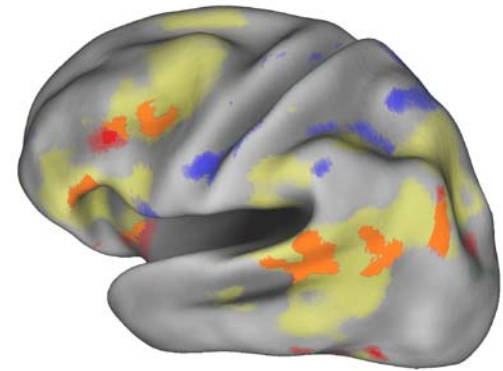


Cortical networks for sound recognition in the congenitally blind

James W. Lewis

IDeA Regional Meeting
Nov 10th, 2009



Overview

Lab focus: *Hearing perception in humans*

- **Question #1:** Is the cortical organization for processing real-world sounds the same in sighted as well as congenitally blind individuals—despite never having had visual experience?
- **Question #2:** If there are differences, what might drive cortical “plasticity” or re-organization?

Hearing abilities of the blind?

- Blind people are known to have better verbal working memory skills
 - Plato: word of mouth stories
- Other “high-level” hearing advantages
 - Auditory attention
 - Auditory scene analysis
 - Echo-locating, peripheral field localization
 - (However, hearing acuity is the same)

Methods: Sound delivery

WVU, Center for Neuroscience

Eliminates need for ear plugs!
Sound muffs



Acknowledgments:

Chris Frum (technician)

Kristina Rapuano (SURI student)

William Talkington (Grad student)

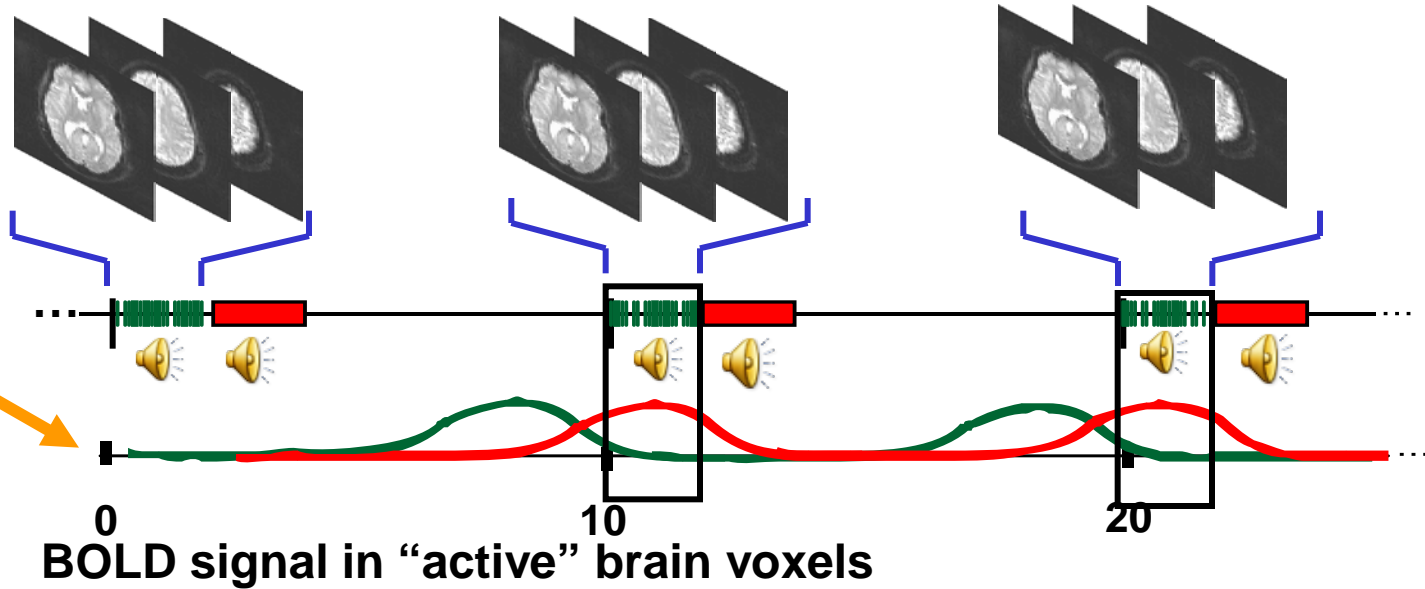
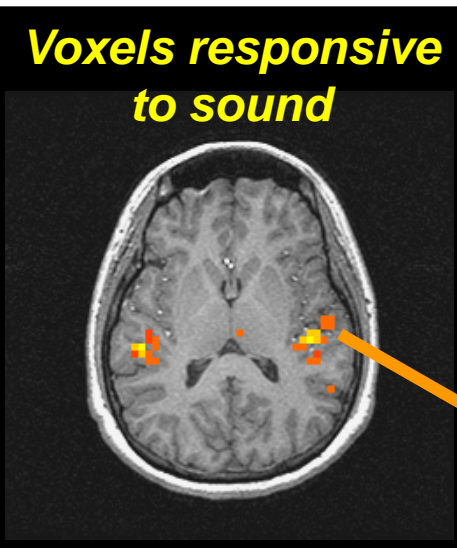
Dr. George Spirou (COBRE director)

