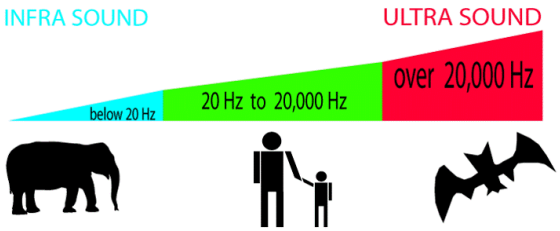
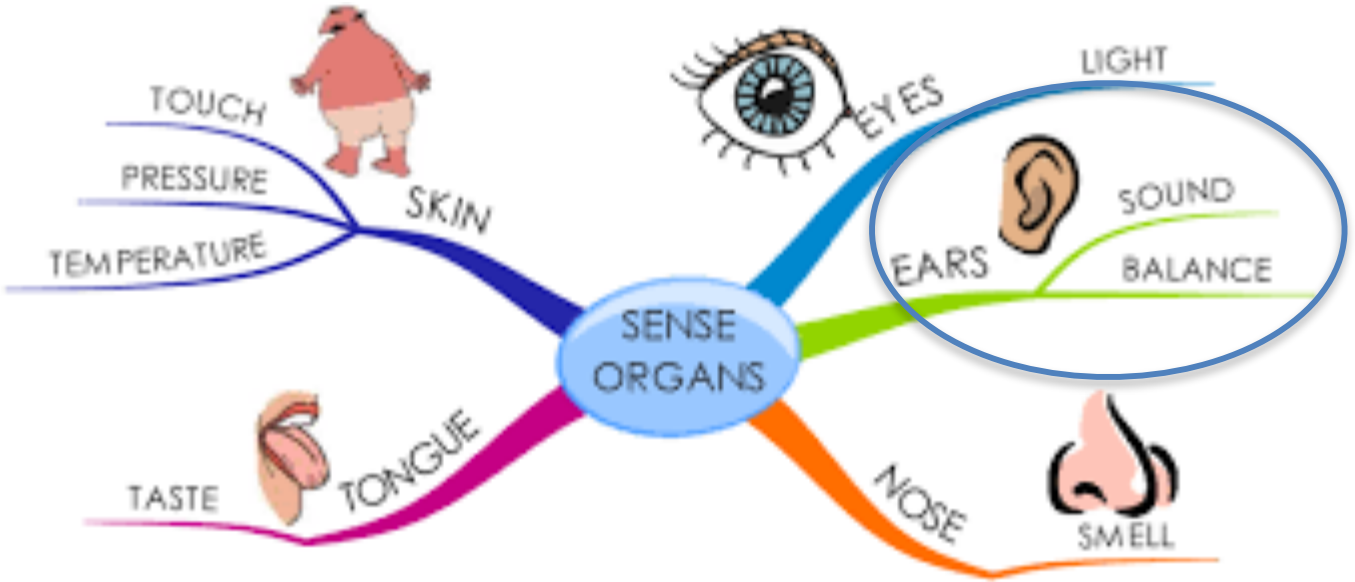
CSE485: Sensation & Sensory Systems

