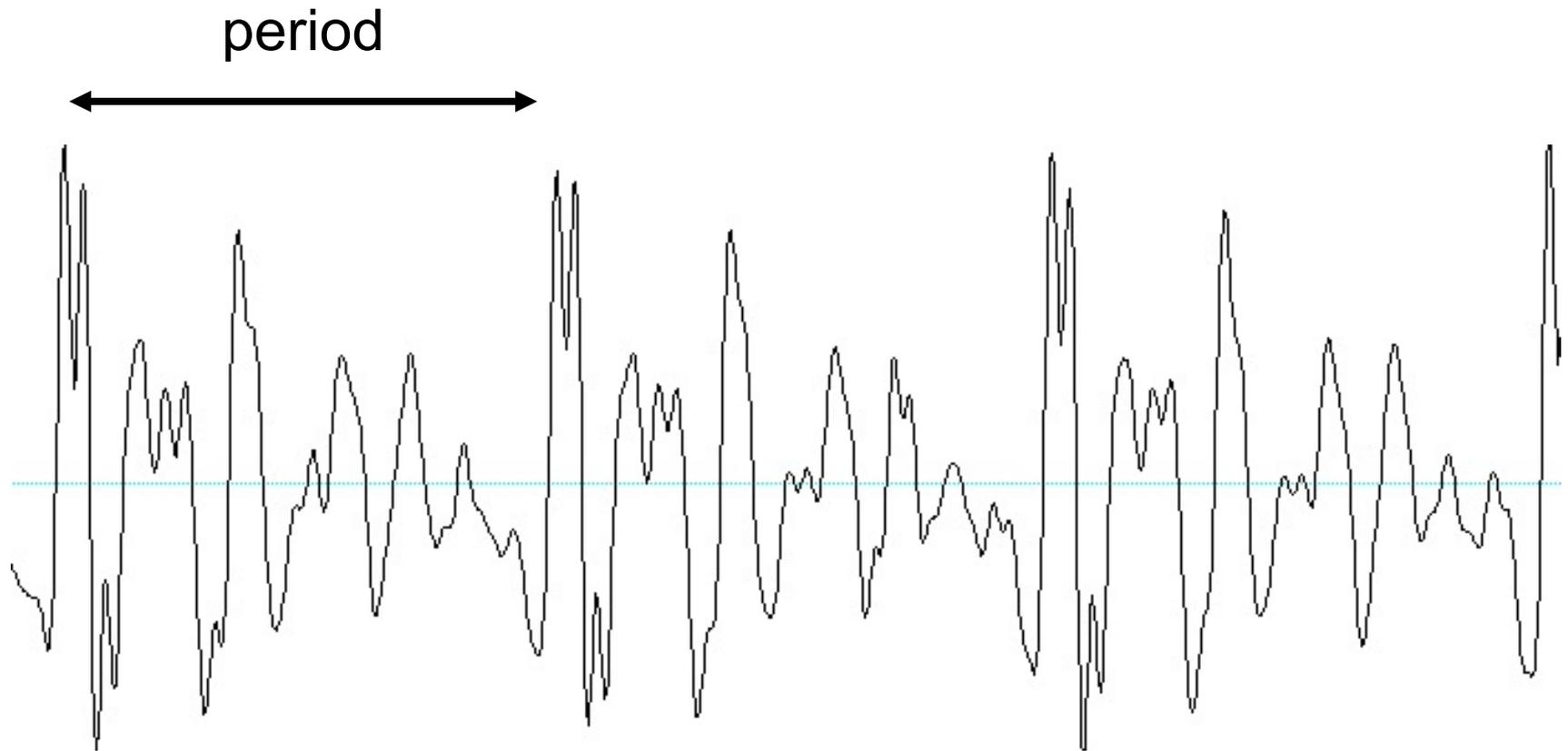
# Voicing bars, really close up

- Voicing is a complex wave. (i.e., not sinusoidal)



- The fundamental frequency of voicing can be calculated by measuring the period between glottal pulses.

# Voicing bars, really close up



- Frequency =  $1 / \text{period}$
- In this case, period = .01 seconds, so frequency = ?