ear bud

headphones



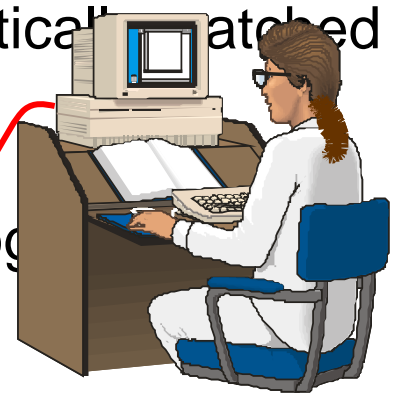
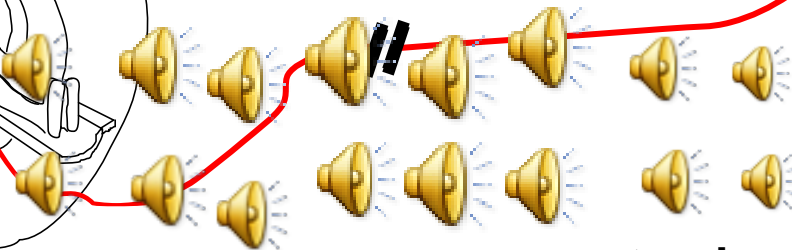
Sound recognition: Experiment



- Use 108 easily recognized non-verbal, natural sounds
- Backward sounds as controls: Unrecognizable, acoustically matched
- 8 Early Blind (EB; avg age 54.4)
- 12 Sighted Control (SC; avg age 54.0)
- Respond by right hand button press if sound was recognized

