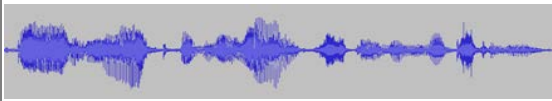


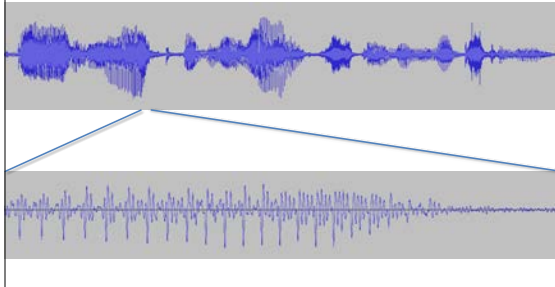
## The Language Problem



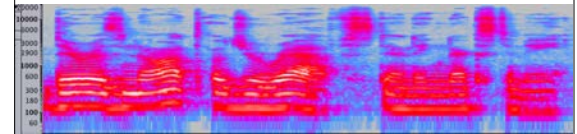
The thinks you can think



## What sound waves look like (kind of)

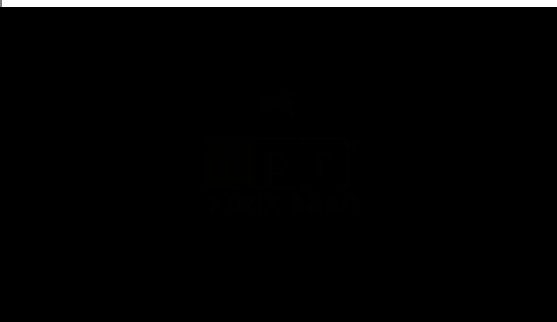


## Sound represented as frequency x time

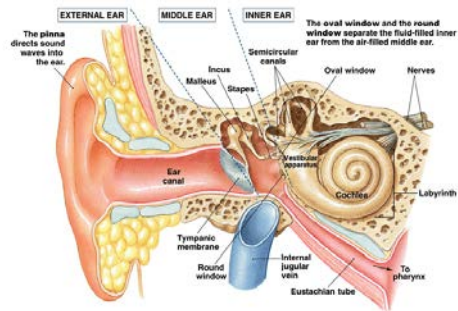


A spectrogram

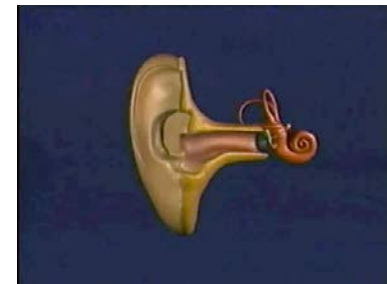
## What sound waves look like (really)

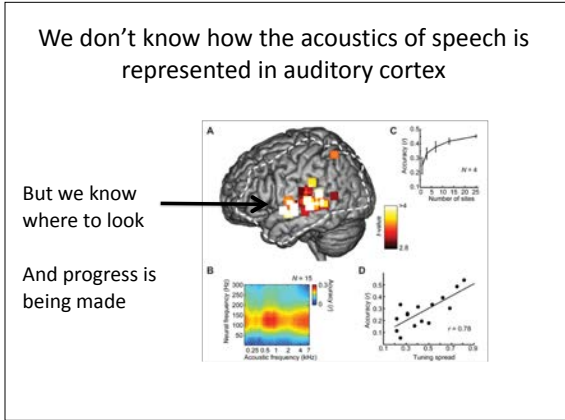
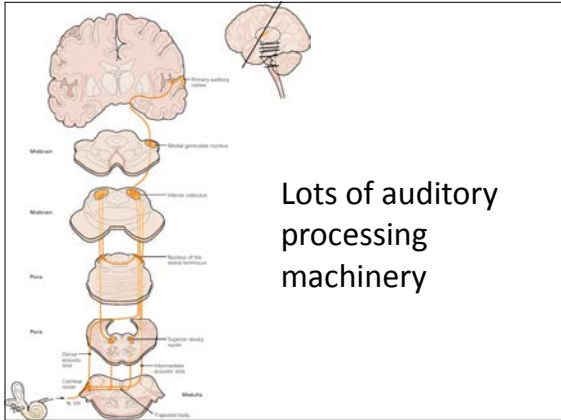


## A mechanism to convert sound into nerve signals



## Frequency Encoding in the Cochlea





BUT...

Even if (when) we figure out how speech acoustic patterns are coded in the brain, we aren't done

### The Language Problem

A complicated think!

There is not a giraffe standing next to me

Hard to even express without language!