# Just So You Know

- Praat has an automatic pitch tracker.
  - Check it out.
- It can be messed up by:
  - voiceless sounds
  - obstruents (stops, fricatives, affricates)
- Also, it can sometimes double or halve the correct fundamental frequency.
  - I'll spare you the technical reasons why.
- In general, though, it works well.

# Tone

- Tone is the linguistic use of fundamental frequency to signal important differences in meaning.

- Note:

- Acoustic = Fundamental Frequency

- Perceptual = Pitch

- Linguistic = Tone

- English is a tone language...

- Sort of. For one set of words only.



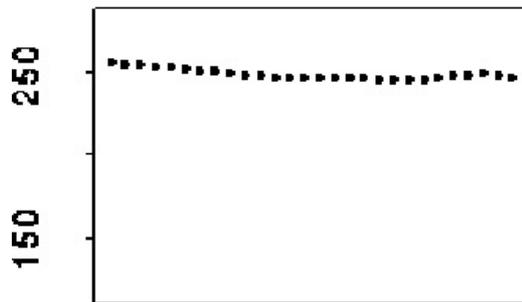
# A Typology

- F0 generally varies in three different ways in language:
  1. Tone languages (Chinese, Navajo, Igbo)
    - Lexically determined tone on every syllable or word
  2. Pitch Accent languages (Japanese, Swedish)
    - The location of an accent in a particular word is lexically marked.
  3. Stress languages (English, Russian)
    - It's complicated.

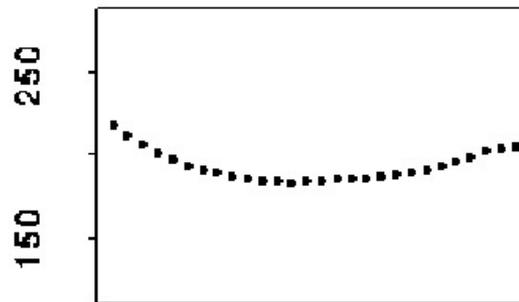
# Mandarin Tone

- Mandarin (Chinese) is a classic example of a tone language.