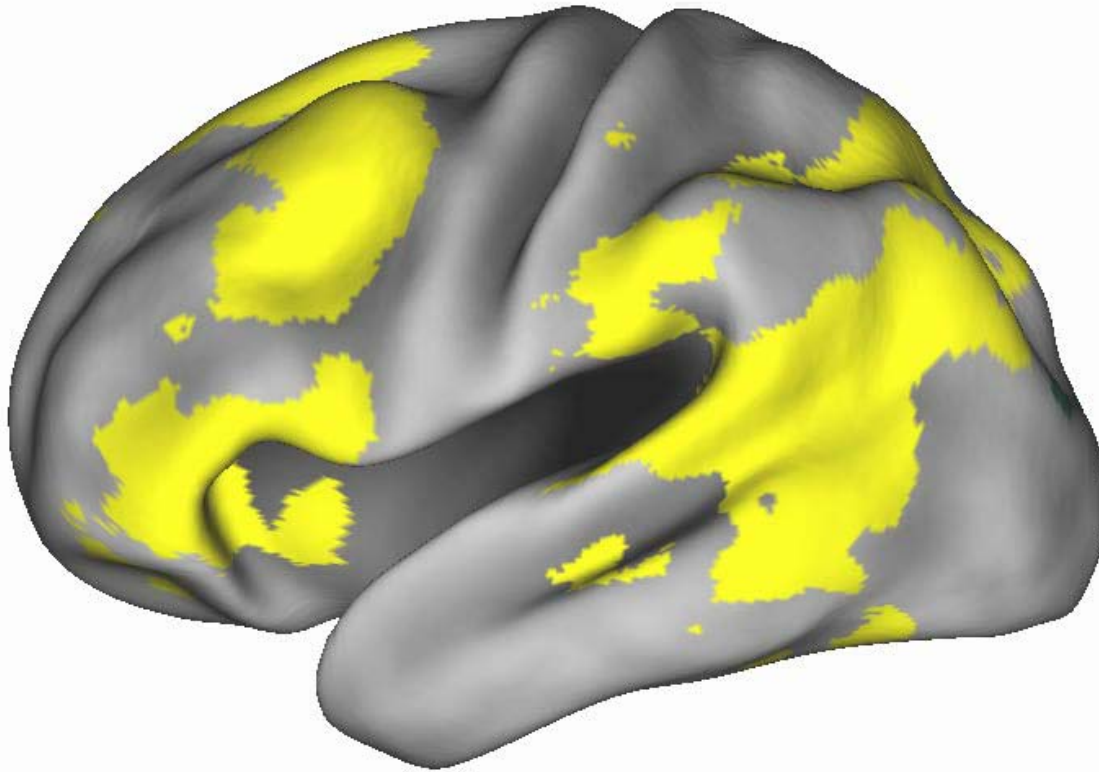
RF Gradient head coil

Forward sounds.
vs.
Backward sounds:



pantomimes? Visualize sounds?

(Sighted, n=12)
 $\alpha < 0.05$

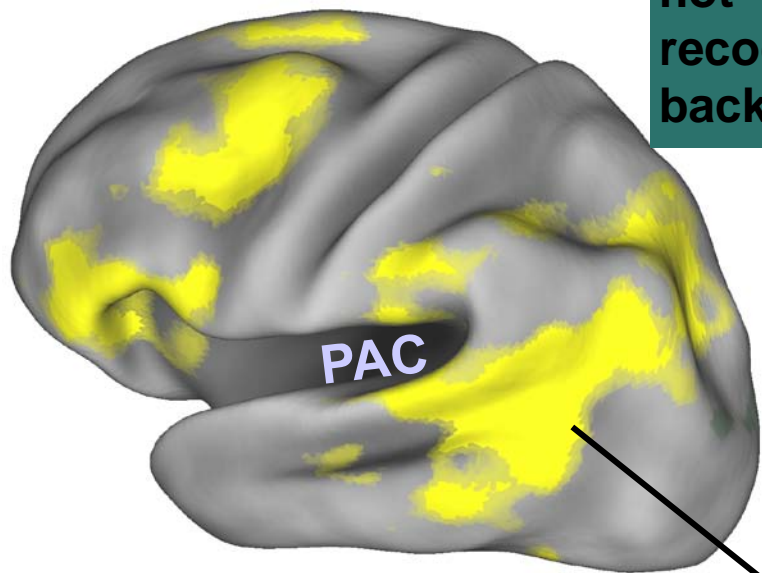


PALS
brain
model

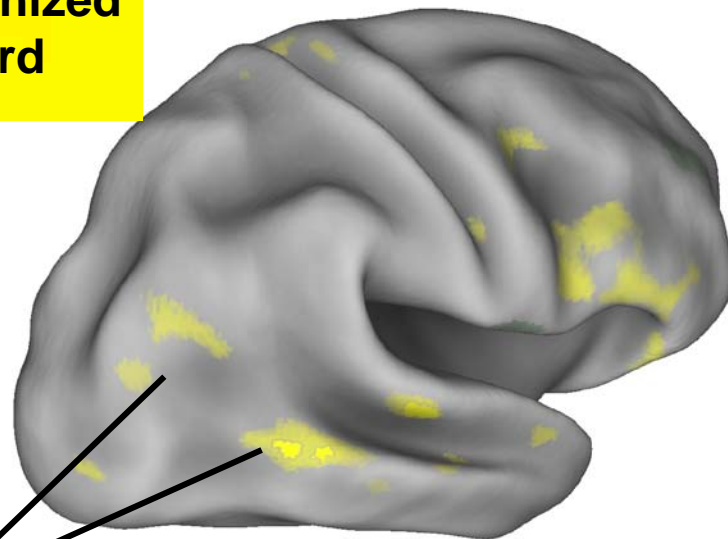
• **Yellow should mostly represent regions for “high-level” sound recognition.**