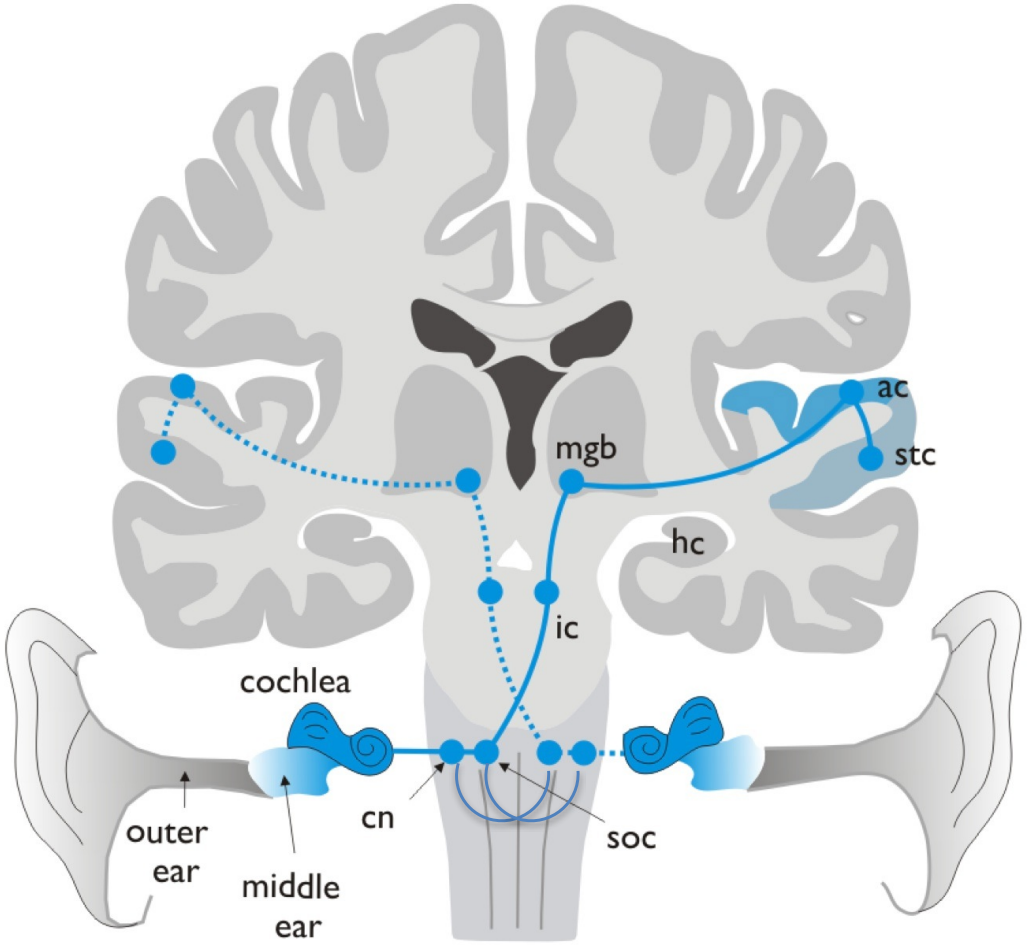
Vinoo Alluri



Sensory Systems



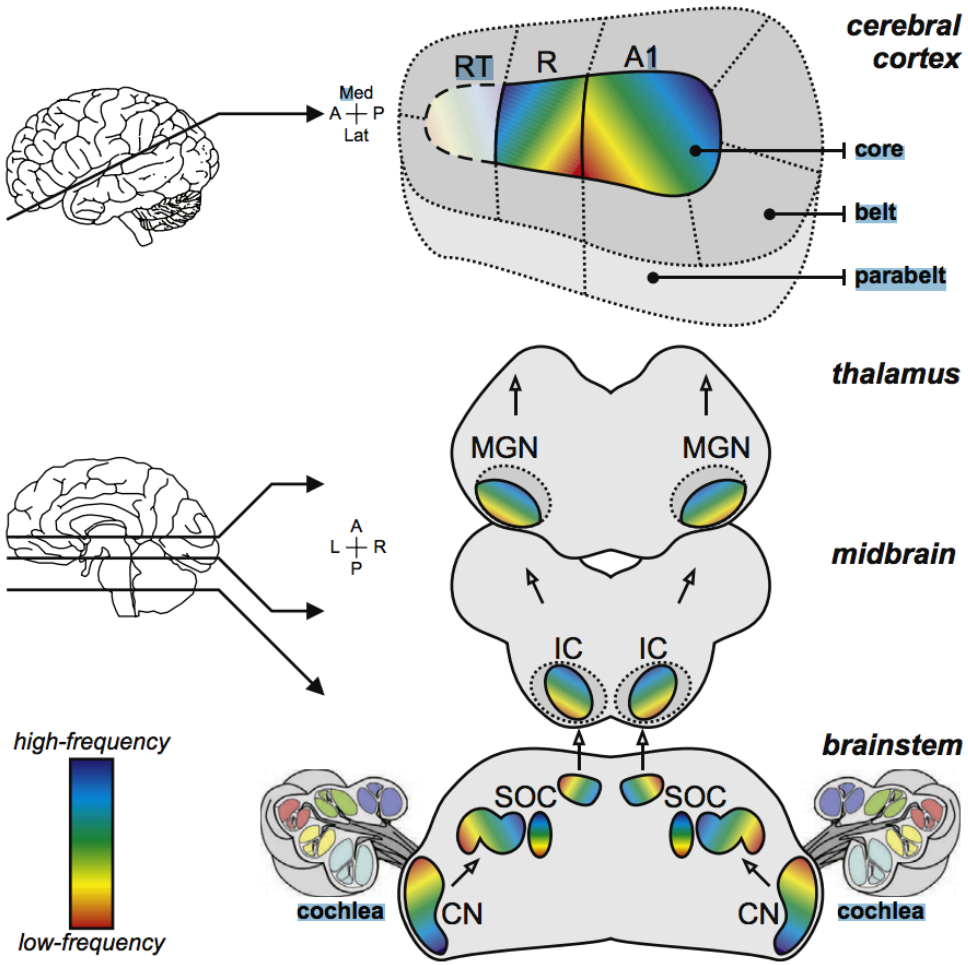
Auditory pathway



tonotopic organization (Ress & Chandrasekaran, 2013)

Frühholz, S., Trost, W., Grandjean, D. (2014) The role of the medial temporal limbic system in processing emotions in voice and music. Prog Neurobiol.

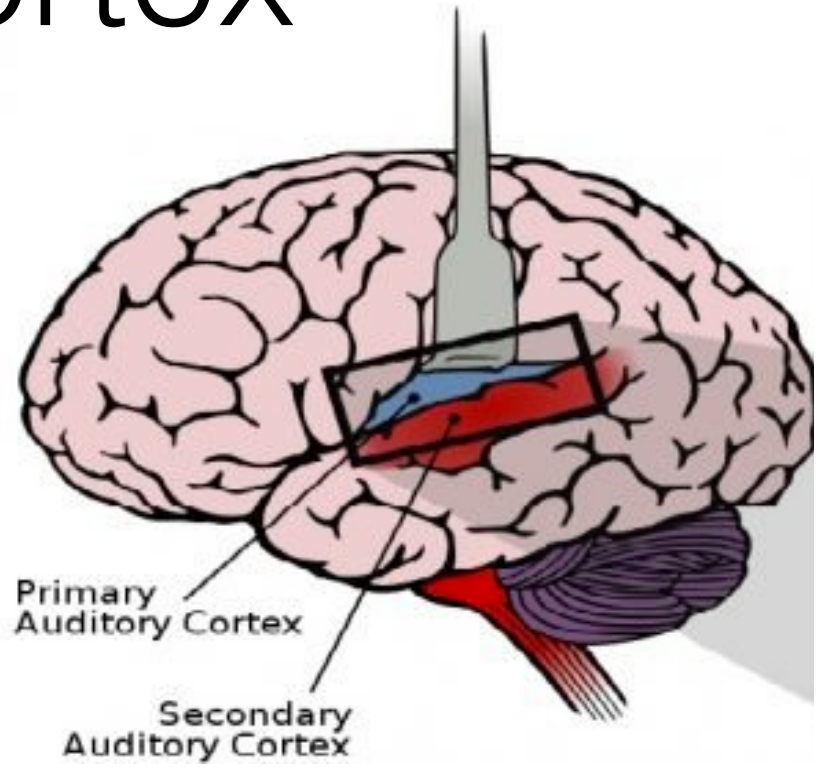
Frequency Encoding

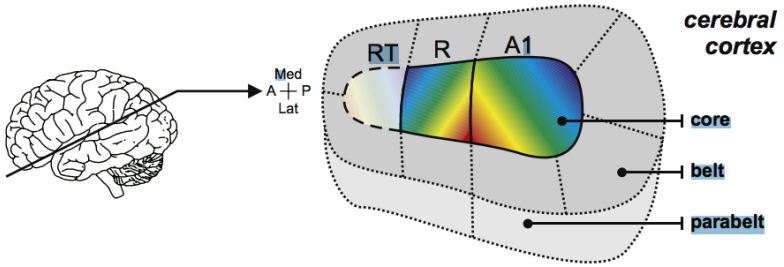


Saenz & Langers (2013) Tonotopic mapping of human auditory cortex. Hearing Research.