Tone 1



Tone 2



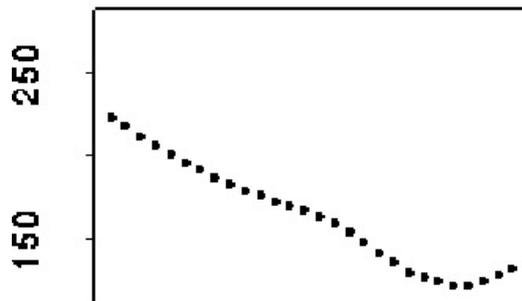
ma1: mother



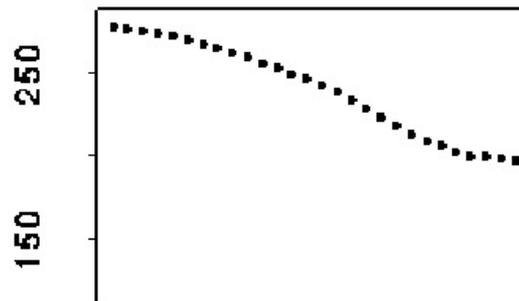
ma2: hemp



Tone 3



Tone 4



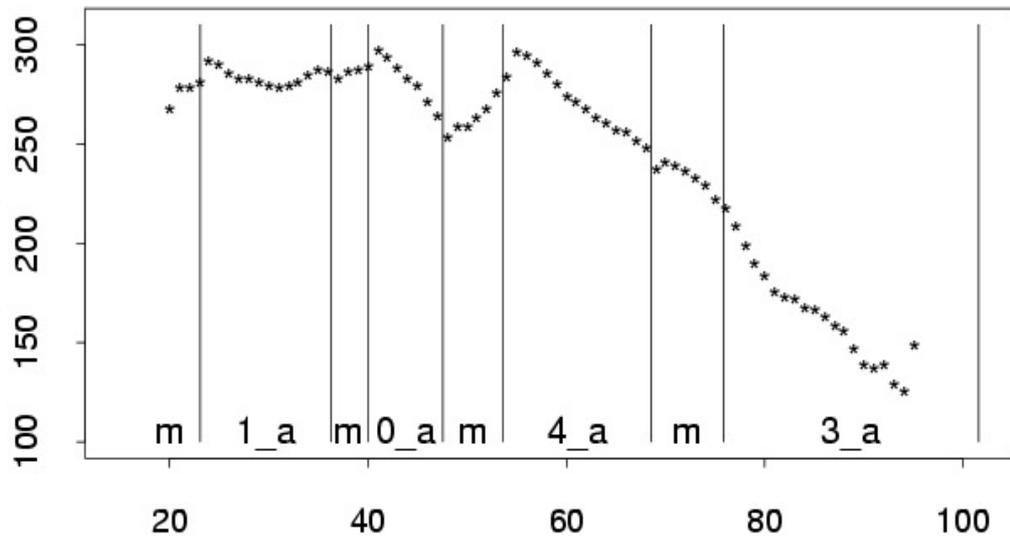
ma3: horse



ma4: to scold

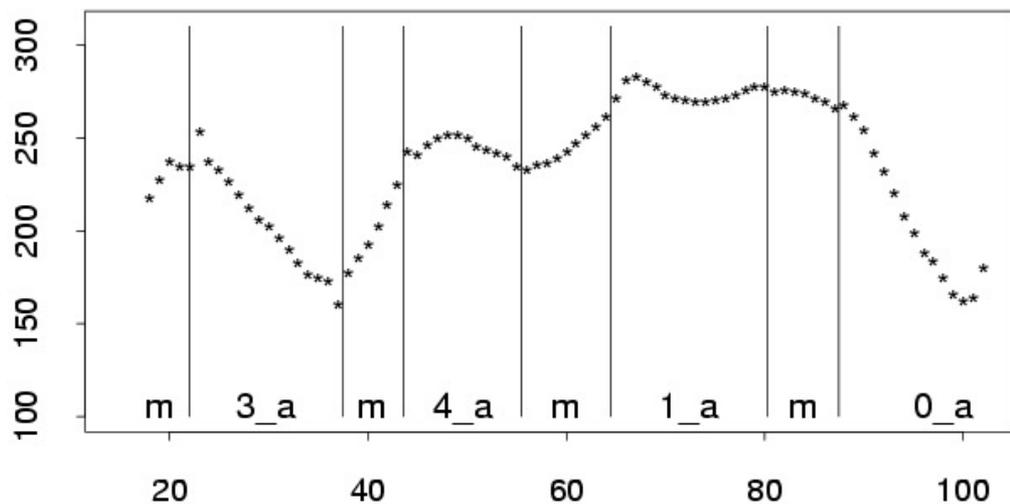


# Mandarin Sentences



ma1-ma0 ma4 ma3.

“Mother scolds the horse.”



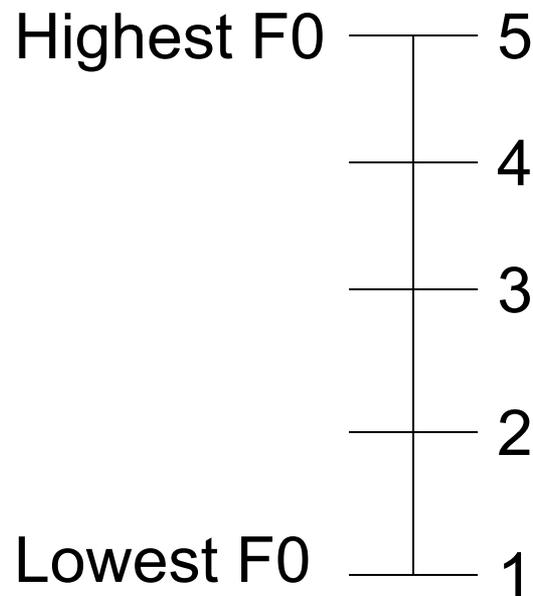
ma3 ma4 ma1-ma0.

“The horse scolds mother.”