Sighted sound recognition networks

not recognized backward
recognized forward



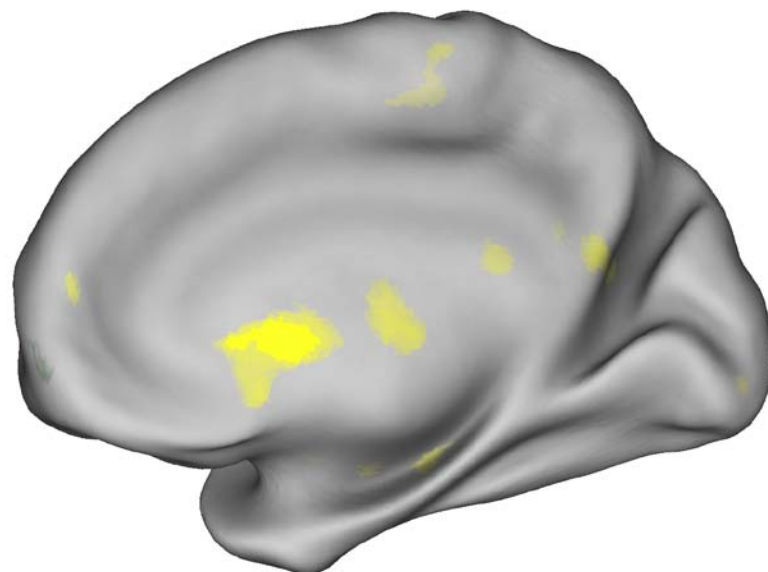
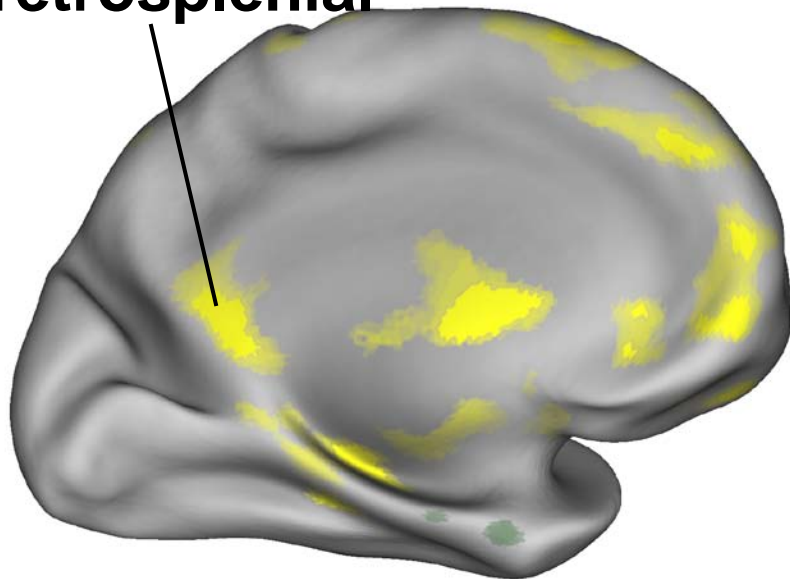
Sighted
(n=12)
 $\alpha < 0.05$