Auditory cortex

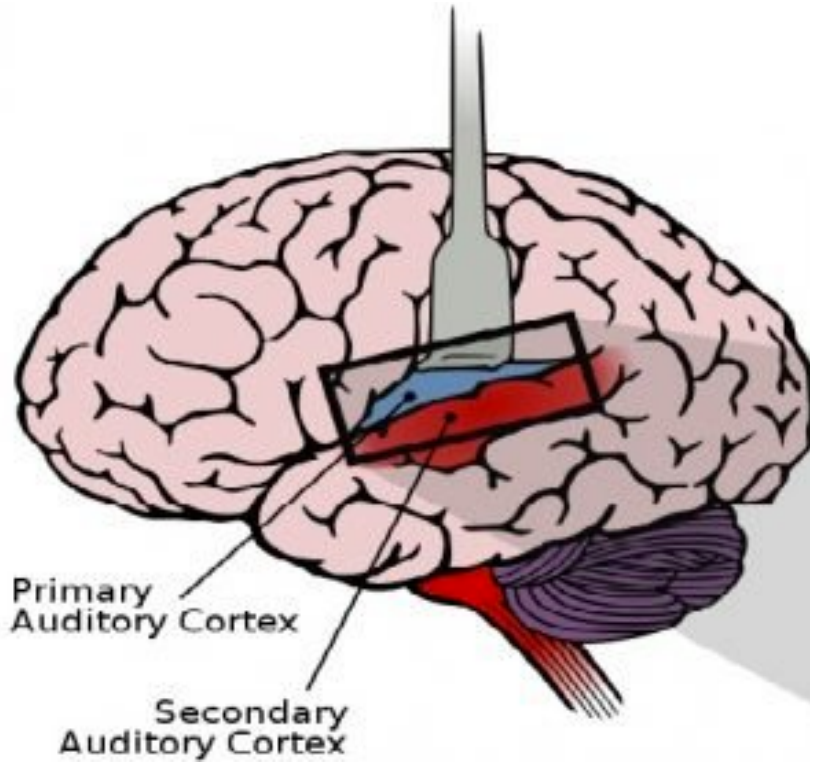
- **primary auditory cortex (PAC)**
  - BA 41 (42) - Heschl's gyrus
  - in the temporal lobe
  - projects to numerous secondary cortical areas including multisensory areas (allow us to recognise animals or humans by both sound and sight) and to regions specifically involved in communication





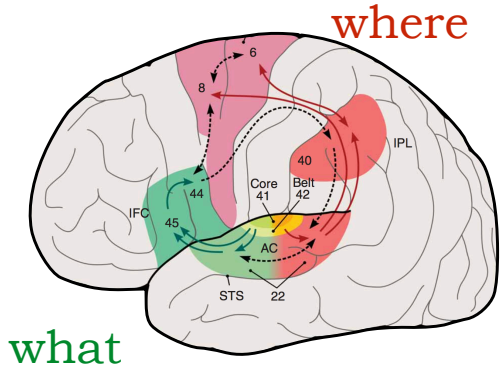
Auditory cortex

- **secondary auditory cortex**
  - BA 22 - Superior temporal gyrus
  - home to Wernicke's area (association)
  - **left** possesses **greater temporal** resolution
  - **right** associated with **greater spatial** resolution
-



Dual Pathways in the brain

- represent the "**where**" and "**what**" of the sound on hand
- postero-dorsal stream that encompasses both **spatial** and **language** functions
- hierarchical organization in the antero-ventral auditory pathway of humans is important in **auditory pattern recognition** and **object identification**.



Rauschecker and Scott, 2009

Speech areas

Broca's area (BA 44,45):

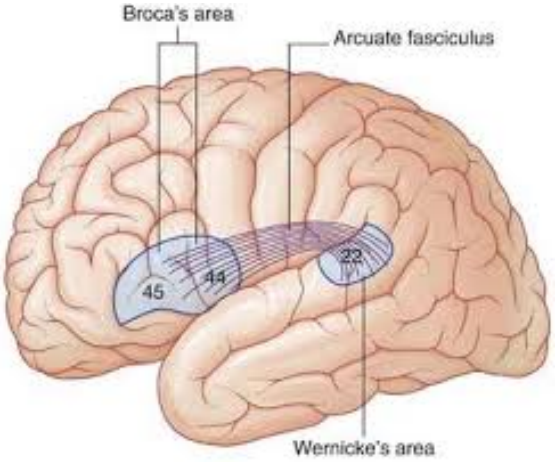
- function: speech **production**/expression
- **lesion: non-fluent aphasia -** partial loss of the ability to produce language (spoken or written), although comprehension generally remains intact