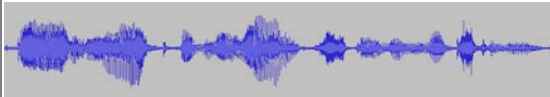
### The Language Problem

It is not a giraffe standing next to me

There is not a giraffe standing next to me

Subtle word change —> changes the think!

## The Language Problem



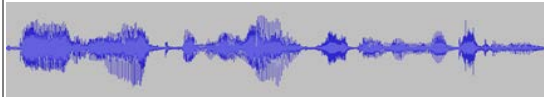
It is not a giraffe standing next to me

There is not a giraffe standing next to me

It is not THE giraffe standing next to me



## The Language Problem



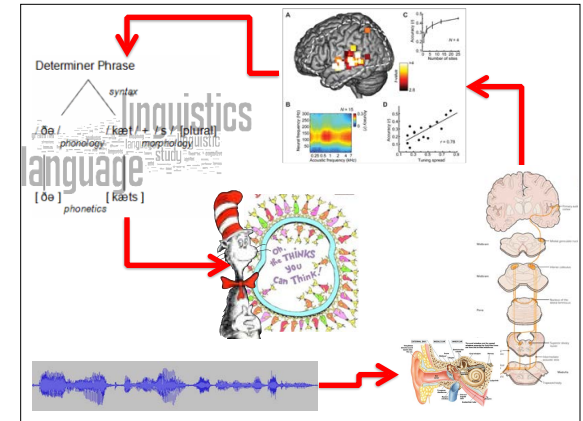
It is not a giraffe standing next to me

There is not a giraffe standing next to me

It is not THE giraffe standing next to me



It is not the giraffe standing next to me that I was thinking about!



What about talking?

## The ridiculous complexity of speech motor control



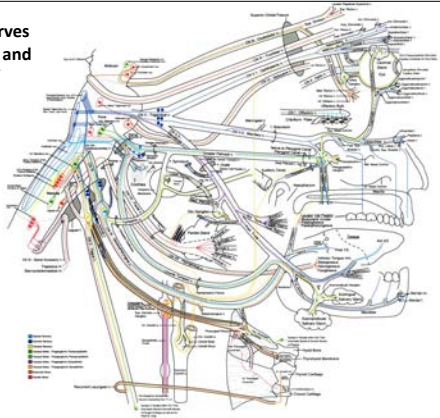
Busta Rhymes on  
Chris Brown—Look at me now

## The ridiculous complexity of speech motor control

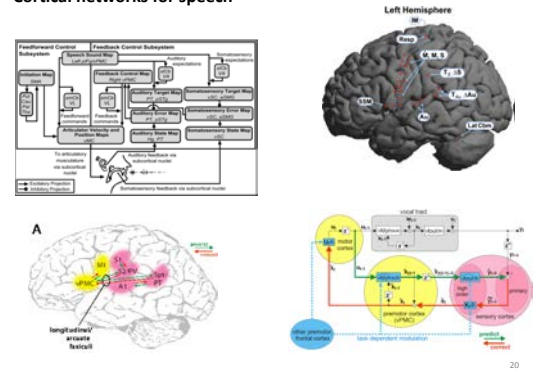


Not Busta Rhymes doing  
Chris Brown—Look at me now

**Cranial Nerves for speech and other stuff**



**Cortical networks for speech**



But again, even if (when) we figure out how the speech articulators are controlled by the brain, we aren't done

Write down a one-sentence description of this scene



Actual sentences people said

- The baby is crying
- Both kids are upset but for different reasons
- The girl covered her ears as her baby brother cried
- The little girl is covering her ears at her little brother's crying

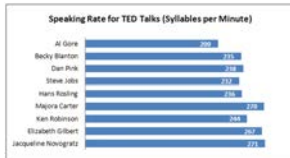
To-do list for sentence building

- Pick the structure that matches the focus
  - The baby's cry...
  - The girl covered her ears...
- Pick the words
  - Cry, scream, yell, screech ...
- Add some morphology
  - -ing, -s, -eg
- Sequence the sounds in the words
- Add stress
  - The KIDS are screaming.
  - The kids are SCREAMING.
  - The kids ARE screaming.

And you do it all on-the-fly at a rate of about 3-4 syllables/second

200 syllables/min =  
3.33 syllables/sec

271 syllables/min =  
4.5 syllables/sec



Speaking Rate for TED Talks (Words per Minute)



133 words/min =  
2.21 words/sec

188 words/min =  
3.13 words/sec

25

And you can lose it all in heartbeat (literally)



Aphasia: the loss of language due to brain injury

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