

# REMINDER

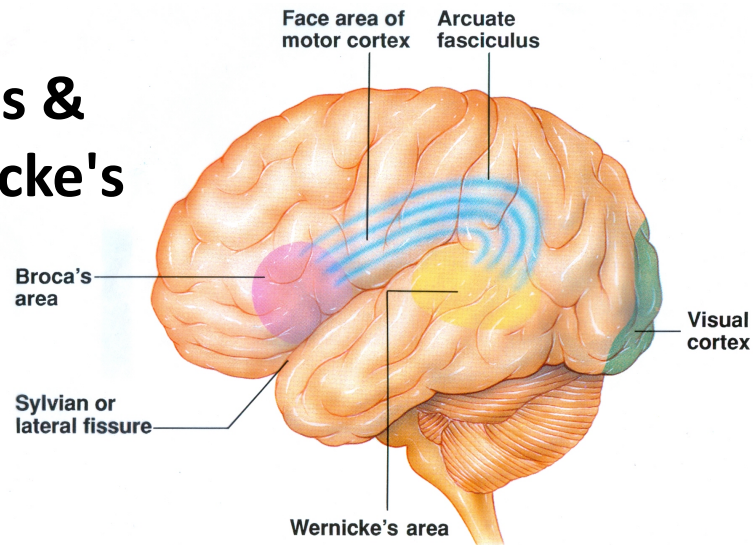
- As per the syllabus, there will be NO DISCUSSION this week!
- That is, we will NOT meet on either Thursday or Friday this week.
- See you in class next Tuesday!

# Emergence of Speech

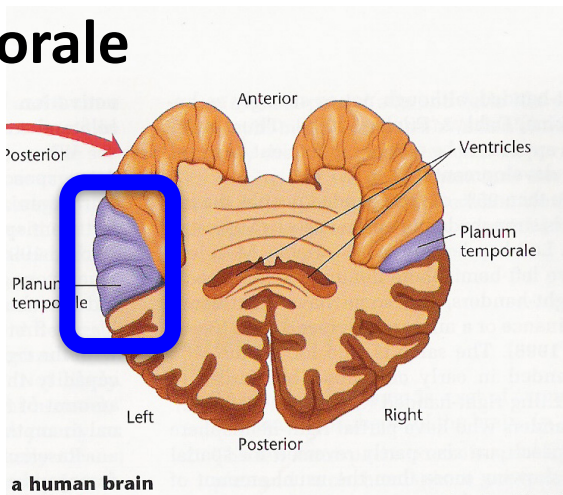


# Brain Specializations for Speech

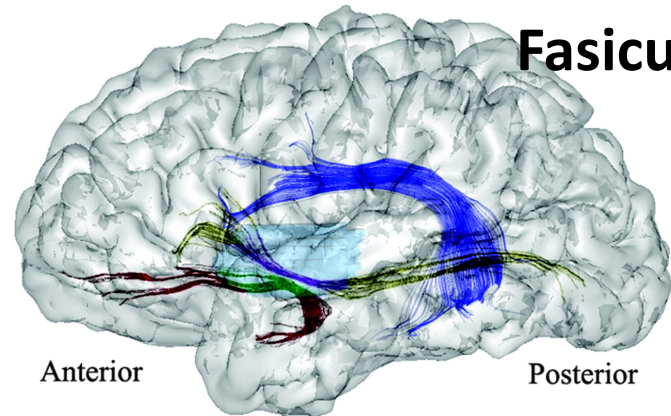
## Broca's & Wernicke's



## Planum Temporale

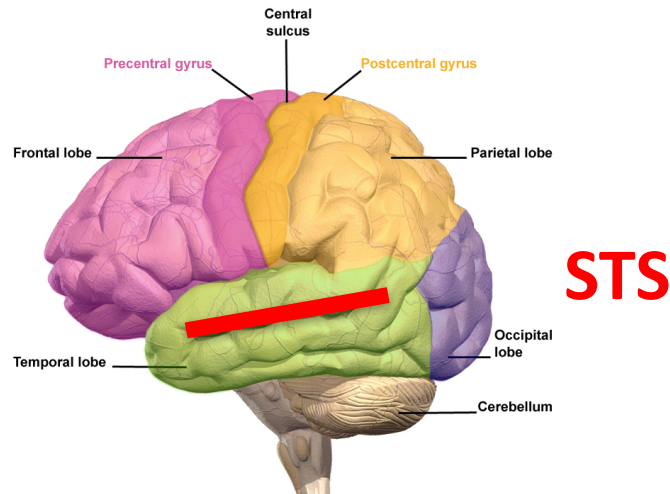


## Arcuate Fasciculus



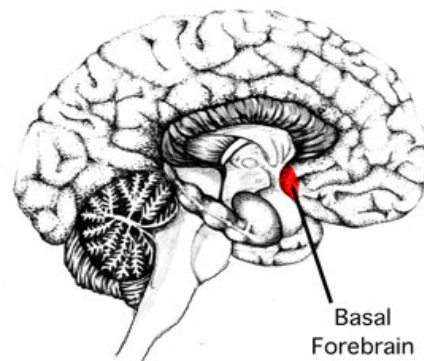
# Brain Specializations for Speech

- **STS (Superior Temporal Sulcus)**
  - For biological motion, including facial expression, lip reading

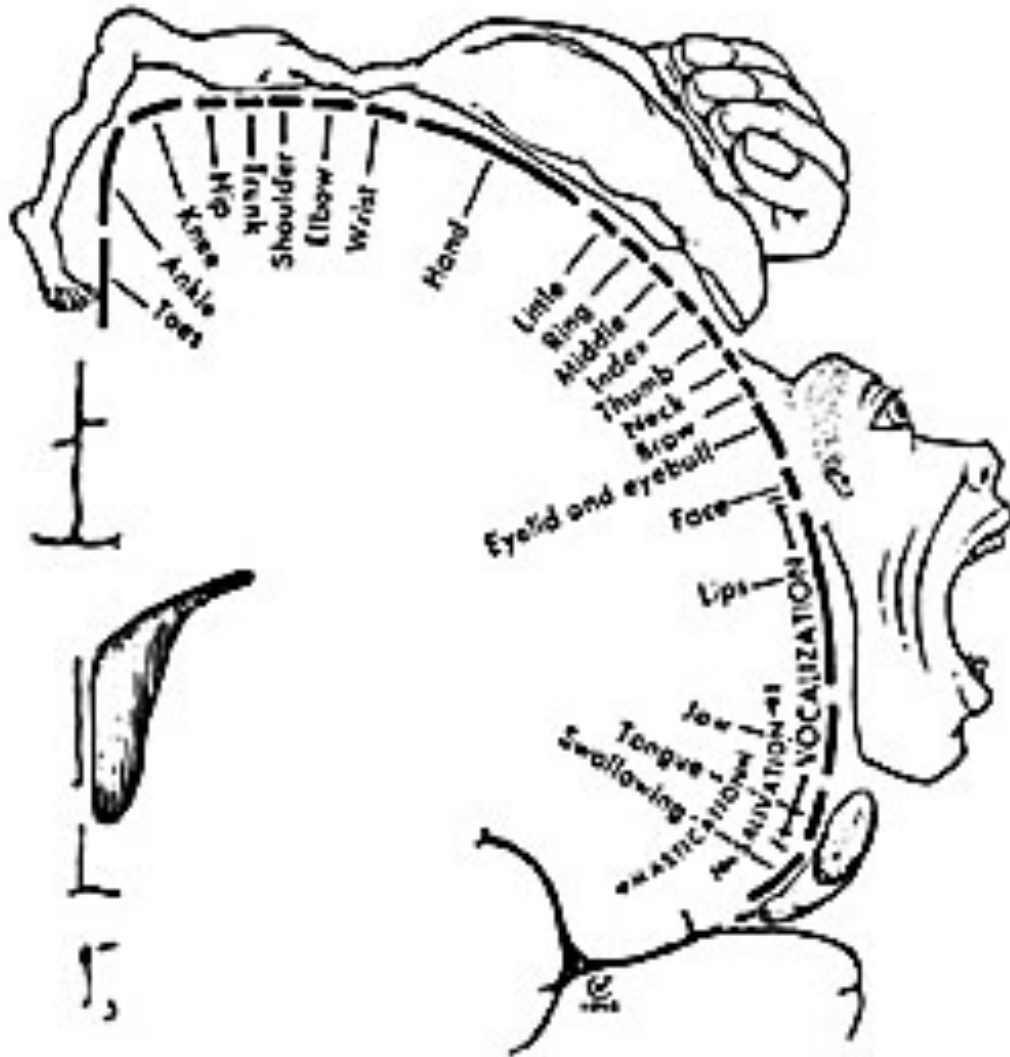


- **Basal Forebrain**

- New arousal nucleus in BF specialized to drive, sustain Broca's activity



# Hand and Mouth

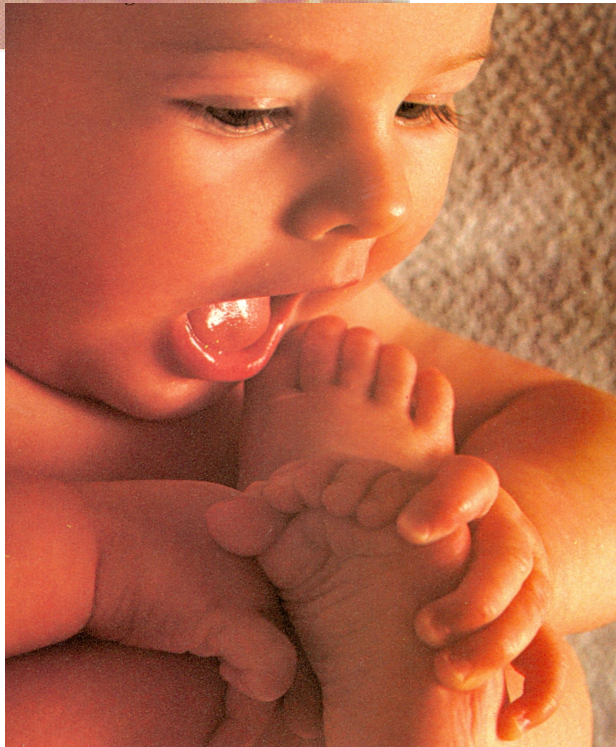
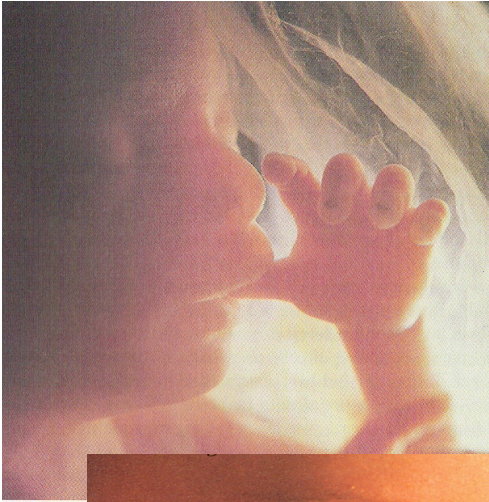


Adjacent in somatosensory and motor cortex



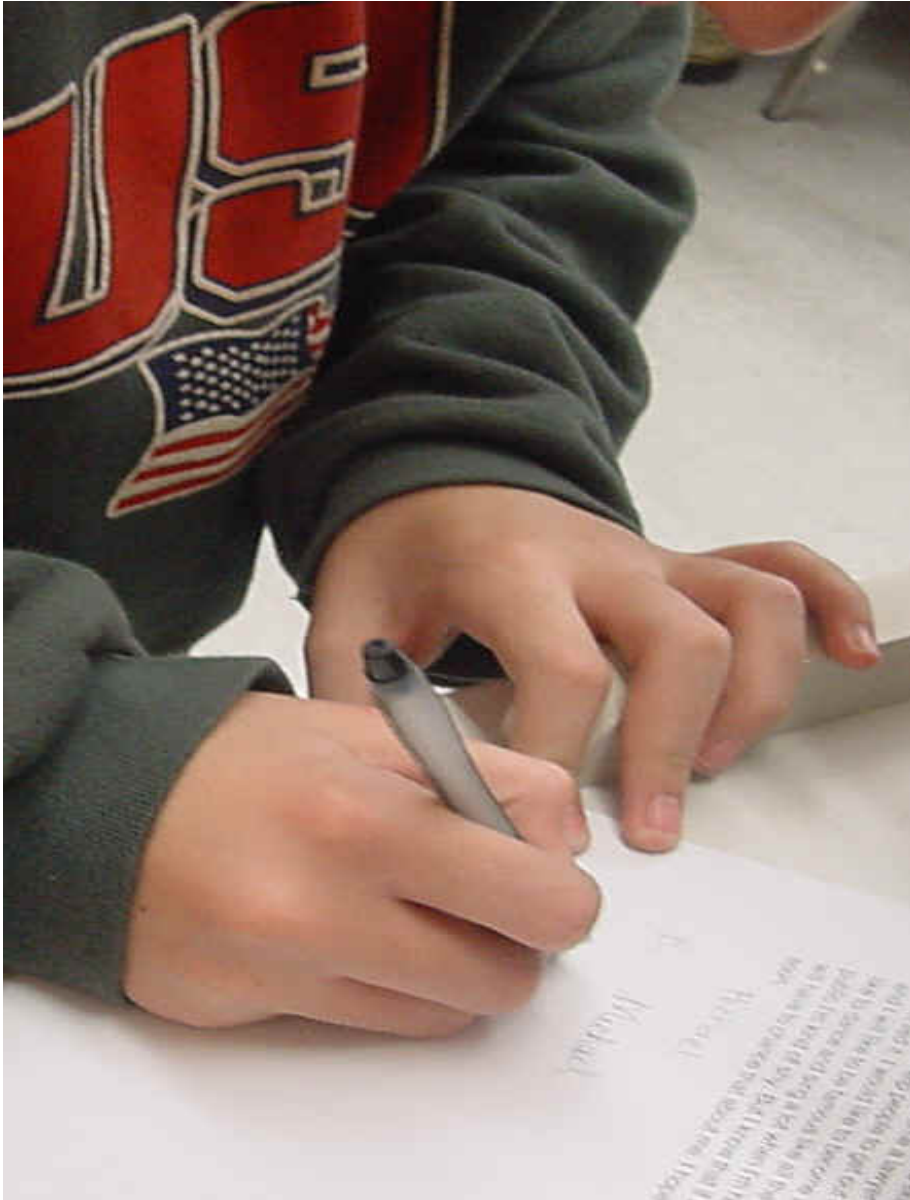
Originally involved in feeding with hand