# How to Transcribe Tone

- Tones are defined by the pattern they make through a speaker's frequency range.
- The frequency range is usually assumed to encompass five levels (1-5).
  - (although this can vary, depending on the language)



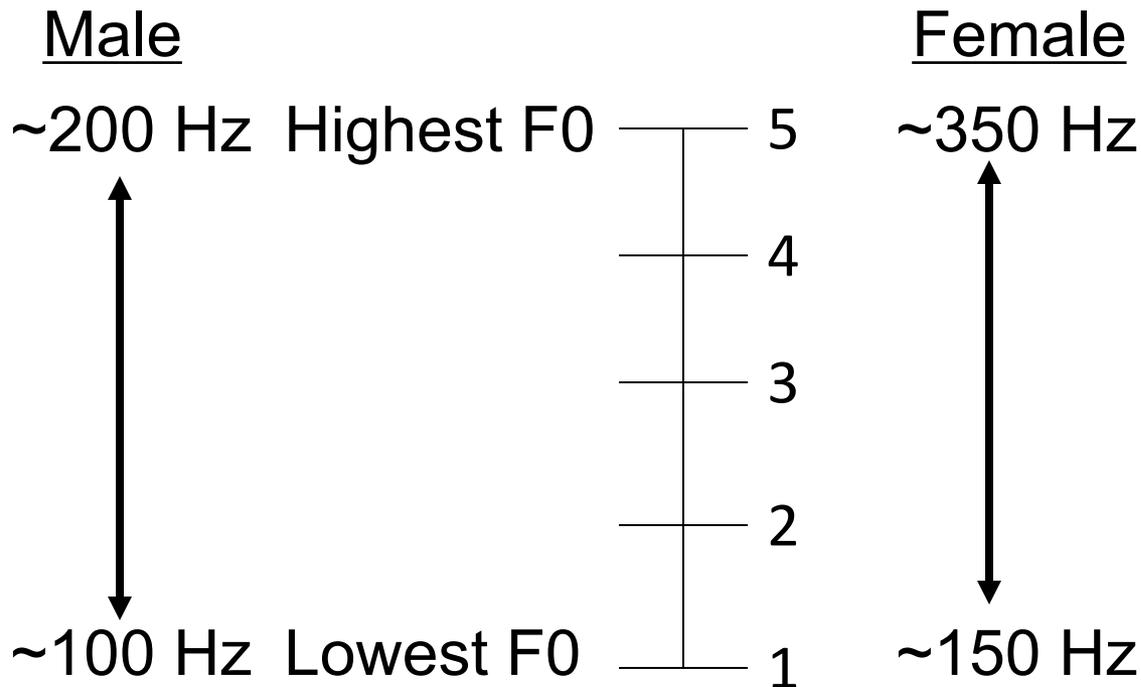
STANDARD CHINESE <b>ma</b>				
Tone	Chinese Character	Tone symbol	Tone description	English gloss
1	媽	˥ 55	high level	'mother'
2	麻	˨˨˨ 35	high rising	'hemp'
3	馬	˨˨˨ 214	low falling	'horse'
4	罵	˨˨˨ 51	high falling	'scold'



- In Mandarin, tones span a frequency range of 1-5
- Each tone is denoted by its (numerical) path through the frequency range
- Each syllable can also be labeled with a tone number (e.g., ma<sup>55</sup>, ma<sup>35</sup>, ma<sup>214</sup>, ma<sup>51</sup>)