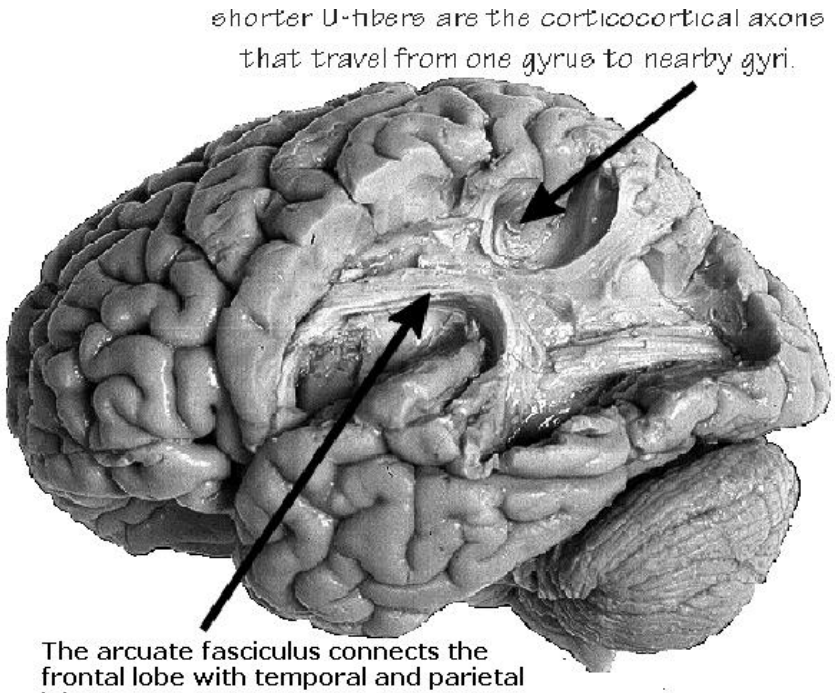
Wernicke's area (BA 22):

- function: comprehension or understanding of written and spoken language/**reception**
- **lesion: fluent aphasia -** fluently connects words but meaningless

Arcuate fasciculus

- a large white matter bundle directly liking Broca's and Wernicke's areas
- greater proportion on the left





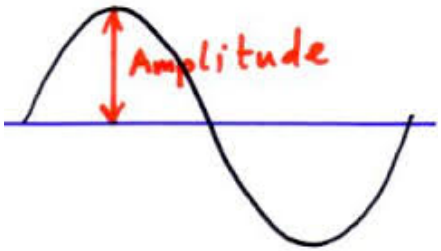
SENSATION

PERCEPTION

LOUDNESS

Frequency

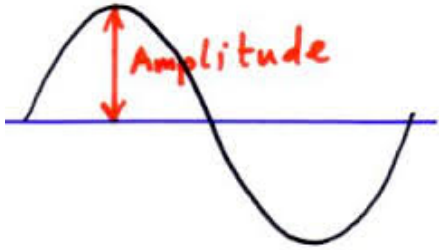
pitch



Timbre

SENSATION

PERCEPTION



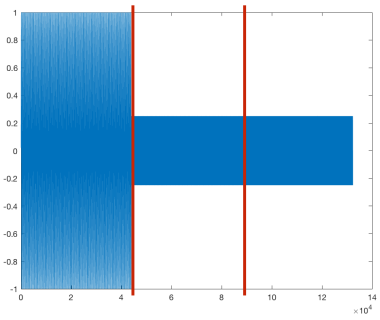
?

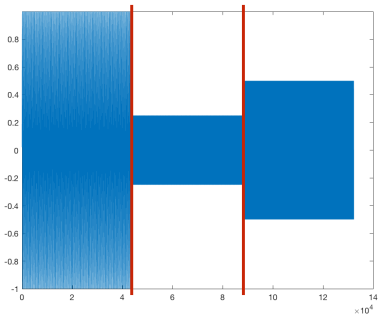
Timbre

interaction

150 Hz **1000 Hz** **5000 Hz**

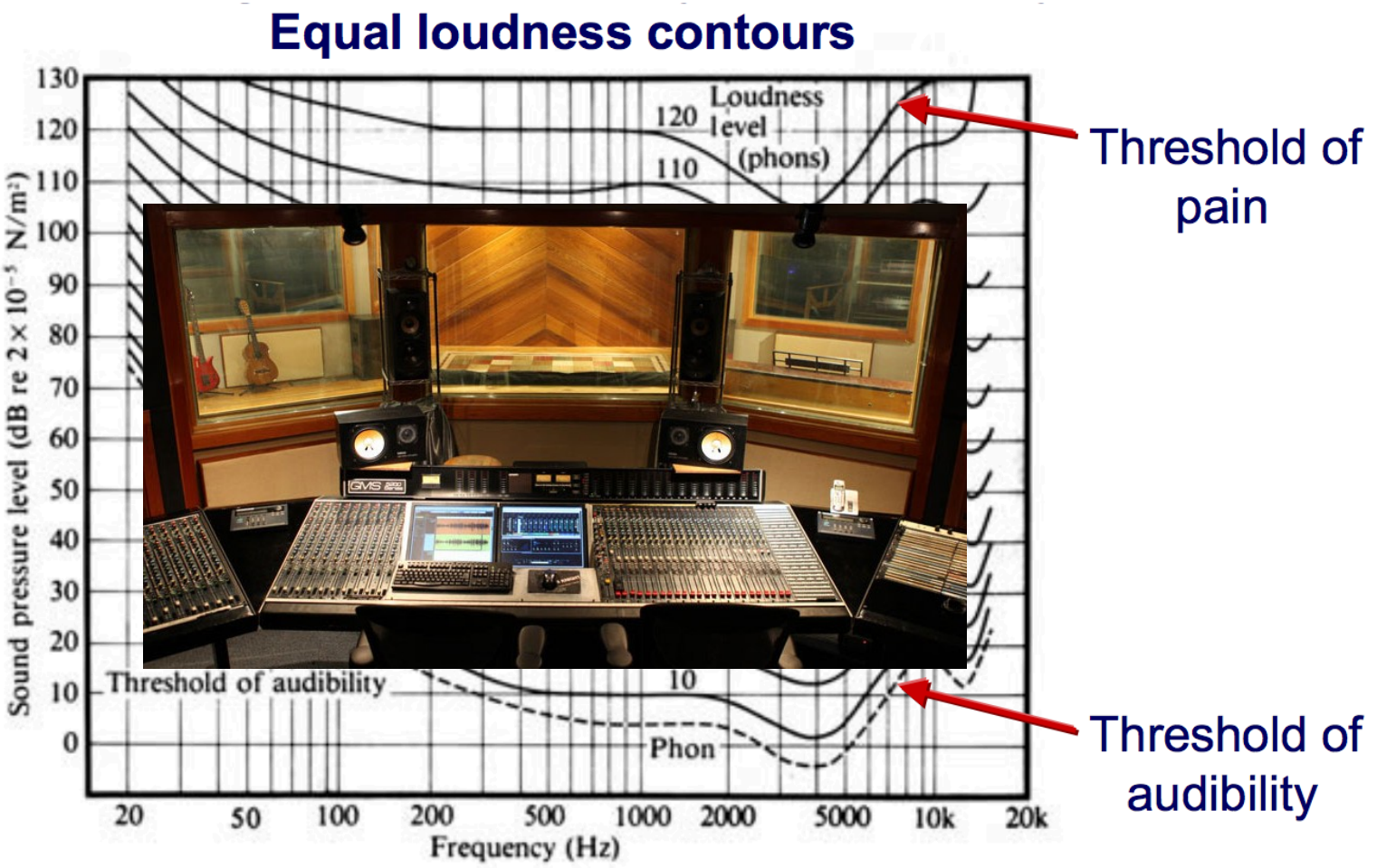
Which sine wave sounds louder?