# Hand & Mouth



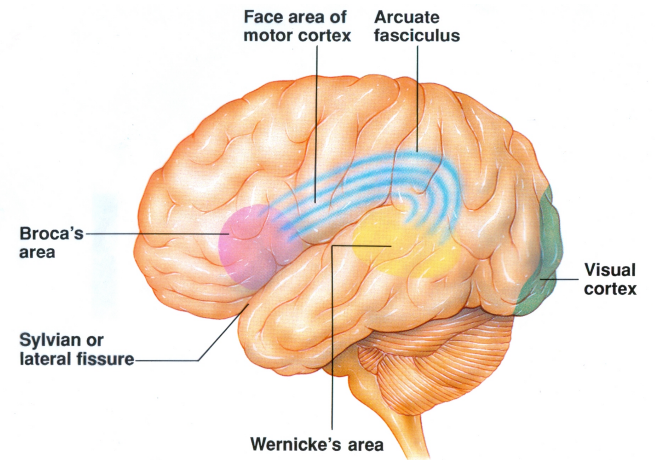
This linkage probably also played a role in the emergence of speech

# Lateralization

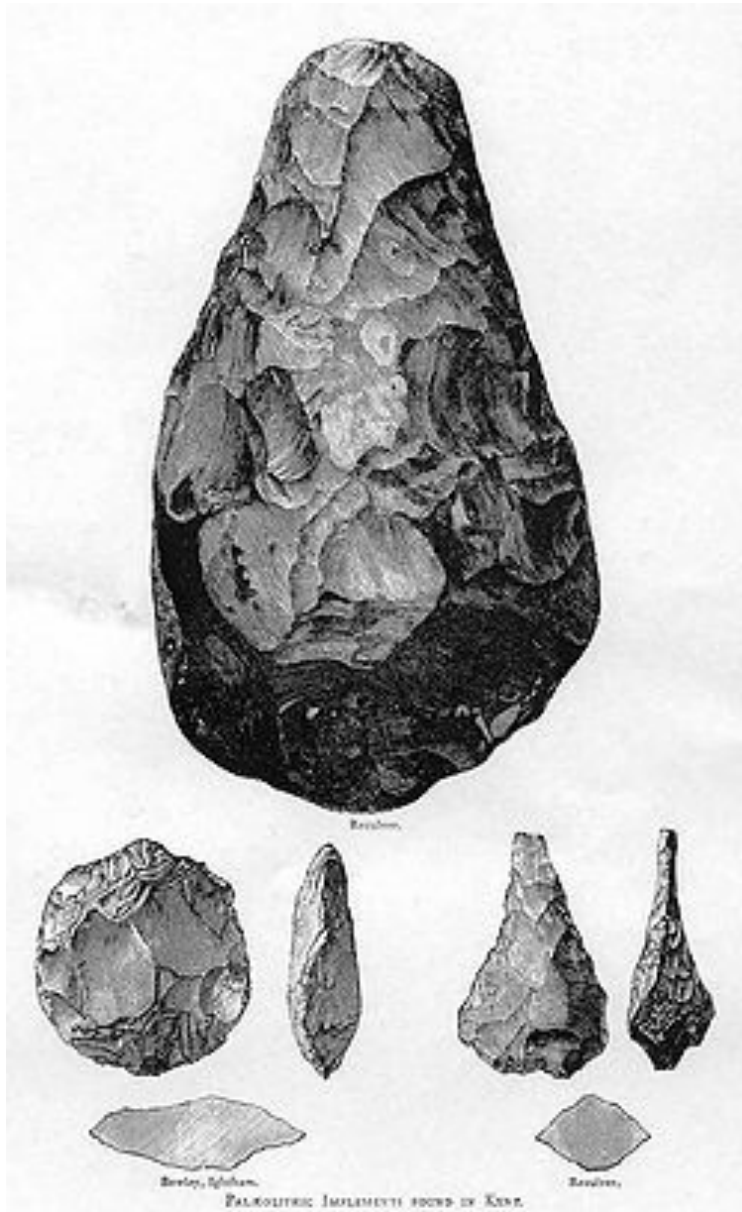


90% Humans right handed  
**(lateralized  
to left cortex)**

Also **lateralized** to left cortex  
for speech



# Lateralization



Already, with Acheulian tools,  
tool-makers (*H. erectus*) were  
right handed

So  
(presuming *H. erectus* did not have speech...)  
Right-handedness came first,  
and was then co-opted (exapted)  
for left hemisphere control of speech --?

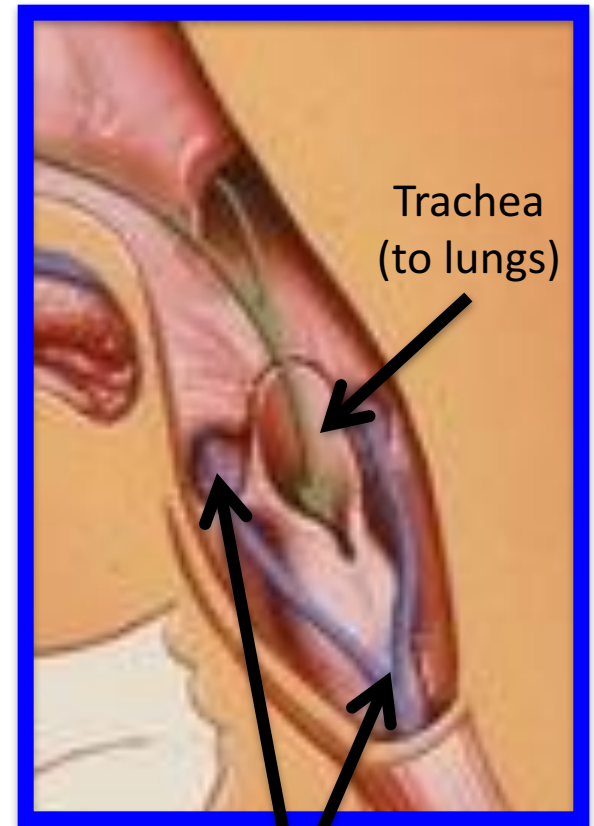
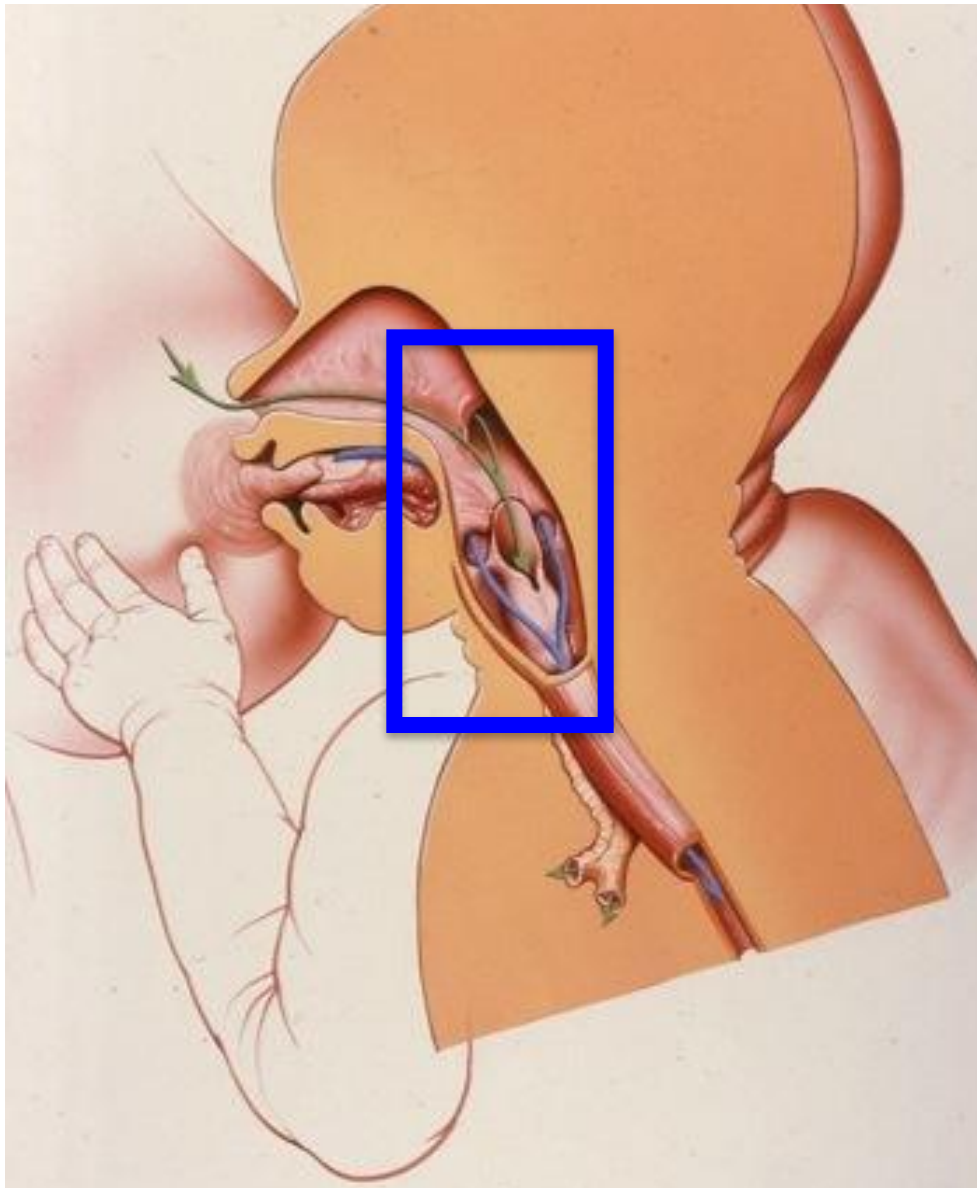


# Articulatory Apparatus



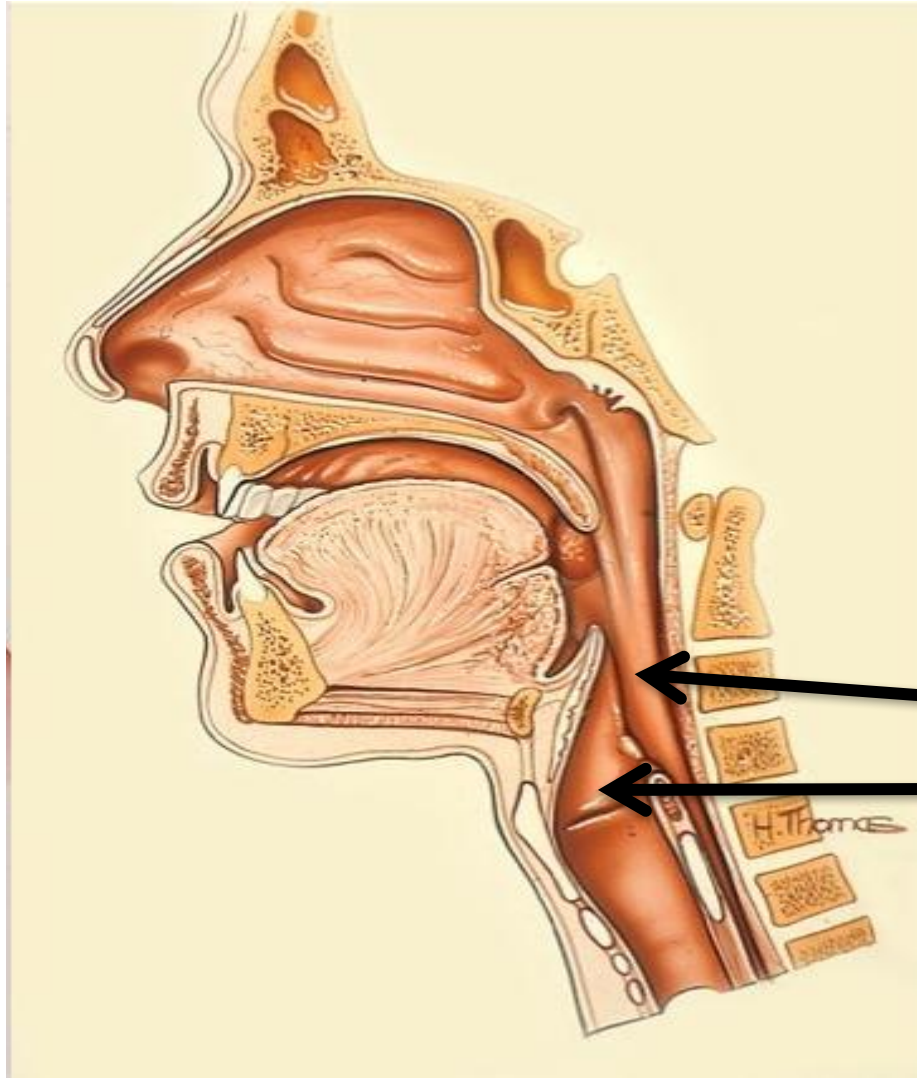
## Human Infant – Trachea still high in throat

So, unlike older, infant can drink  
& breathe at same time



Esophagus (to stomach)

# Human Adult – Trachea has dropped



Adaptation for Speech  
(more cavity for sound production/control)

>>Trachea & Esophagus now  
share a passage.