V1

pMTG

retrosplenial



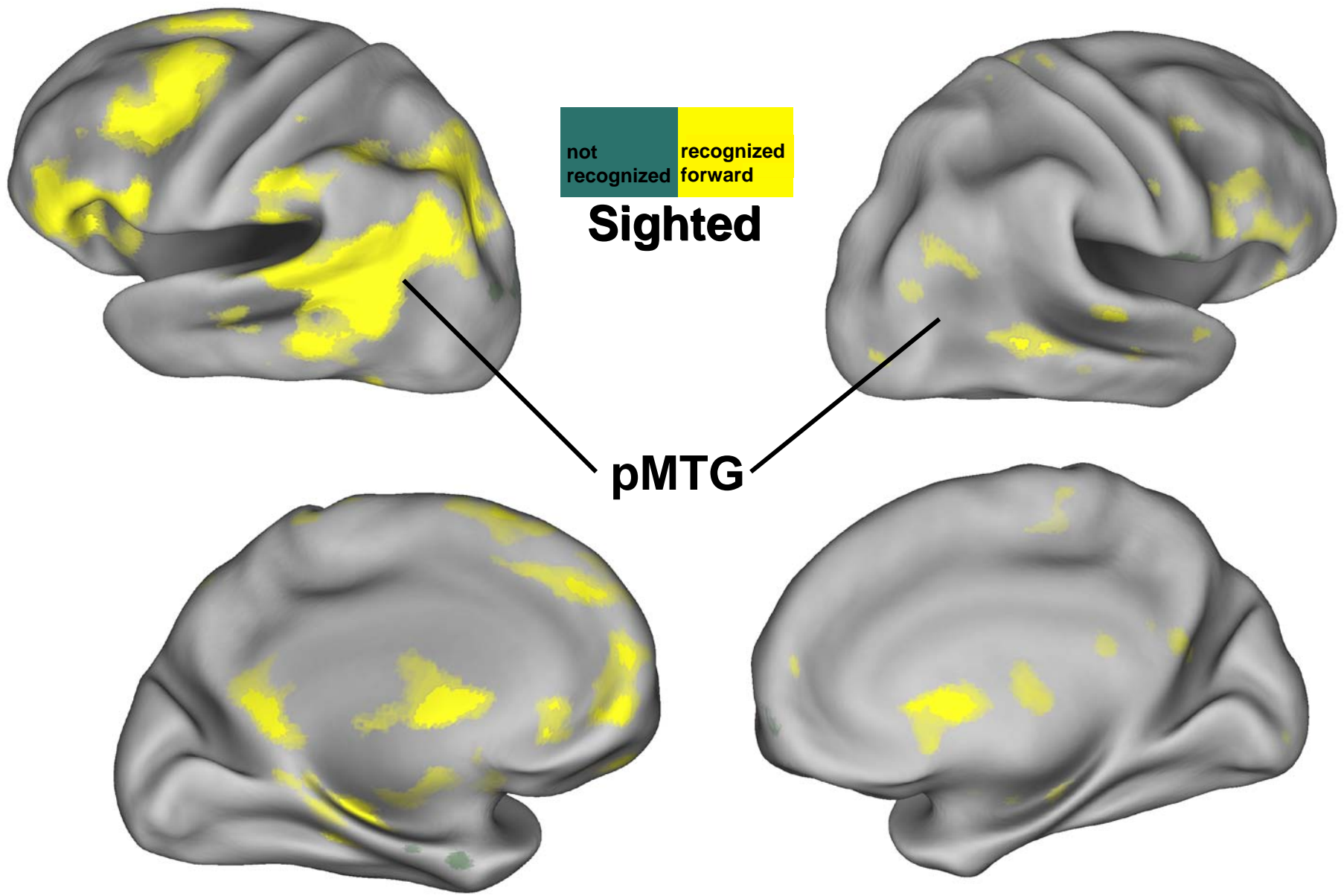
Conclusion #1: Sighted

- No differential Primary auditory cortex activity
- Left-lateralized network
 - Perhaps verbal/semantic label
- Left Parietal → “audio-motor” functions?
- pMTG activity → “audio-visual” functions?
 - Situated between primary auditory and visual cortices