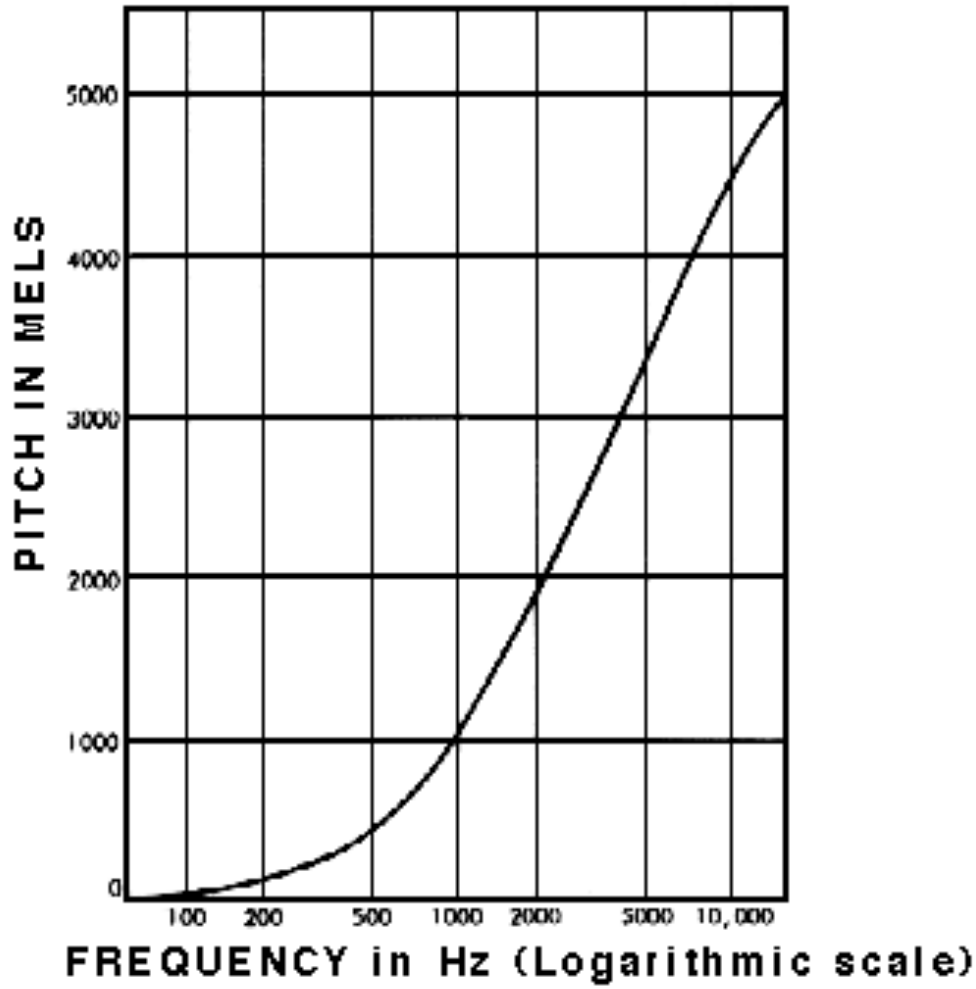
Sensation to Perception

- sensitivity of hearing depends heavily on frequency




Frequency


pitch


PITCH IN MELS
5000
4000
3000
2000
1000
0
100
200
500
1000
2000
5000
10,000
FREQUENCY in Hz (Logarithmic scale)