Esophagus

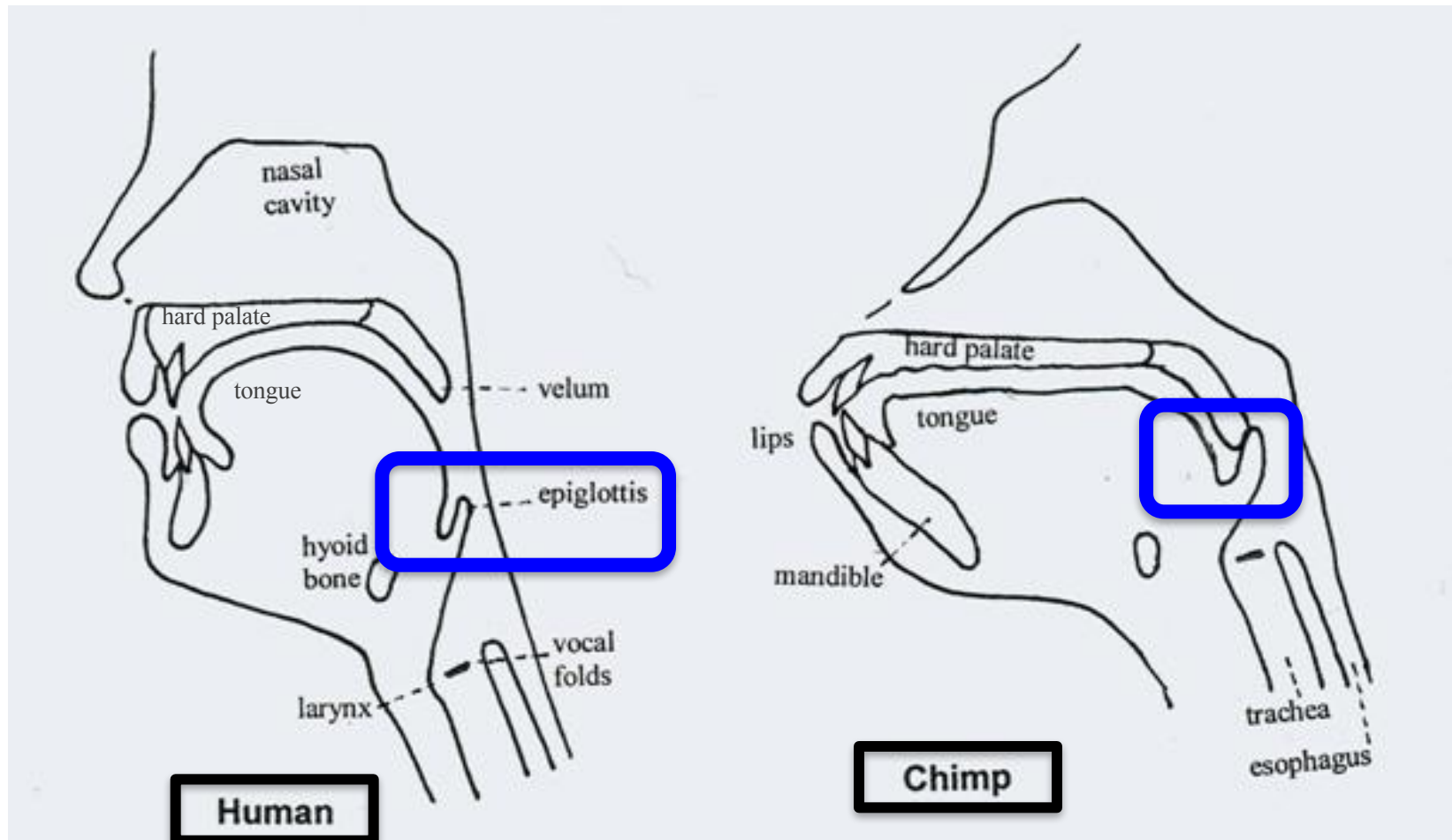
Trachea

**High Cost:** Food can block airway  
Choke to death!

# Evolution of the Articulatory Apparatus

Other Soft Tissue changes:

Epiglottis drops, no longer can close off esophagus

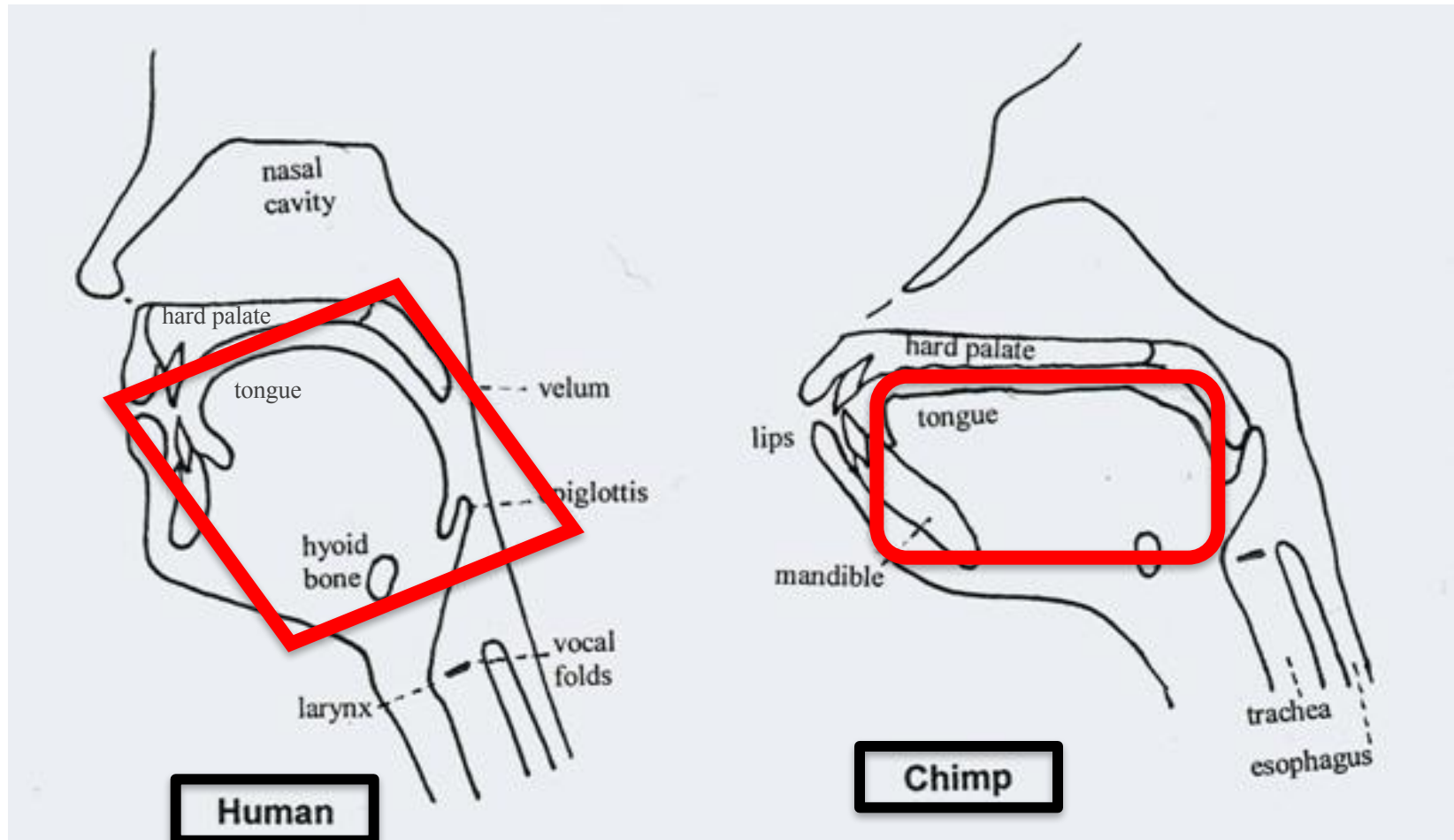


Soft tissue – so only evidence from development or comparative morphology

# Evolution of the Articulatory Apparatus

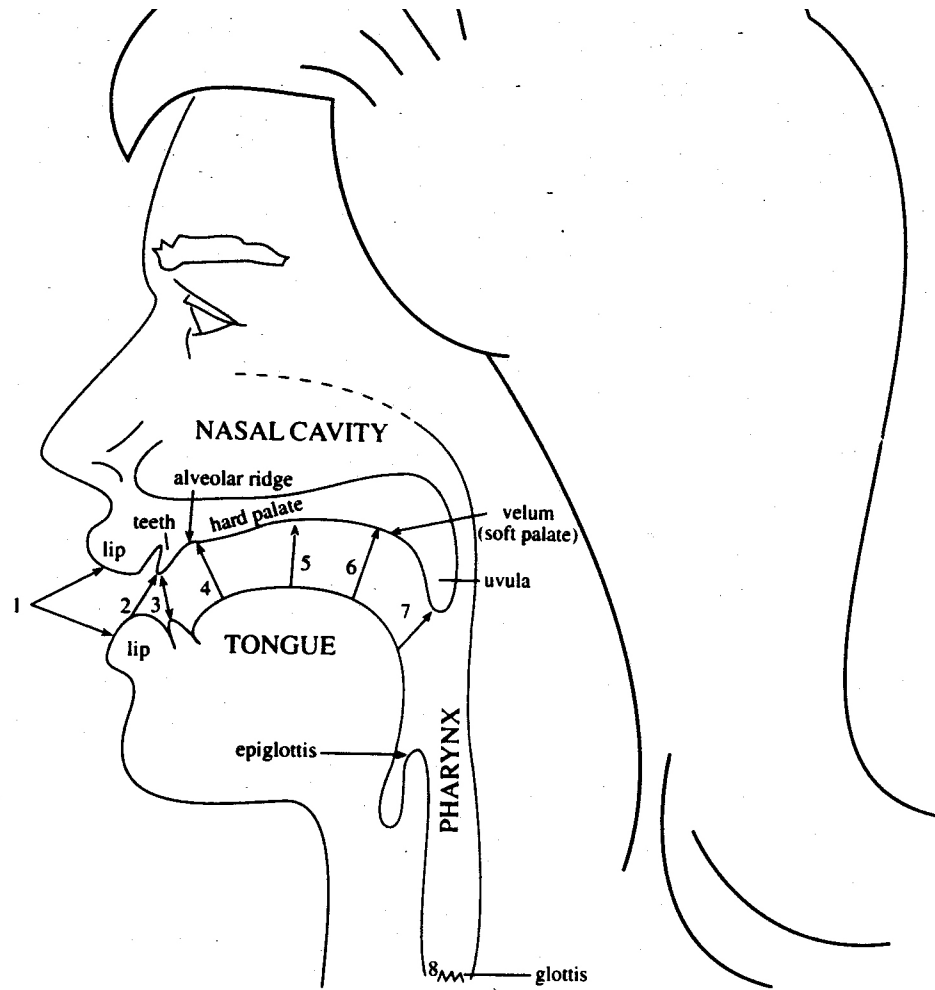
Other Soft Tissue changes:

Tongue reaches deeper into throat



# Places of Articulation

Refined  
Sensory-motor  
Control



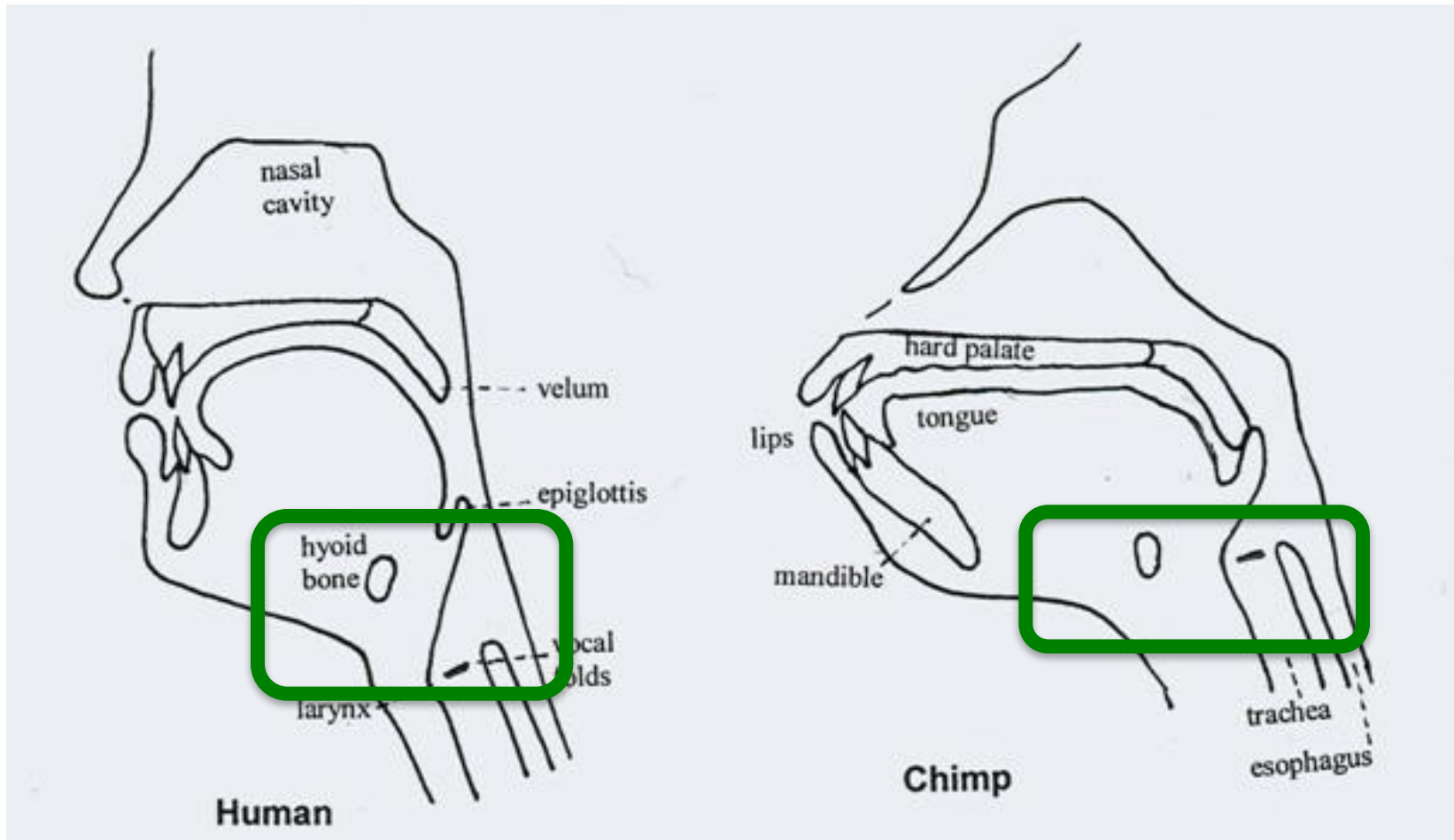
The vocal tract; places of articulation are marked.

1. bilabial; 2. labiodental; 3. interdental; 4. alveolar; 5. (alveo) palatal; 6. velar;  
7. uvular; 8. glottal.

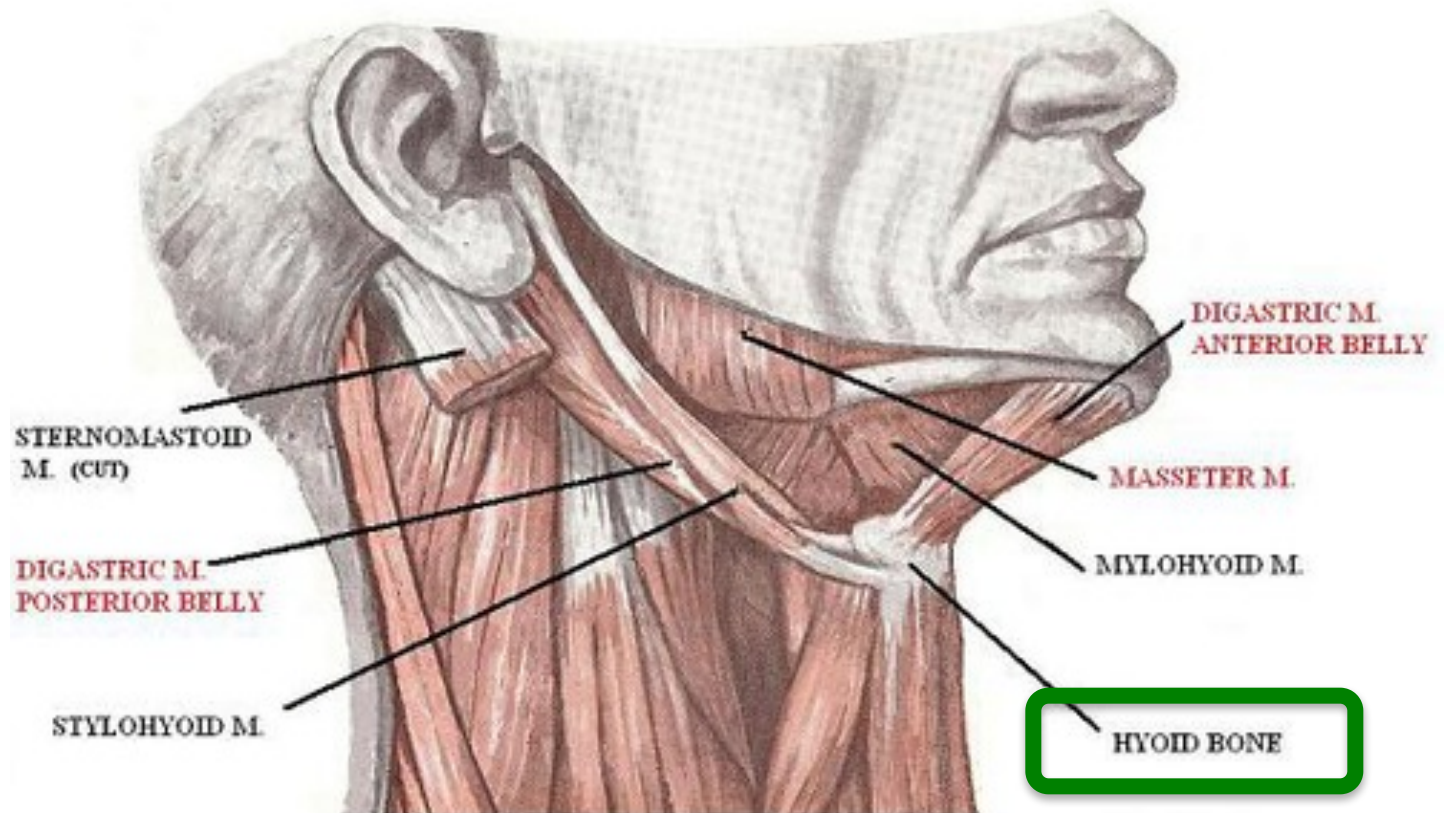
# Evolution of the Articulatory Apparatus

Other structural changes:

Position of (floating) **Hyoid Bone** – Higher in neck & tilted in Humans



# Hyoid Bone



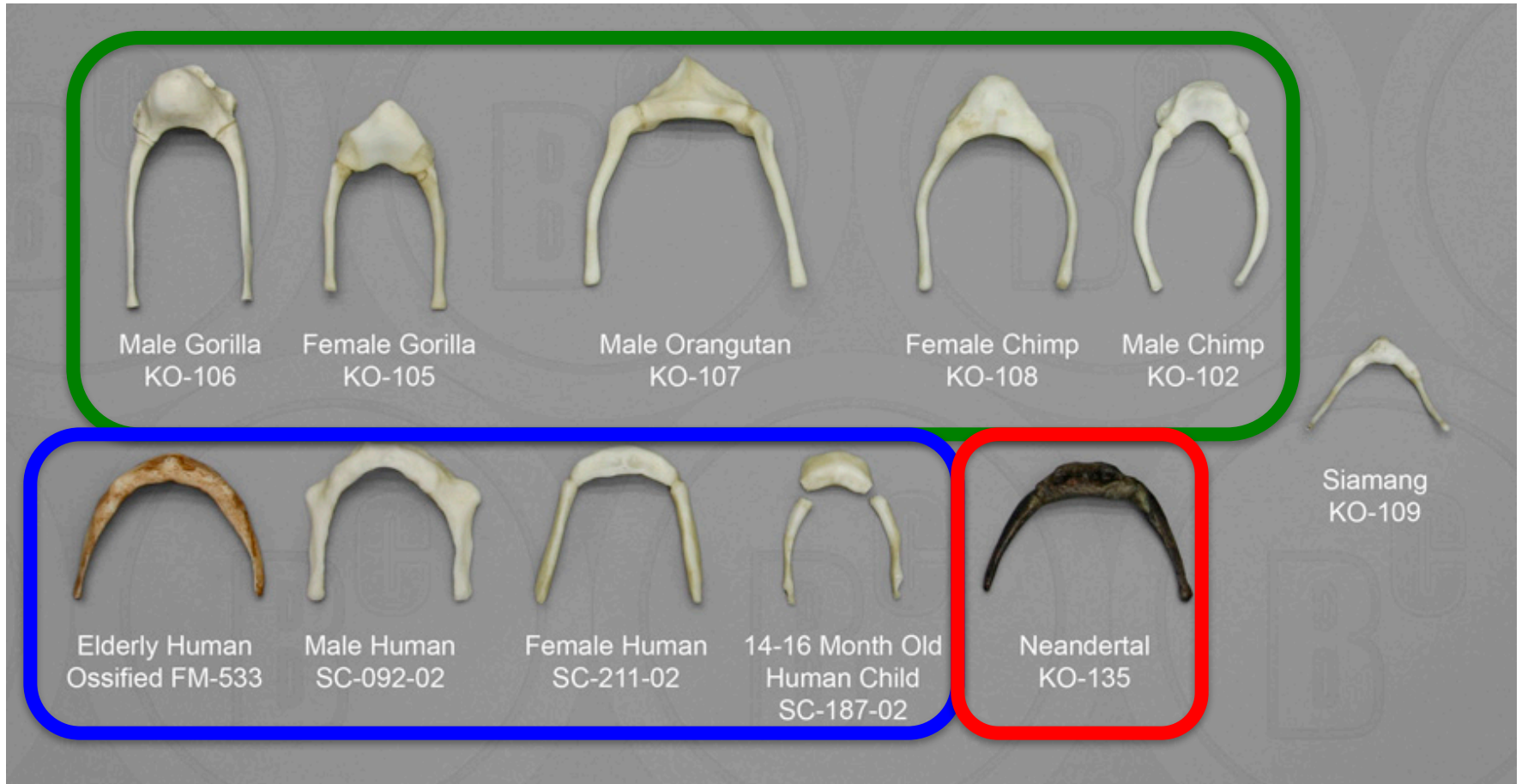


# Hyoid Bone

Apes

Humans

Neandertal

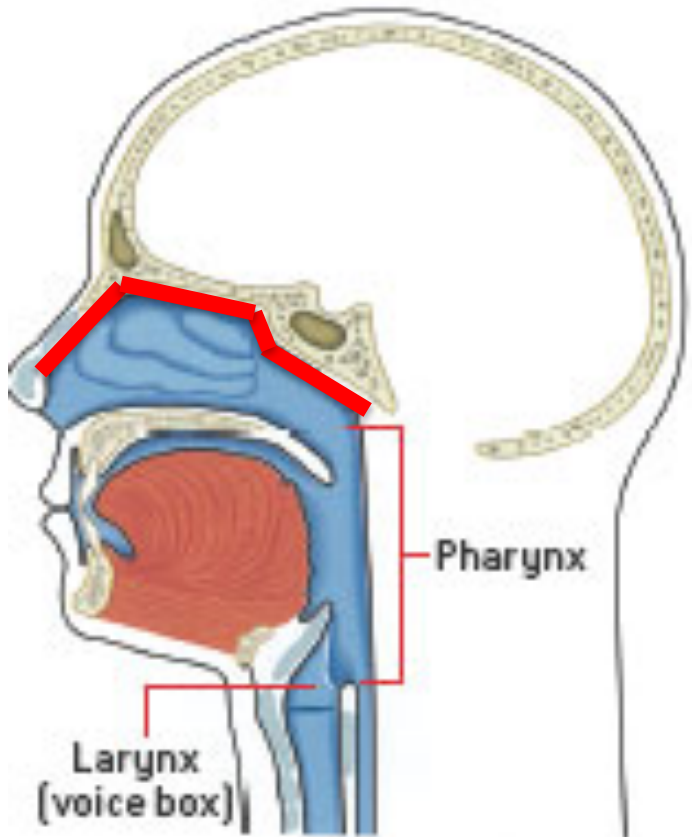


?? Is there a real shape difference between Human & Neanderthal ??