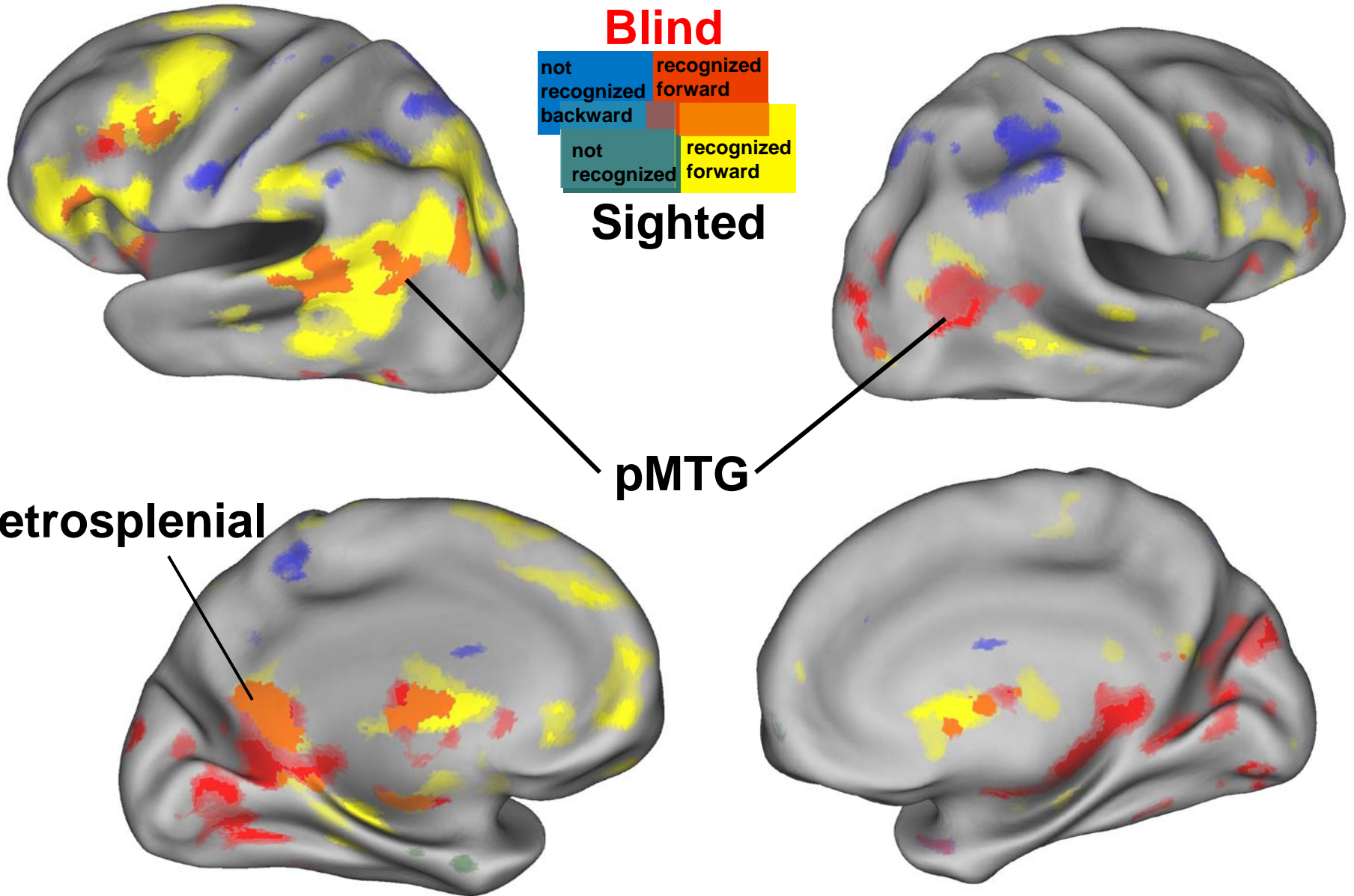
... Does pMTG activity reflect *visual imagery* to aid in identification of the sound-source?

...study congenitally blind individuals!

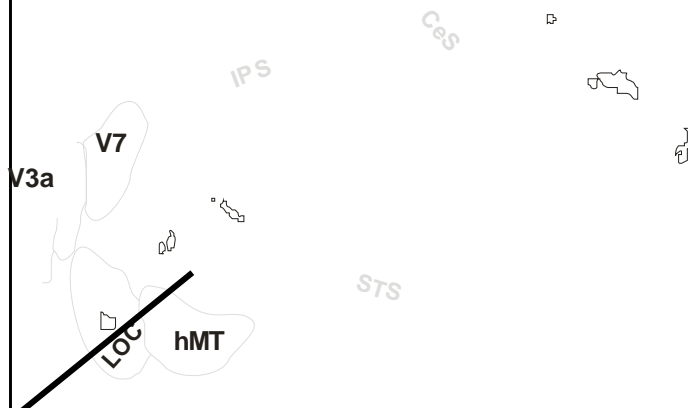
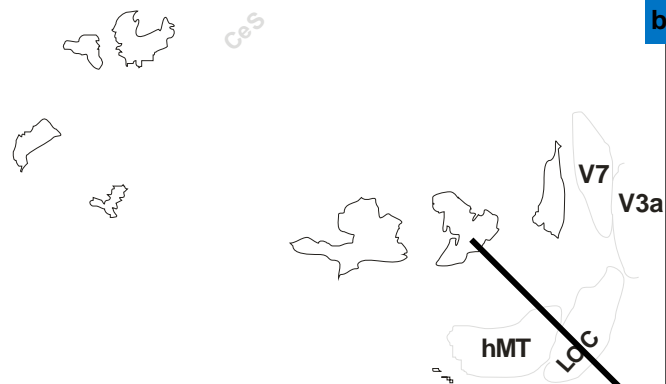
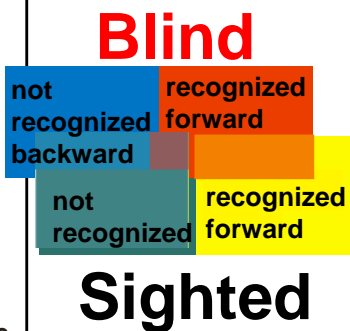
Sighted sound recognition networks