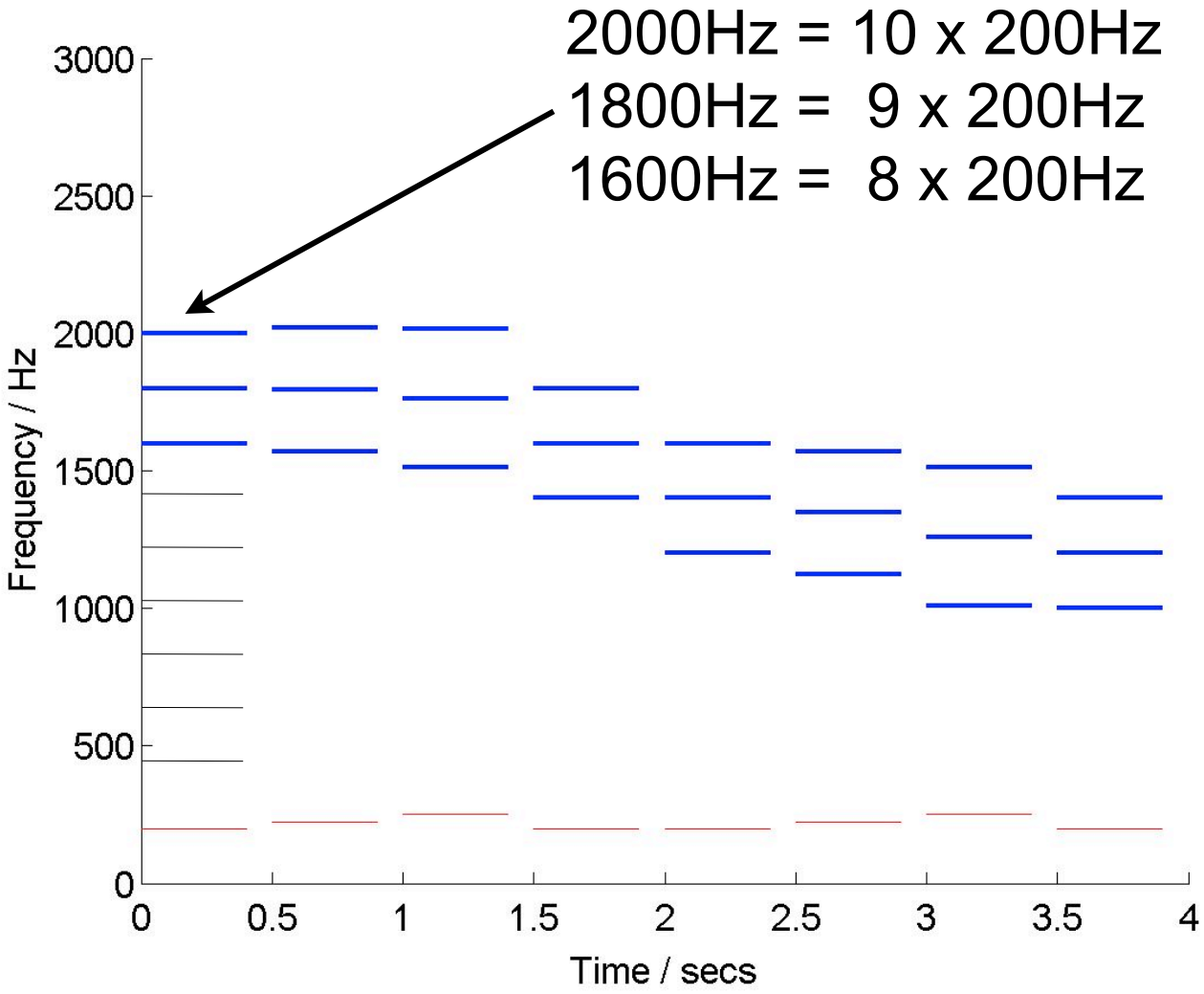
Spectral vs. virtual pitch

- spectral pitch
    - corresponds to frequencies present in the tone
- virtual pitch
    - corresponds to frequencies not necessarily present in the tone