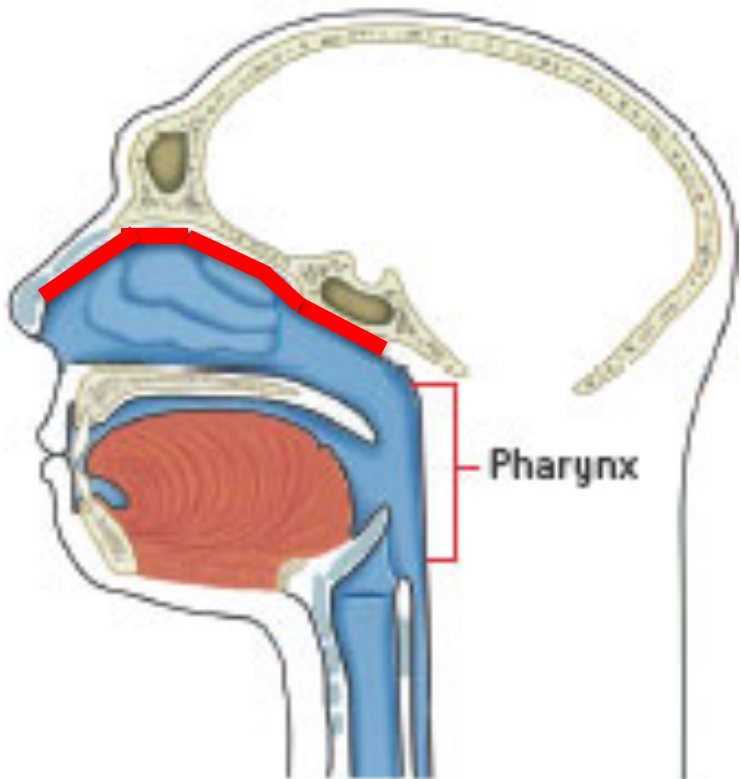
Since it is a floating bone, no way to tell if it “articulates” differently...

# Basiscranial Flexure

**MODERN HUMAN**



**NEANDERTAL**



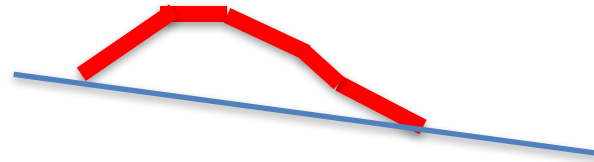
# Basiscranial Flexure

**MODERN HUMAN**



Greater flexure in humans  
for larger resonating chamber

**NEANDERTAL**



Perhaps the strongest “hard” evidence  
for a speech difference  
between *H. sapiens* & *H. neanderthalensis*

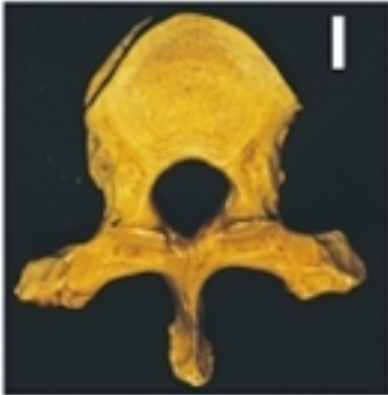
# Did Neanderthal Speak???



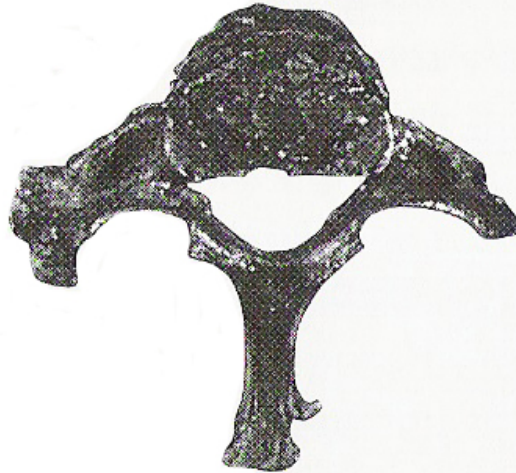
# Thoracic Spinal Column

Vertebral canal increases through Hominid evolution

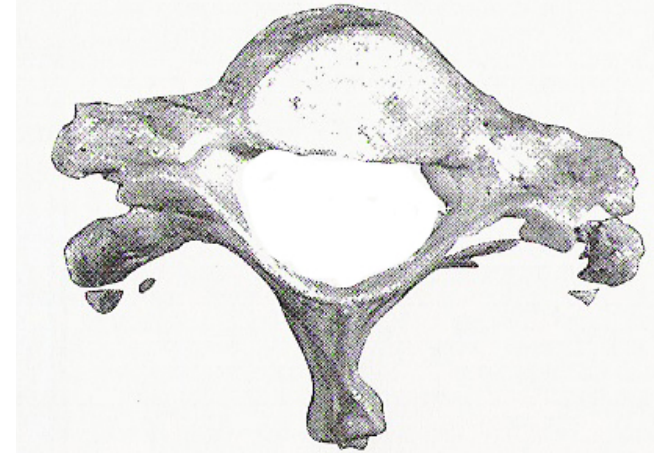
*Gorilla gorilla*



*Homo erectus*



*Homo sapiens*

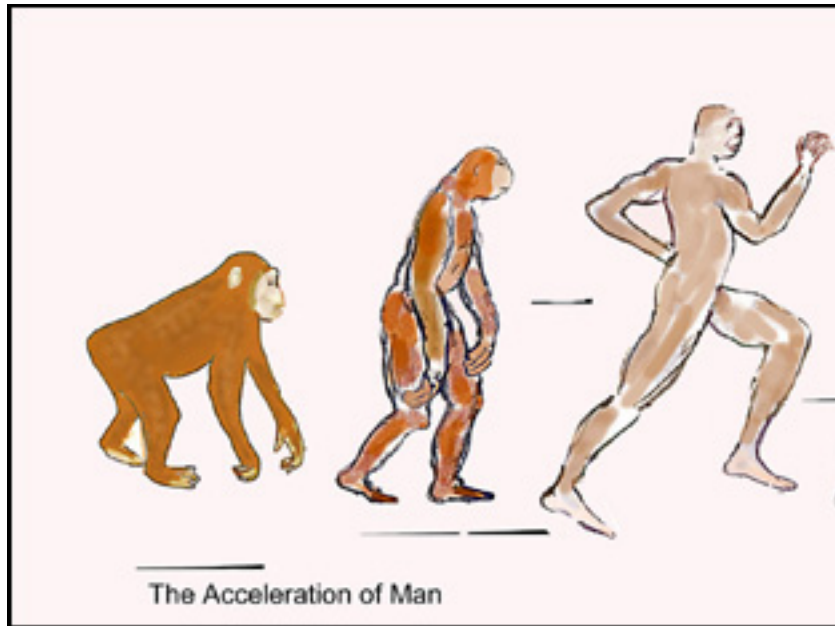


Indicates greater enervation of lungs  
for subtle **control of breathing**

Possibly adaption for long distance walking?

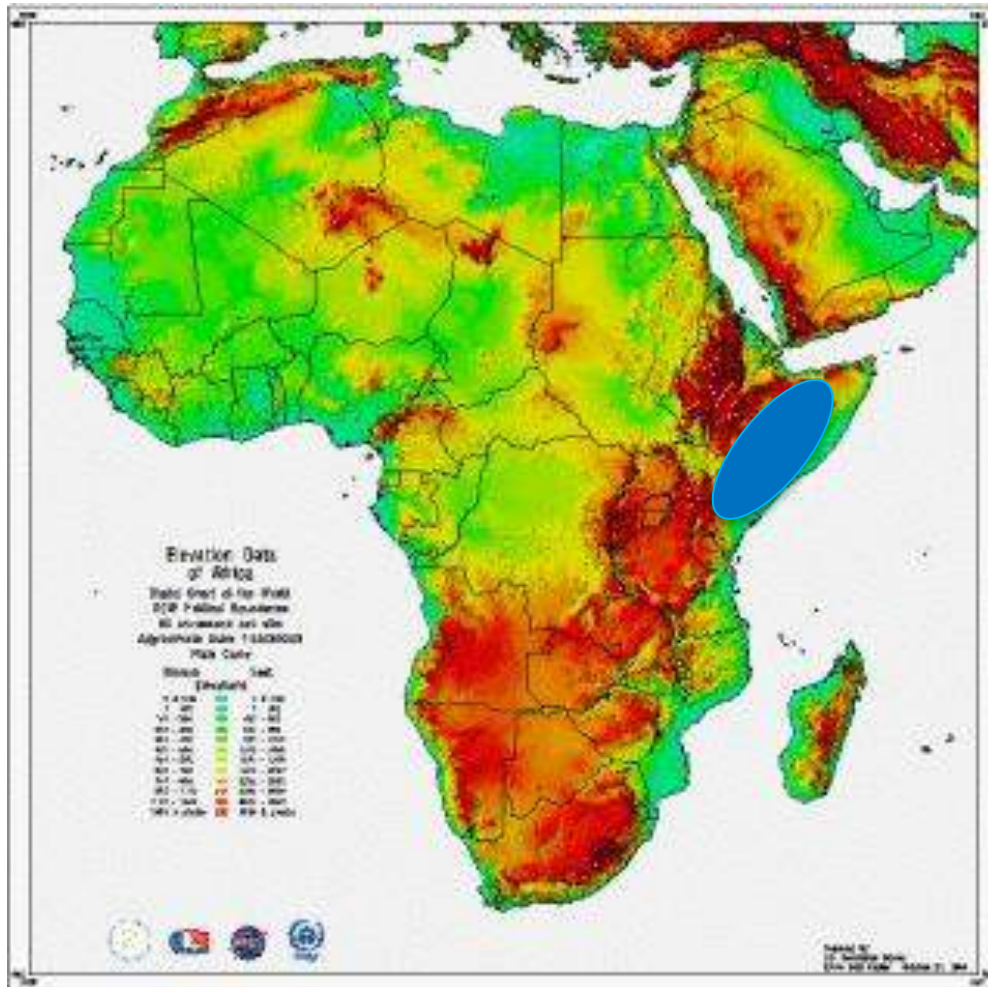
For control of voice in Motherese &/or song??  
(see upcoming FALK reading)

*Homo erectus* (and later?) hunters may have  
run prey to ground



So note, being BIPEDAL not only freed hands, but also promoted a new means of LOCOMOTION  
> > which in turn may have provided exaptation for Vocal Control  
> > which in turn may have provided basis for further Vocal Elaboration... Speech!

# Breath control for swimming?



- Lake in Great Rift Valley
  - Grows/shrinks through climate changes over eons
  - At times, largest lake on planet
- Early hominids likely foraged in lake
  - Developing swimming skills involves breath control

# Combinatorics

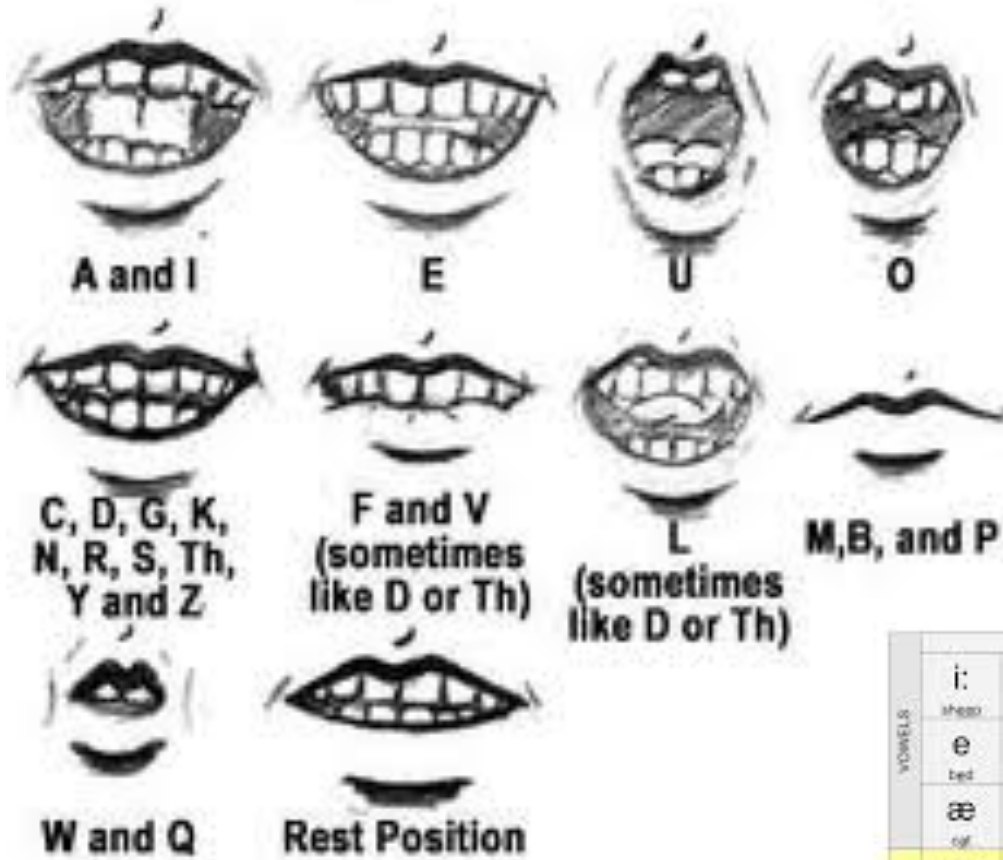
and the Emergence of Syntax

Speech involves **Subassembly** at multiple levels...