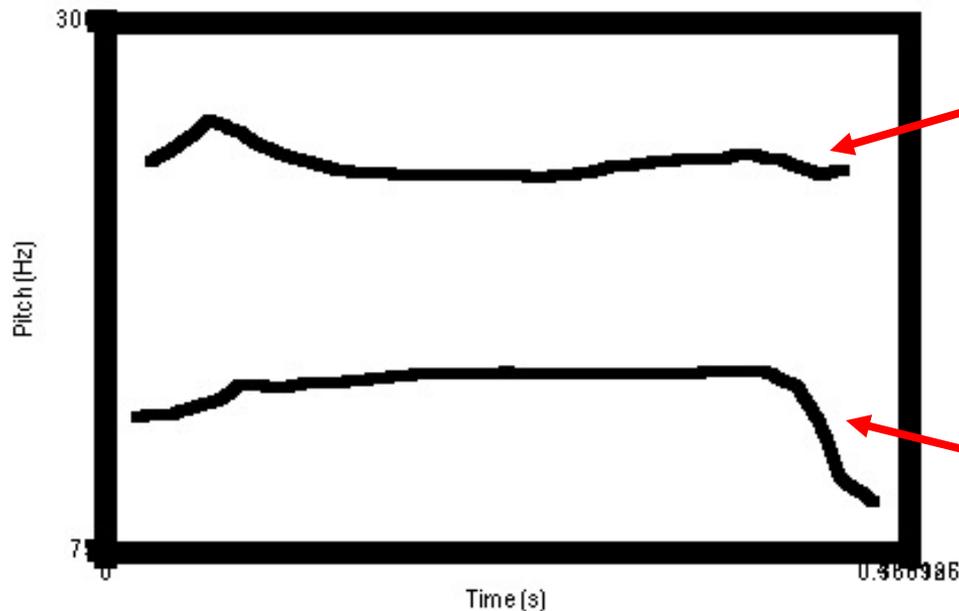
# How to Transcribe Tone

- Tone is relative
  - i.e., not absolute
- Each speaker has a unique frequency range. For example:



# Relativity, in Reality

- The same tones may be denoted by completely different frequencies, depending on the speaker.
  - $\Rightarrow$  Tone is an abstract linguistic unit.