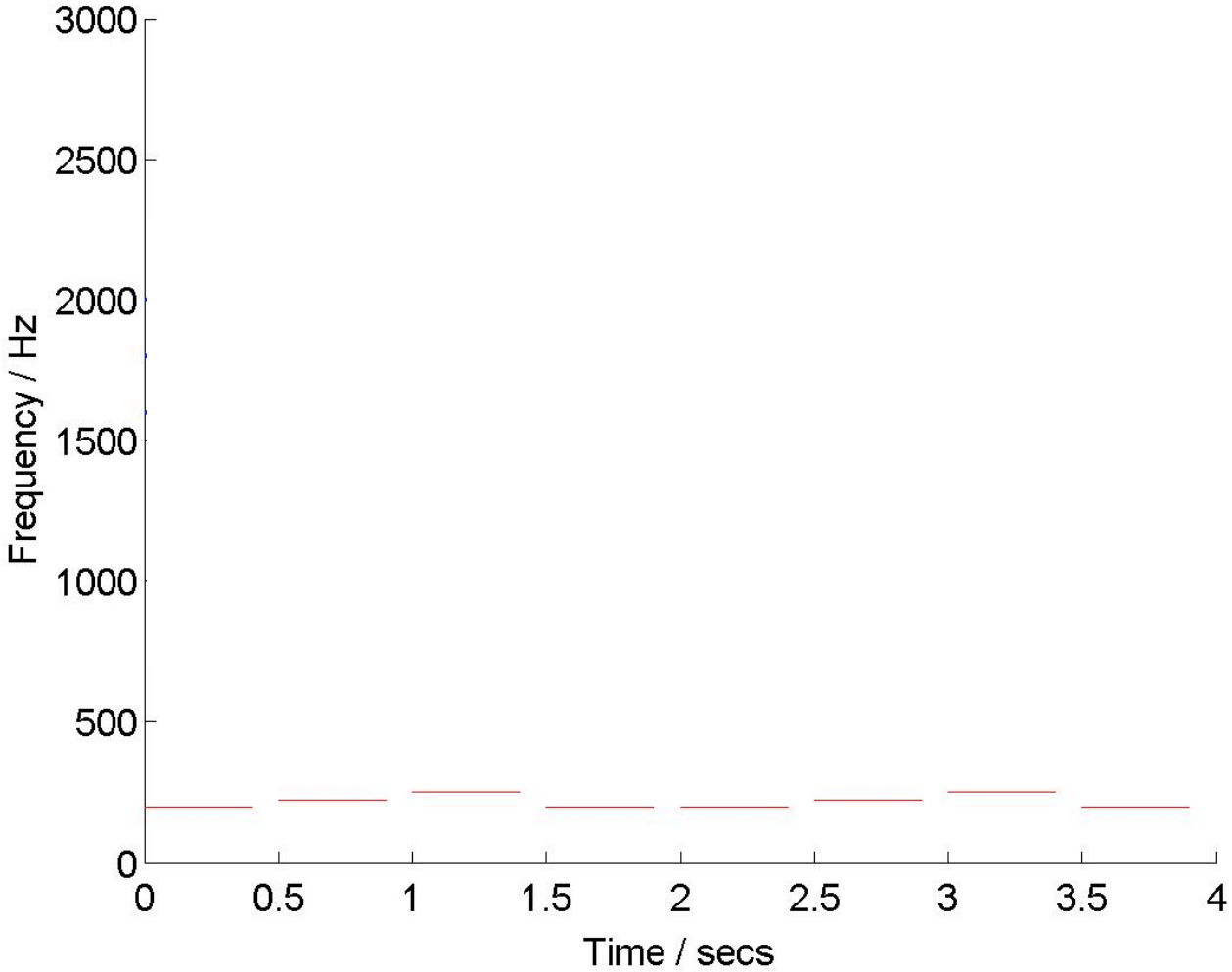
Two kinds of pitch

spectral pitch

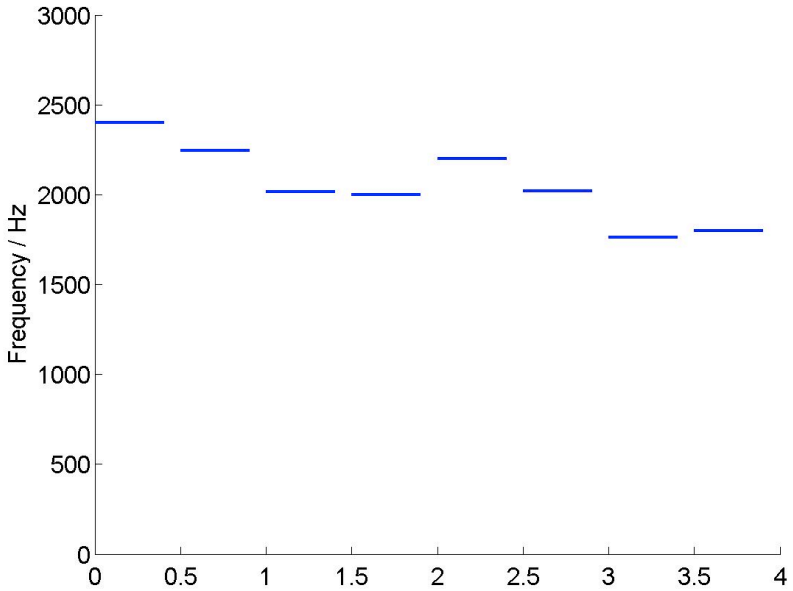
virtual pitch

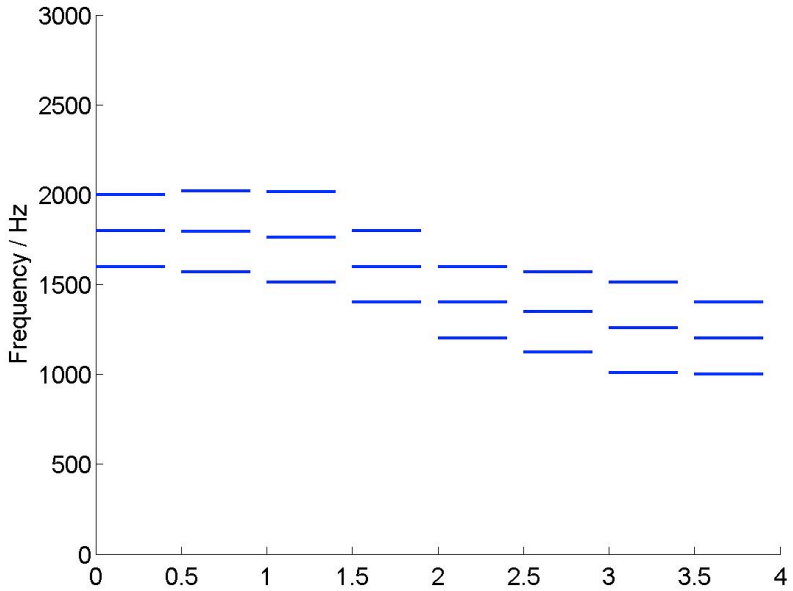


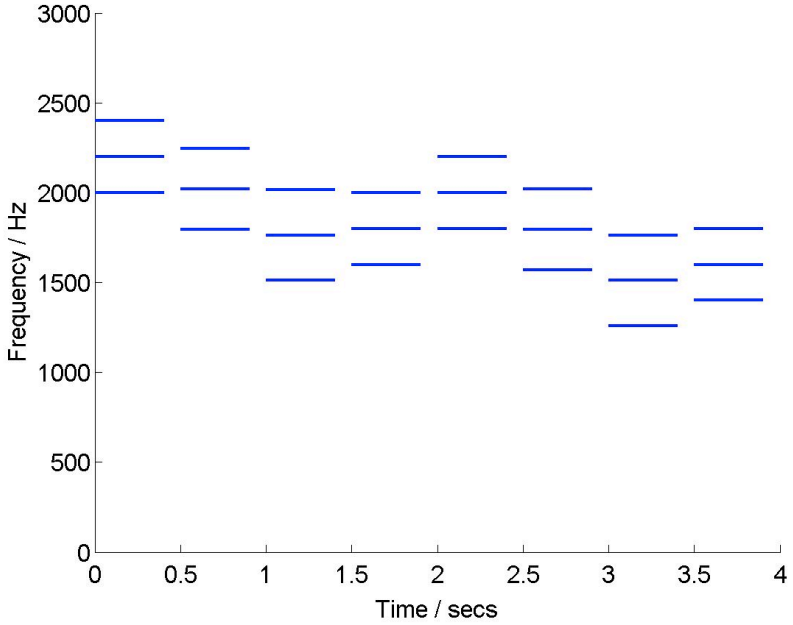
Two kinds of pitch

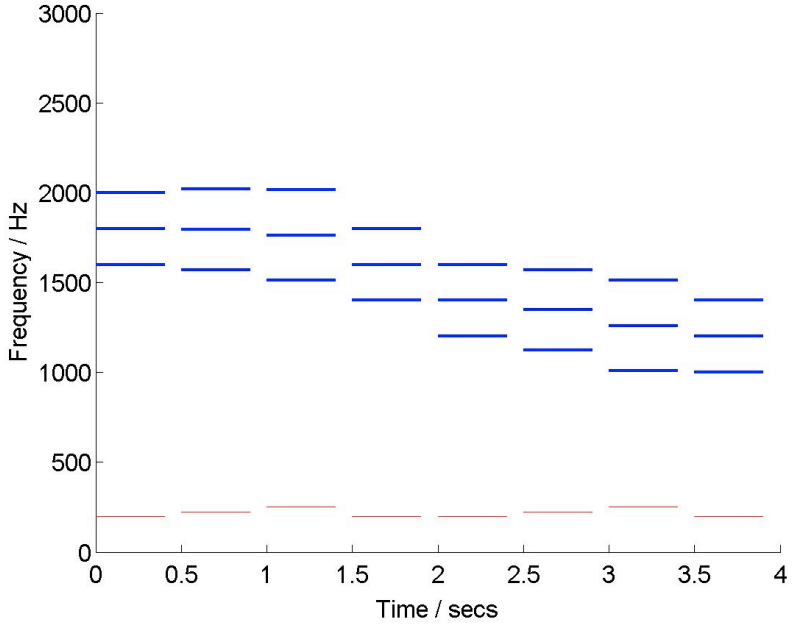


Do you hear a familiar melody?









The case of the Missing Fundamental

The Overtone Series

Harmonic	Frequency	Note
Fundamental	110 Hz	A_2
1st Overtone	220 Hz	A_3
2nd Overtone	330 Hz	E_4
3rd Overtone	440 Hz	A_4
4th Overtone	550 Hz	$C\#_5$
5th Overtone	660 Hz	E_5

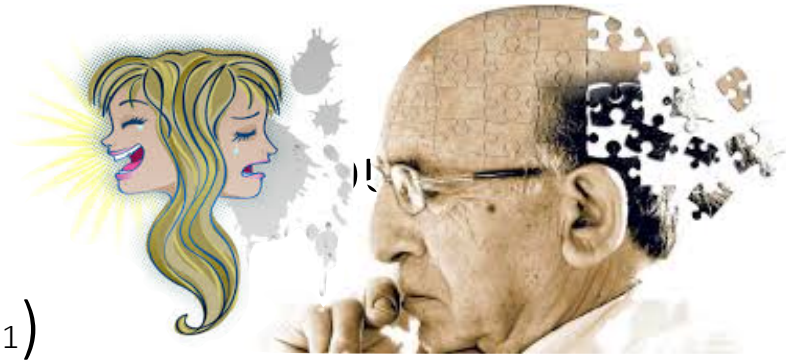
https://www.youtube.com/watch?v=0amvhGzeCnQ

Virtual pitch in everyday life

- mobile phone
  - bandwidth 500-3000 Hz
  - male voice 100-200 Hz
- small multimedia speakers
  - music 50- Hz

Auditory hallucinations

"the apparent, often strong, subjective perception of an object or event when no such stimulus or situation is present - perceiving sounds without auditory stimulus"



- schizophrenia, mood disorders, AD, [illegible] related
- transient (eg: excess caffeine Crowe et al. 2011)
- musical ear syndrome (hearing loss and subsequently develop auditory hallucinations)

Auditory hallucinations

- abnormal activation of normal auditory, language perception and production pathways
- activation of PAC, amygdala (emotion), hippocampus (memory), frontal (consolidation) and sensorimotor cortex in schizophrenics (Dirks et al., 1999; Lennox et al., 2000)
- increased blood flow in Broca's area in schizophrenics (McGuire set al., 1993)