# Phonemes

The motoric components of speech



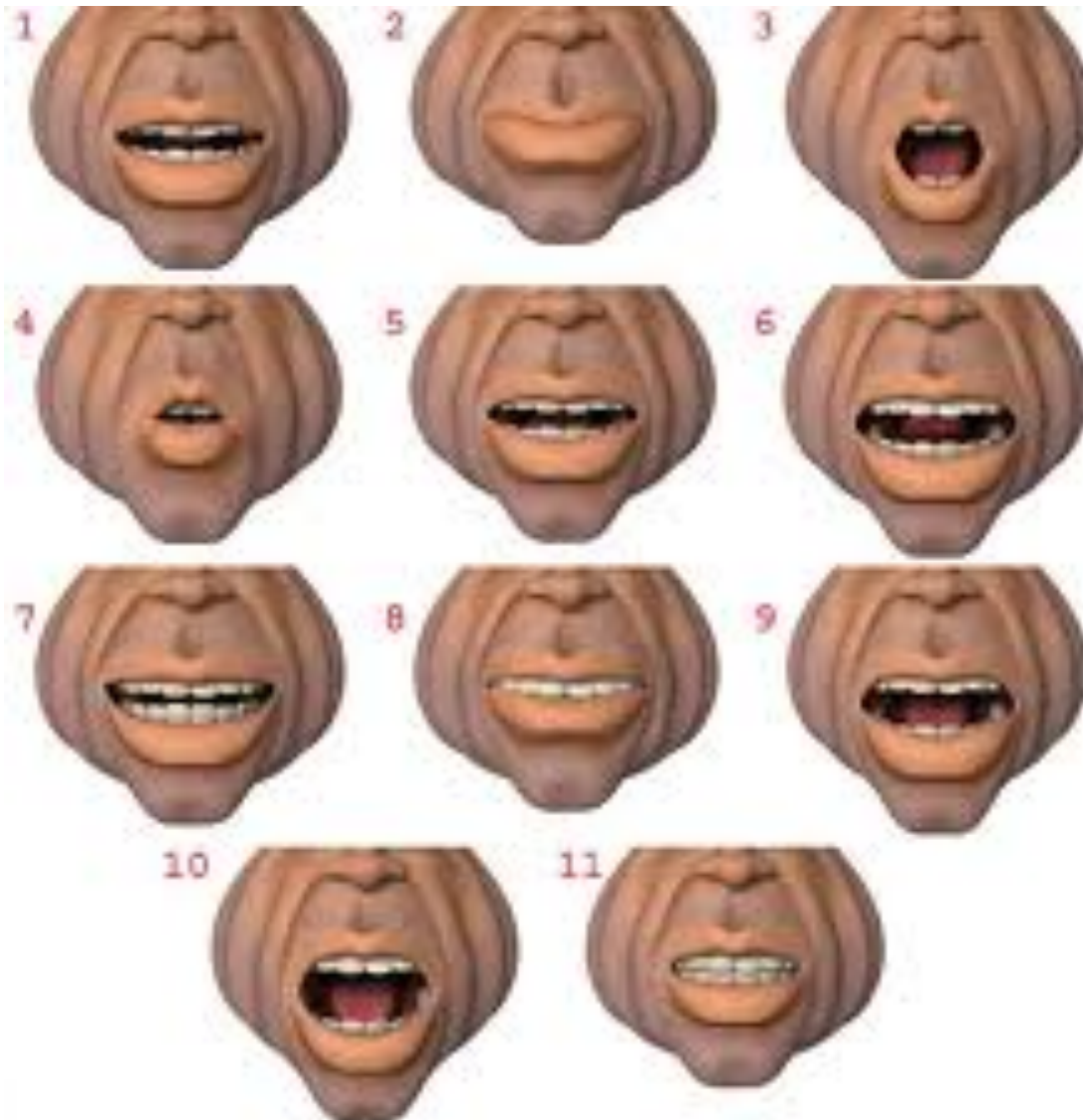
		inside of things				outside of things			Phonemic Chart voiced unvoiced
VOWELS		i:	ɪ	ʊ	u:	ɪə	eɪ		
		sheep	ship	good	shoot	here	wait		
		e	ə	ɜ:	ɔ:	ʊə	ɔɪ	əʊ	
		bed	teacher	bird	door	tourist	boy	show	
		æ	ʌ	ɑ:	ɒ	eə	aɪ	aʊ	
		rat	up	far	or	hair	ey	obe	
CONSONANTS		p	b	t	d	tʃ	dʒ	k	g
		pat	boat	tea	dog	church	June	car	go
		f	v	θ	ð	s	z	ʃ	ʒ
	by	video	think	this	see	zero	shall	televizjən	
	m	n	ŋ	h	l	r	w	j	
	man	now	sing	hat	love	red	yet	yes	

# Phonemic Sub-Assembly

Evidence from Speech Errors – “Spoonerisms”



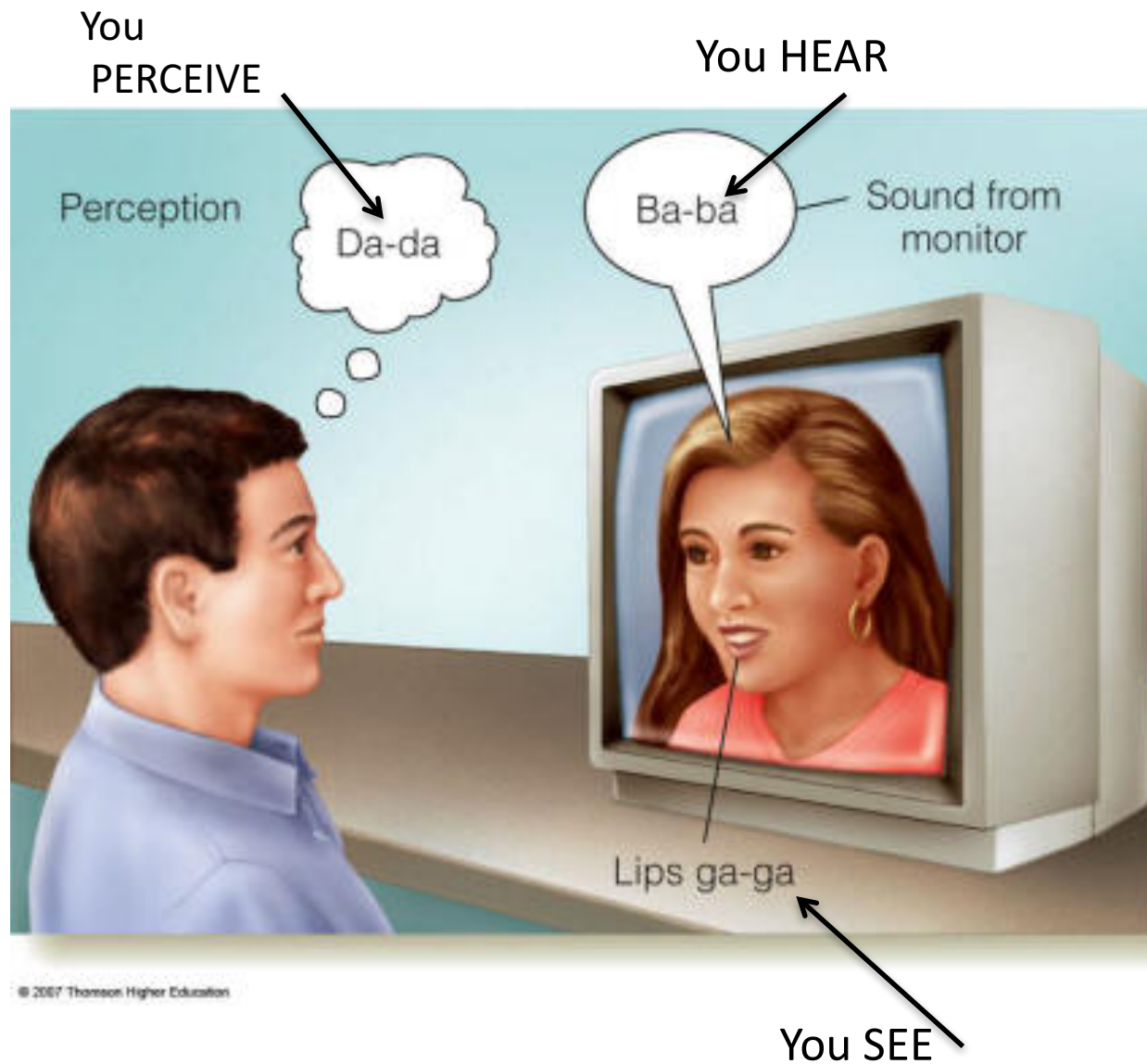
# Perception of Phonemes



Multi-Modal!

i.e. there is a visual component to speech reception

# Mc Gurk Effect - The Multi-Modality of Speech



# Prosody

Emotional tone, emphasis, cadence, etc.



Right hemisphere dominance!

# Morpheme – Smallest “meaningful” unit

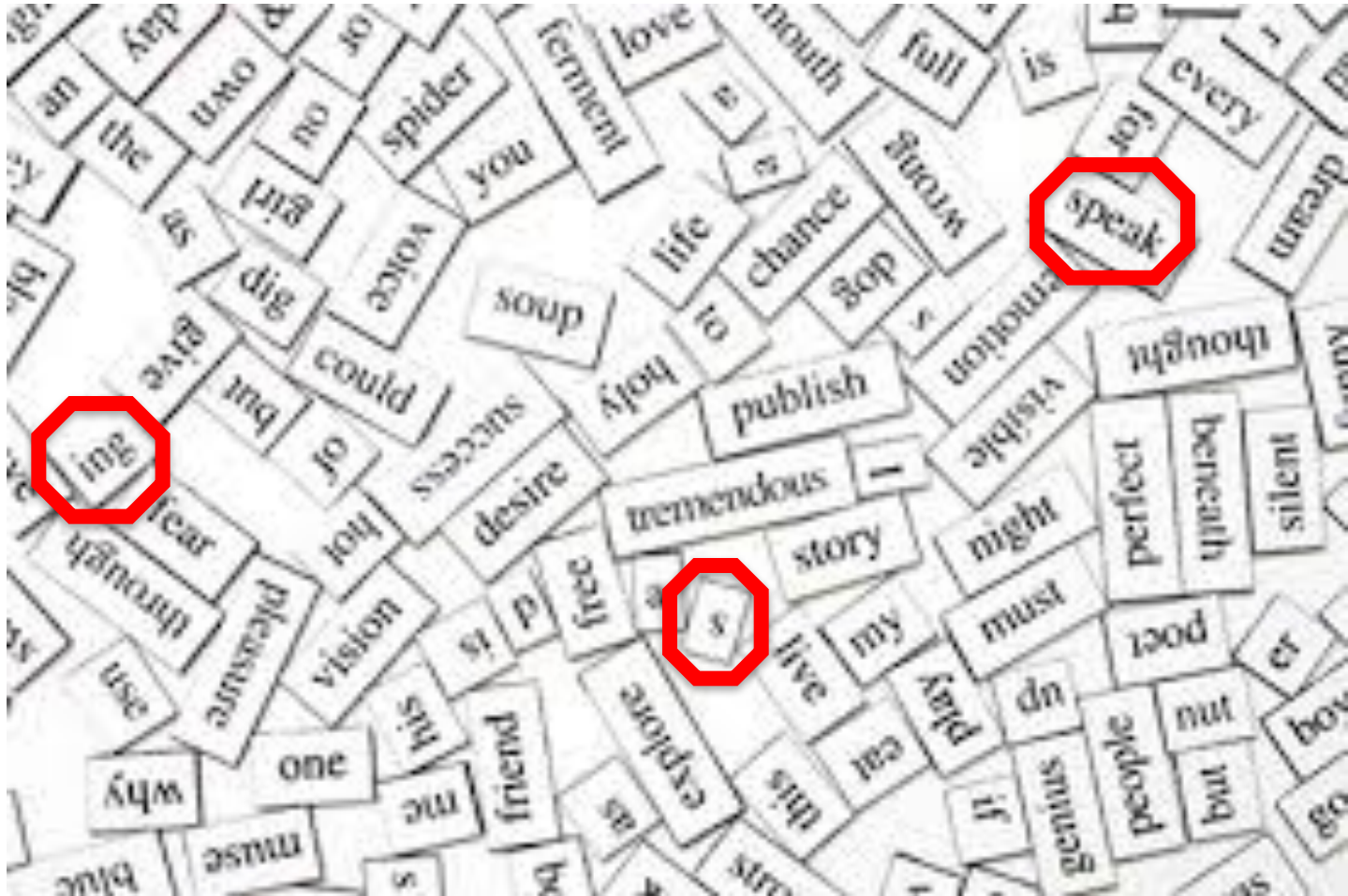
## MORPHEME

is the most elemental grammatical unit in the given language. A single word may be composed of one or more morphemes :