female speaker

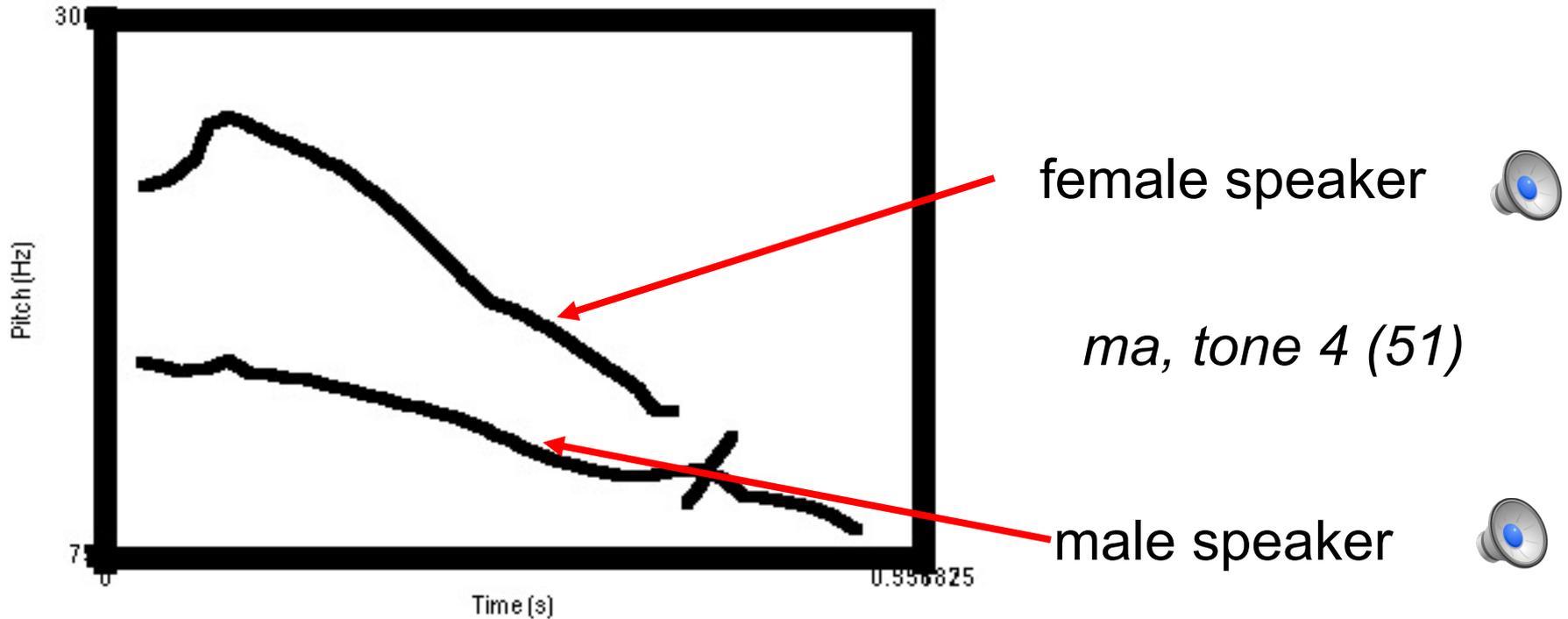


*ma, tone 1 (55)*

male speaker



# How To Transcribe Tone



Some speakers also use more of their frequency range.

# Even More Tones

**level**  
tones

**contour**  
tones

CANTONESE si			
Chinese Character	Tone symbol	Tone description	English gloss
詩	˥ 55	high level	'poem'
試	˨˨ 33	mid level	'to try'
事	˨˨ 22	low level	'matter'
時	˨˨˨ 21	low falling	'time'
使	˨˨˨˨ 24	low high	'to cause'
市	˨˨˨ 23	low mid	'city'



# Thought Question

- How do we know that a certain tone bears the highest tone value in a certain language?
  - It's complicated!
  - Record the contrasting items (e.g. 'ma')
  - Measure the average ranges for male and female
  - Graph the average movement of F0 for each word
  - Compare
  - Make assumptions
  - Check those assumptions!

# Variations

- Other tone languages only have two or three tone targets
- These are transcribed as sequences of High (H) and Low (L) tones. (or also Mid (M) tones)
- They can also be labeled with accents over vowels
  - High = ´
  - Low = `
- In these languages, tone can be used for grammatical markers (tense, possession)

# Ibibio Tones

- Ibibio is spoken in southern Nigeria

Ibibio				
	High tone followed by		Low tone followed by	
<b>High</b>		ákpá 'expanse of ocean'		àkpá 'first'
<b>Falling</b>		ákpân 'square woven basket'		àkpô 'rubber tree'
<b>Low</b>		ákù 'priest'		àkpà (small ant)

# Pitch Accent Languages

- In pitch accent languages, there is only one **pitch accent** associated with each word.
- The pitch accent is realized on only one syllable in the word.
  - The other syllables in the word can have no accent.
- Accent is lexically determined, so there can be minimal pairs.
- Japanese is a pitch accent language...
  - for some, but not all, words
  - for some, but not all, dialects

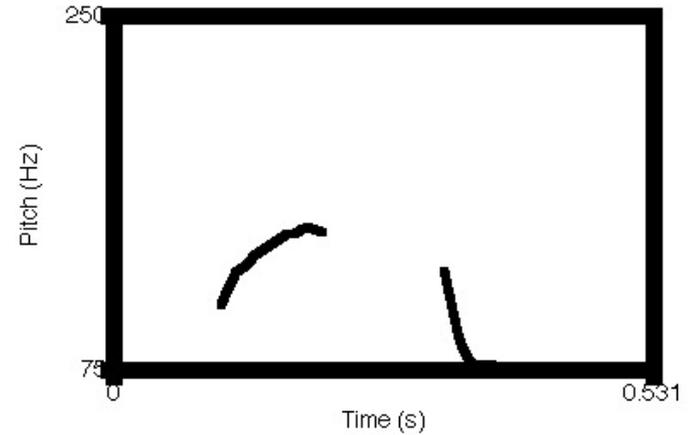
# Japanese

- Japanese words have one High accent
  - it attaches to one “mora” in the word
- A mora = a vowel, or a consonant following a vowel, within a syllable.
- For example:
  - [ni] ‘two’ has one mora.
  - [san] ‘three’ has two morae.
- The first mora, if not accented, has a Low F0.
- Morae following the accent have Low F0.