"Broca's area is a surprise, since that's where you make sounds, not where you hear them," said Dr. Jerome Engel, a neurologist at the medical school of the University of California at Los Angeles. "I would have expected more brain activity in Wernicke's area, which is where you hear; the usual assumption is that people are listening to thoughts during auditory hallucinations. But this finding suggests that, in terms of unusual brain activity, auditory hallucinations have more to do with the generation of words in the brain than listening to them."

Auditory hallucinations

- Sensory depravation
  - brain compensation
- Deprivation of social interaction(human conversation)
  - brain more likely to produce hallucinated conversations (eg: sailors)
- Heightened emotional states
  - increase the propensity of the brain to produce corresponding verbal messages (eg: abuse, bullying)

Tinnitus

- “tinnitus” - tinkling in Latin
- noises in the head, not related to any psychiatric condition
- ringing in the left/right ears (ex: after a loud concert)
- may vary in pitch
  - buzzing
  - hissing
  - humming
  - thumping
  - whistling
  - ticking
  - clicking

Tinnitus Causes

- damage to the microscopic endings of the hearing nerve in the inner ear due to acoustical trauma
- middle ear infections
- stiffening of the middle ear bones
- foreign object, or earwax touching the eardrum
- high or low blood pressure (blood circulation problems)
- certain types of tumors
- head trauma
- large doses of anti-inflammatories, antibiotics, sedatives, antidepressants, and aspirin
- age

Tinnitus Treatment

- sound therapy
    - broadband noise maskers (white noise) - (auditory masking)
    - living in india helps!!!!!!!!!
- healthy lifestyle
- use ear protection in noisy areas

Types of Hearing Loss

- **Conductive Hearing Loss**: Problems in transmitting sound waves to the cochlea
- **Sensorineural Hearing Loss**: Caused by damage to inner ear or auditory nerve
- **Mixed Hearing Loss**

Cochlear implant