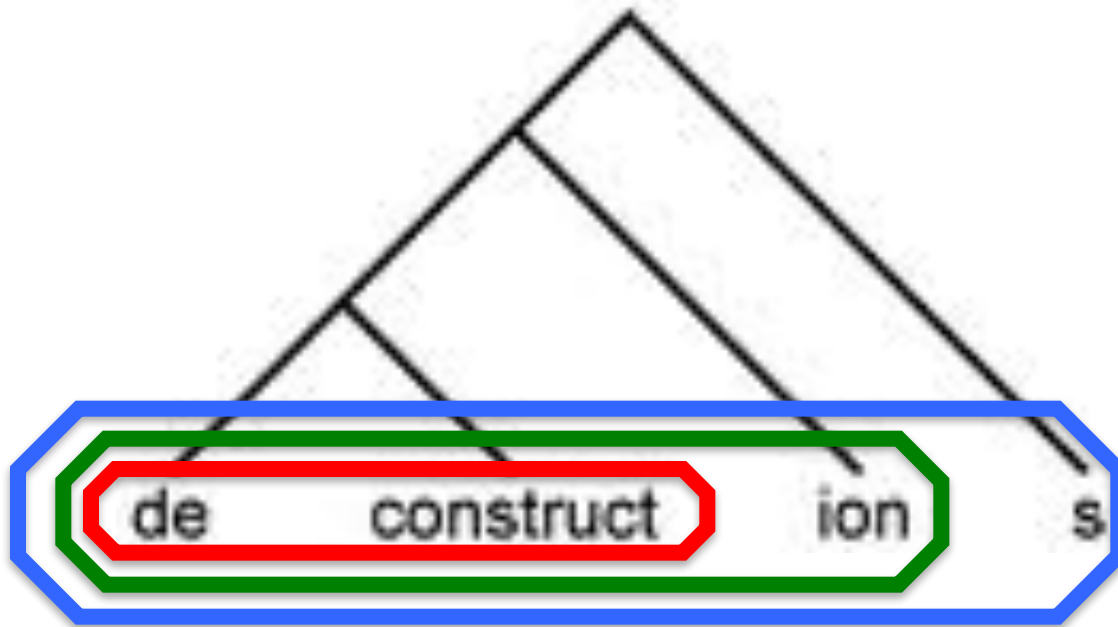
- one morpheme: boy
- two morphemes: boy+ ish
- three morphemes: boy+ish+ness
- four morphemes: un+ desire+able+ity



# Morphemes – Smallest meaningful unit



# Morphemes combined



= Words

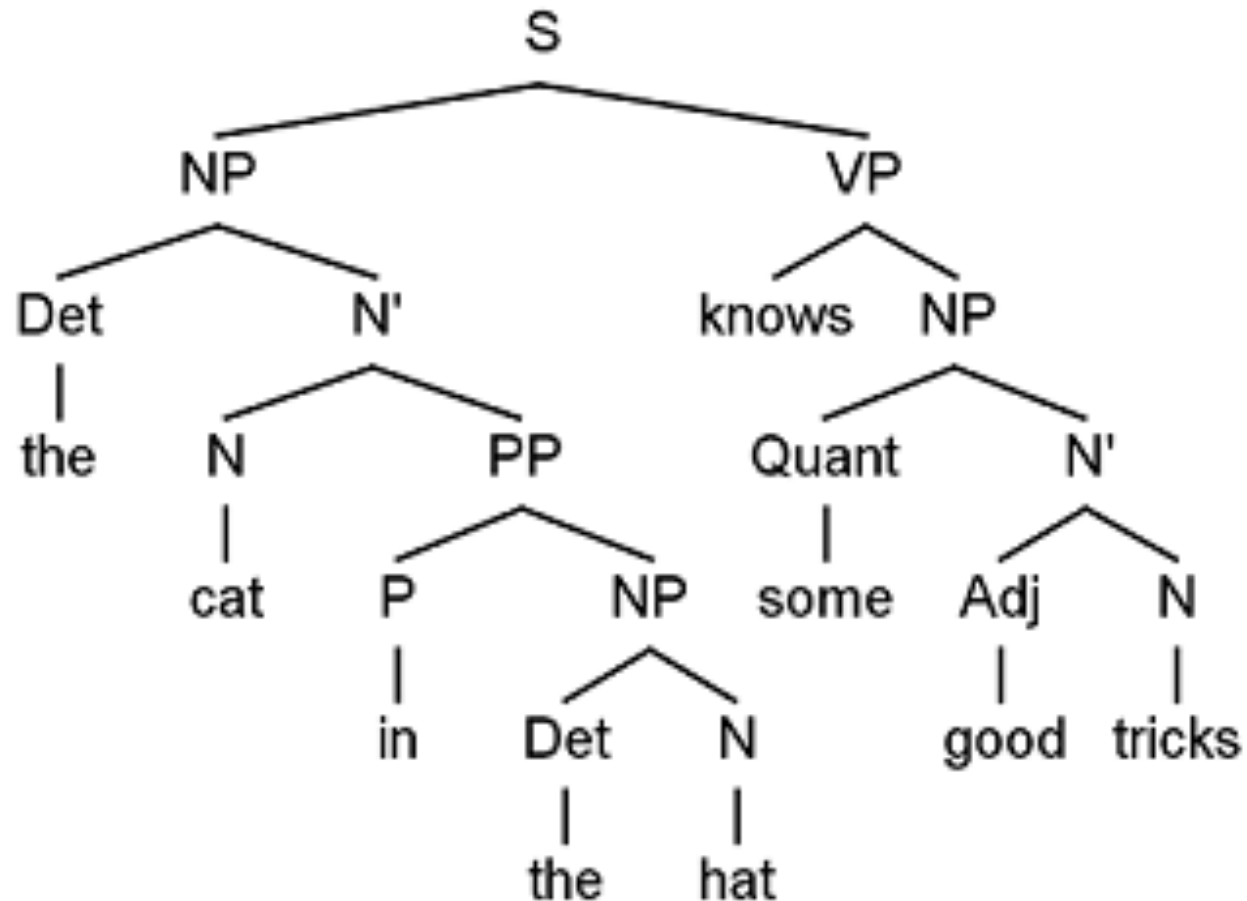




# Diversity! Paralleled in praxis?

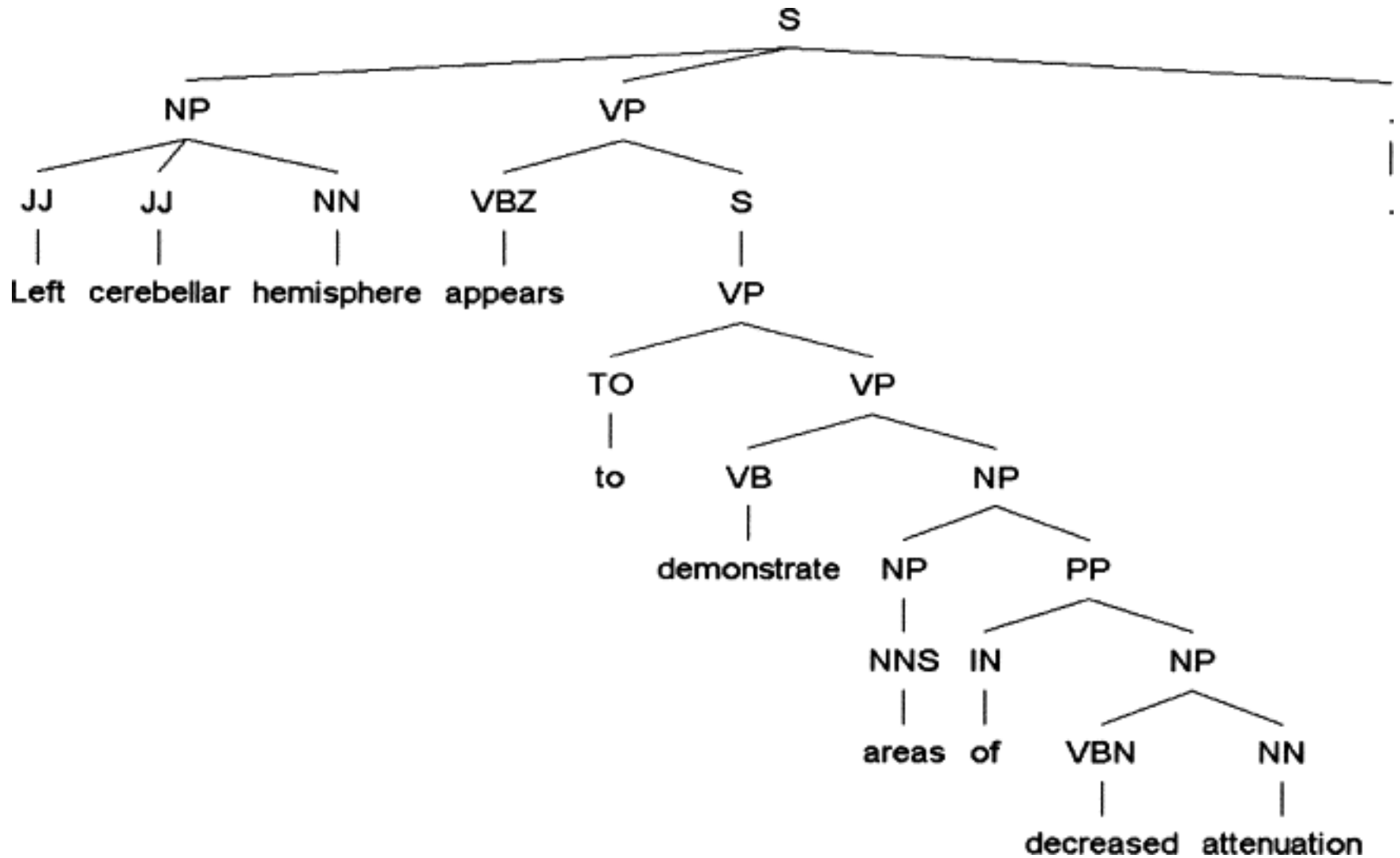


Sentences = Words are Sub-Assembled



**Hierarchically Embedded**

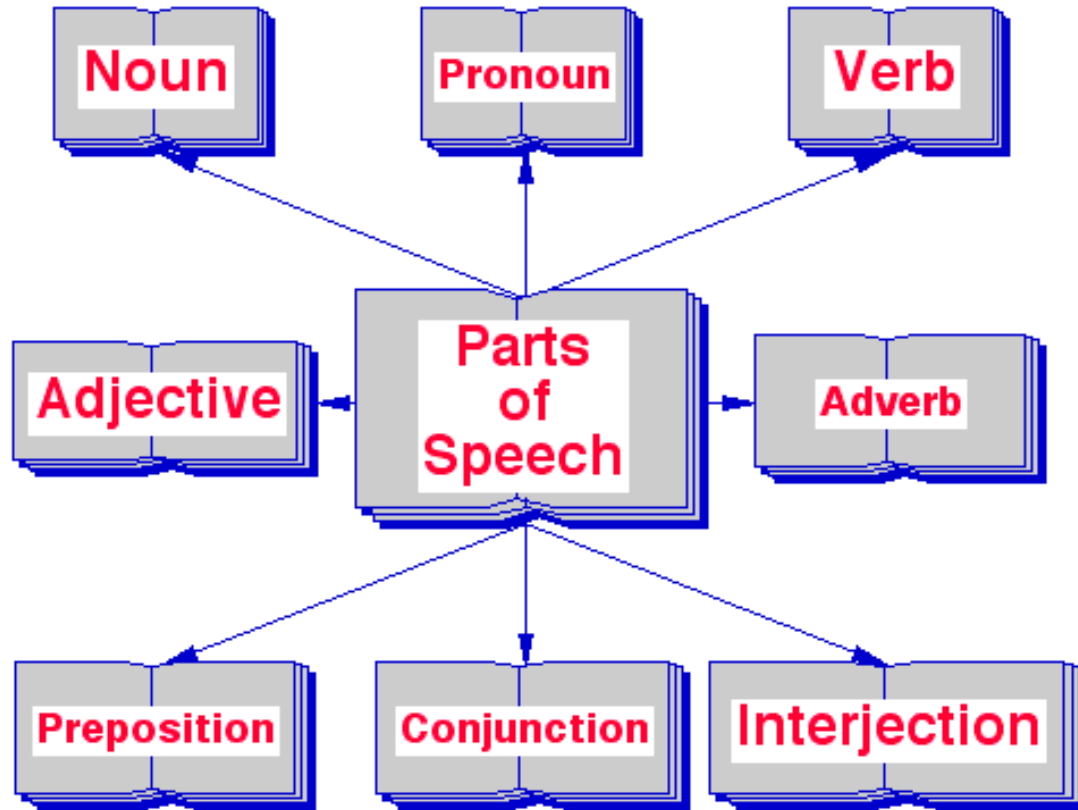
# Sentences – Words Sub-Assembled



## Syntactic Rules of Organization

- Rules for combining morphemes into coherent strings = “complete idea” (sentence)
  - e.g. NP(Art,N), VP(V, NP(Art,N)) etc
  - e.g. Word Order (Dog bites man, Man bites dog)
- Robust schematic scaffolding that prompts content & supports interpretation
  - e.g. “The boy saw the \_\_\_\_\_”
  - Select: “easily”? “sang”? “brown”? “book”?
  - From position in sentence, know that missing word must be a NOUN
- NOTE: Language trained animals can also learn what “type” of symbol required by its position in such a sequence!