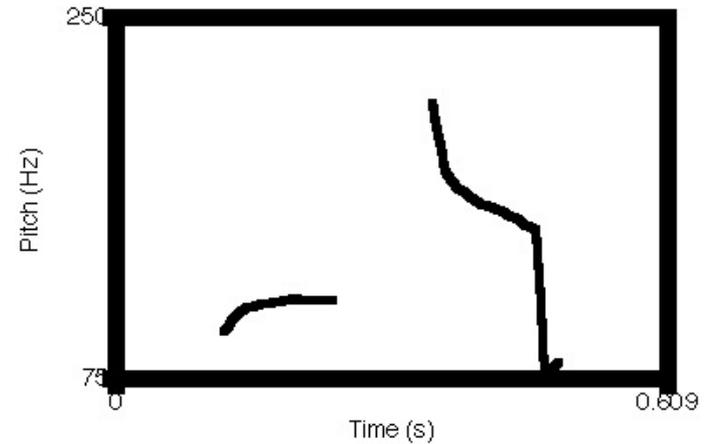
It's actually slightly more complicated than this; for more info, see:  
<http://sp.cis.iwate-u.ac.jp/sp/lesson/j/doc/accent.html>

# Japanese Examples

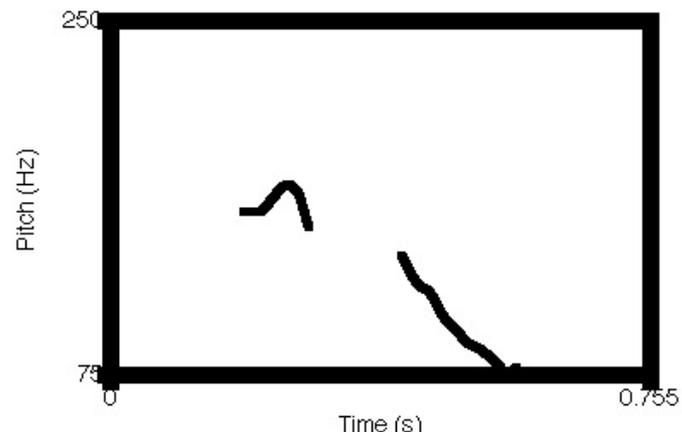
- asa 'morning' H-L



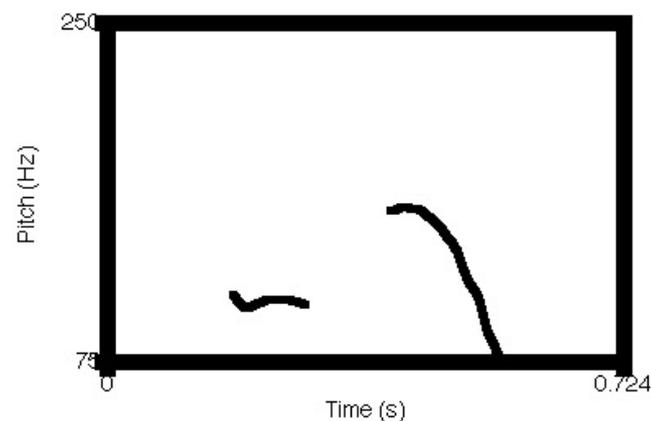
- asa 'hemp' L-H



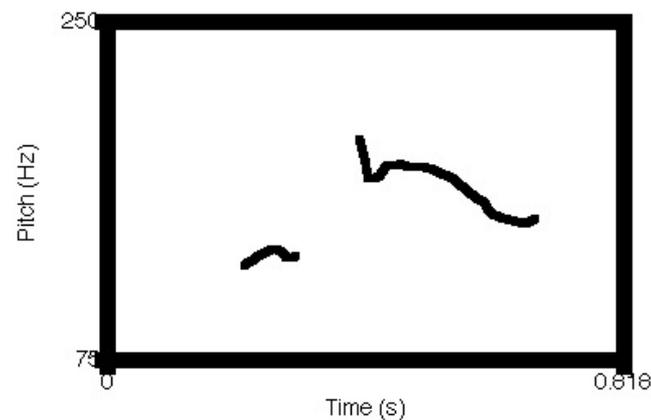
- [hasiŋa] “chopsticks” H-L-L



- [hasiŋa] “bridge” L-H-L



- [hasiŋa] “edge” L-H-H



# Length Distinctions

- Another suprasegmental linguistic feature is **quantity**.
- Note:
  - Quantity = Linguistic
  - Length = Perceptual
  - Duration = Acoustic
- Quantity distinctions are also relative.
  - depend on speaker
  - depend on speaking rate

# Danish Vowels

vi:ðə

'white'  
[def]



vilə

'wild'  
[def]



vilə

'rest'



ve:ðə

'wheat'



menə

'remind'



me:nə

'mean'



ve:ðə

'wet'



lesə

'load'



le:sə

'read'



væ:ðə

'wade'



mæsə

'mass'

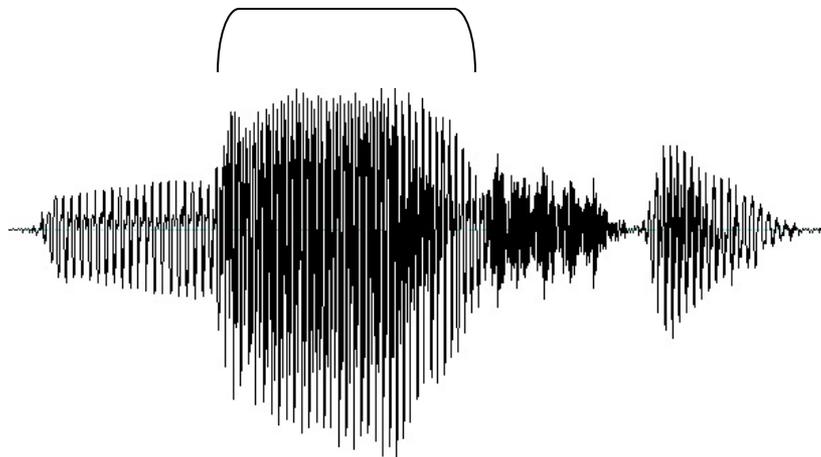


mæ:sə

'mash'



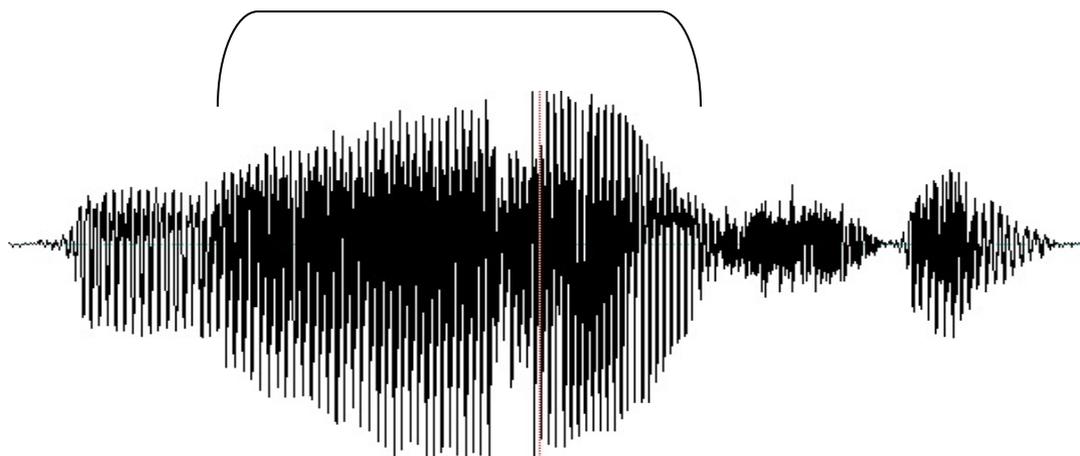
= 150 milliseconds



lɛsə  
'load'



= 275 milliseconds



lɛ:sə  
'read'



- Differences in quantity between segments translates to relative differences in duration.

# Italian

- Italian contrasts both long and short vowels and consonants.

li 'there'	li 'to him'	no:mi 'names'	no:mi 'gnomes'
fo:la 'crowd'	fo:la 'leaf'	non:zo 'grandfather'	son:zo 'dream'
velare 'conceal'	ve:are 'keep watch'		

- Note: Italian has both palatal nasals and palatal laterals.