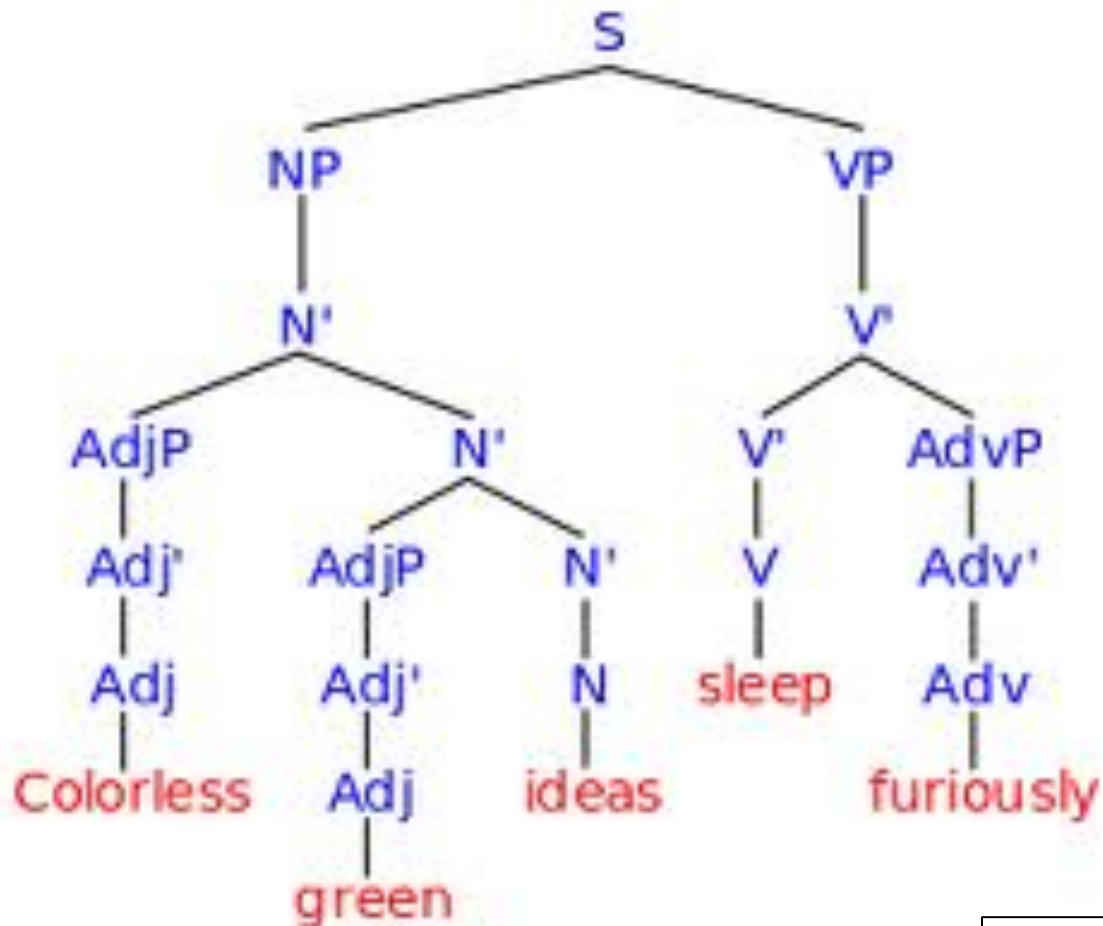
We classify words, in part, by their syntactic roles



The meaning of words is also influenced by these classifications

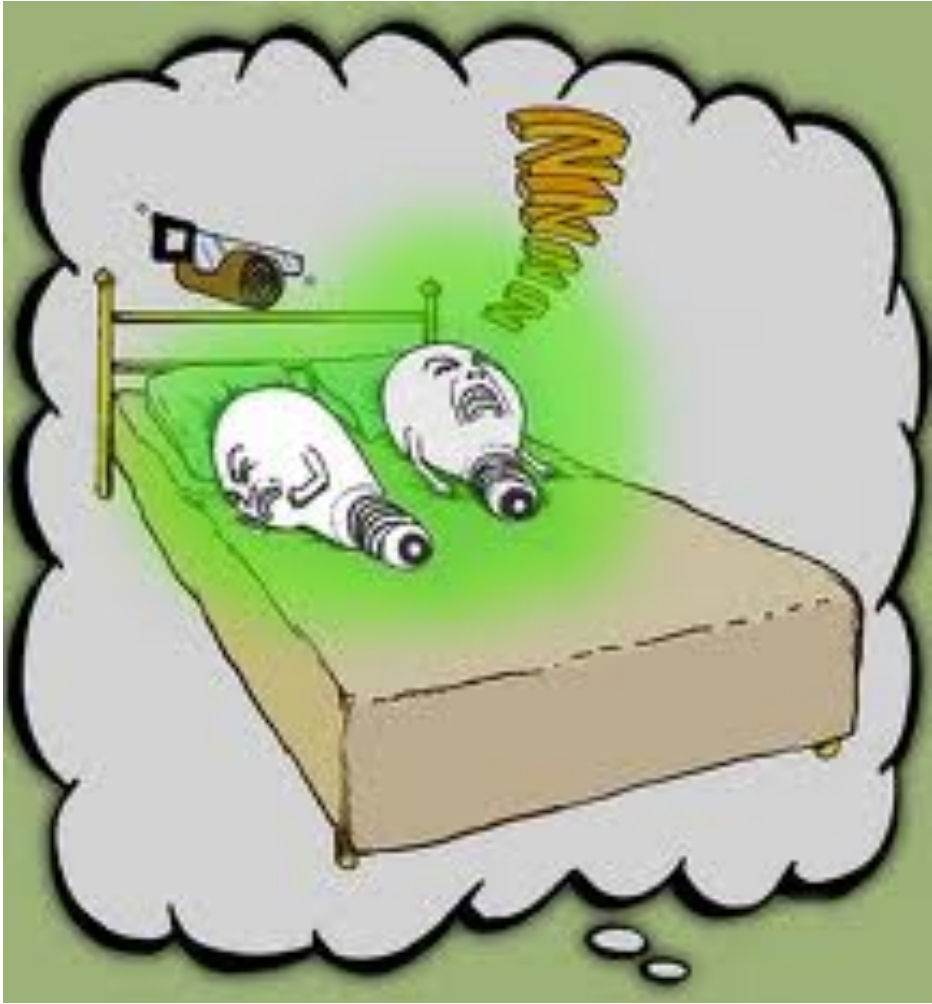
# Syntactical meaning

Colorless green ideas sleep furiously Vs. Green furiously ideas colorless sleep



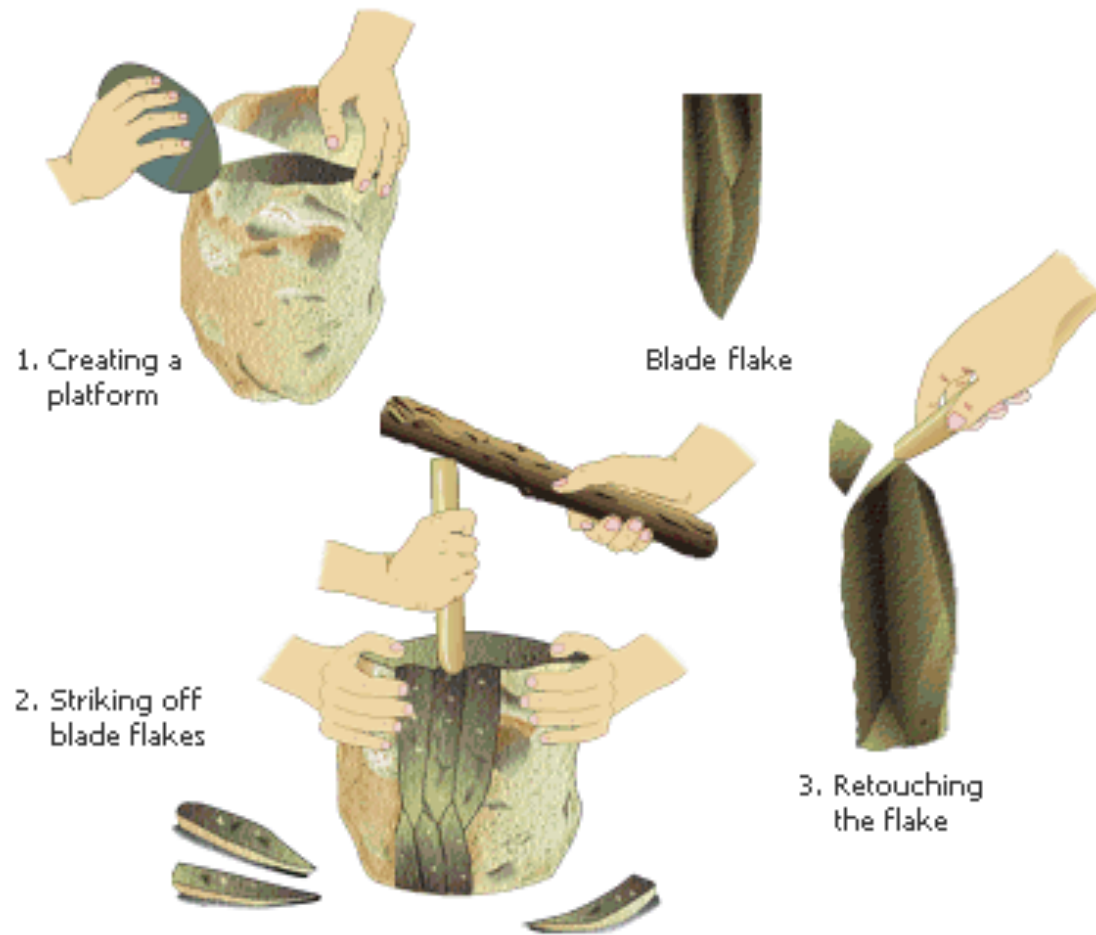
Noam Chomsky

Colorless Green Ideas Sleep Furiously ?





# Combinatorics in Prehistoric Tool Making



**LAVALLOIS**  
(*Homo neanderthalensis*)  
Preparing the core  
requires  
**embedded subroutines**  
in a specific order

# Combinatorics in Prehistoric Tool Making



## **MOUSTERIAN**

*(Homo neanderthalensis)*

### **Subassemble**

different materials  
from different places  
to make composite tools

# Combinatorics in Prehistoric Tool Making



*Homo neanderthalensis*  
Jewelry

So again, if  
Neanderthal shows  
tool combinatorics,  
how about vocal??

# Reference

Point to, Represent, Be about...  
something else



dog



Iconic vs. (Arbitrary) Symbolic Reference

# Reference

## Iconic Reference

Signal bears a resemblance to that to which it refers



## Symbolic Reference

Arbitrary signal refers by our mutual (conventional) agreement

- Bears no resemblance to its referent

**big**      **infinitesimal**

If Mimesis (Iconic Reference) came first,  
how did we shift from Iconic to Symbolic reference??

# Prehistoric Reference

Material evidence of "reference" emerges in HUMANS ~35,000 YA



Notice how **ICONIC** they are!

But, given that they are **REPRESENTATIONAL** (e.g. 2D not 3D)  
they are still "about" something other than themselves...

# Earliest Markings



~9,000 Years Ago  
"Tally marks"



~5,500 Years Ago  
First writing  
(Hiroglyphic)



Note, still *kind of* "iconic"  
in that there is  
a fairly direct, perceptual mapping  
from symbol to referent...

# From Icon to Symbol . . . ?!



Mimic  
a bird



Agree to  
call it  
"bird"



Imitate a  
bird's call



Bird as metaphor



# Mimetic Narrative

- Develops initial combinatorics (combining iconic bits) for telling lies, fiction, humor, etc
- Social practices become more & more dependent on such “telling” (e.g. scouts, gossip)
- Refined practice involves more detail, finesse, precision, imagination . . .



# Lexicon Growth

## Onomatopoeia



Helps establish REFERENCE (esp to *absent* events) as typical, then required in communication

Perhaps gradually lose dependence on resemblance, shift to conventional association...

# Lexicon Growth Combinatorics



"Ow!" plus "Gurgle"  
= "Owrgurgle"  
= Creek where I fell that time...



Gradually can forget (no longer depend on) iconic reference,  
as practice of associative naming increases

# The Emergence of the Lexicon

## Expertise / Apprenticeship

- Co-develop refinements in discrimination and practice
- Including generating terms to refer to those distinctions
- i.e. Experts & Novices converge on a set of terms - "jargon"



# The Emergence of the Lexicon

## Expertise / Apprenticeship

- Co-develop refinements in discrimination and practice
- Including generating terms to refer to those distinctions
  - i.e. Experts & Novices converge on a set of terms - "jargon"

## Goodwin 1994: "Professional Vision"

- Geologists-in-training have to learn to see what matters to a geologist
- This supported by attention-directing,  
domain-specific vocabulary.



All collaborative activity  
has an associated vocabulary

# The Emergence of the Lexicon

As *Homo sapiens* diversify, specialize

>> a multiplication of things to say



More types, more aspects,  
to name and discuss . . .

# The Emergence of the Lexicon

Just as growing hominid dependence on tools selected for  
tool making/designing/using abilities,  
perhaps....

A growing dependence on Mimesis  
selected for better narrative abilities...

...and growing dependence on Narrative  
(deceiving/informing) selected for better capacity for reference...

...and growing dependence on Reference ("Hearsay"),  
selected for expansion of vocal repertoire, including symbols.....

...and growing dependence on Symbols,  
selected for enlarged lexicon, syntax, external representations, etc...

??!