Blind vs. Sighted sound recognition networks

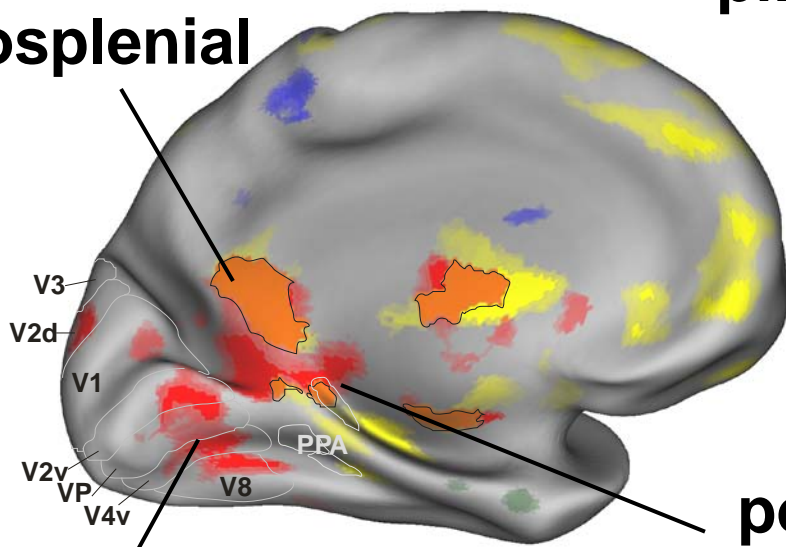


Blind vs. Sighted sound recognition networks



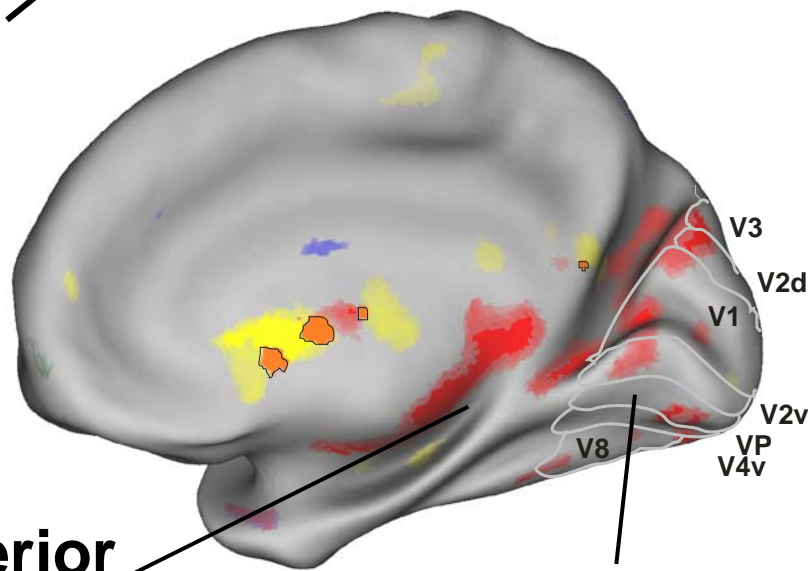
pMTG

retrosplenial



posterior

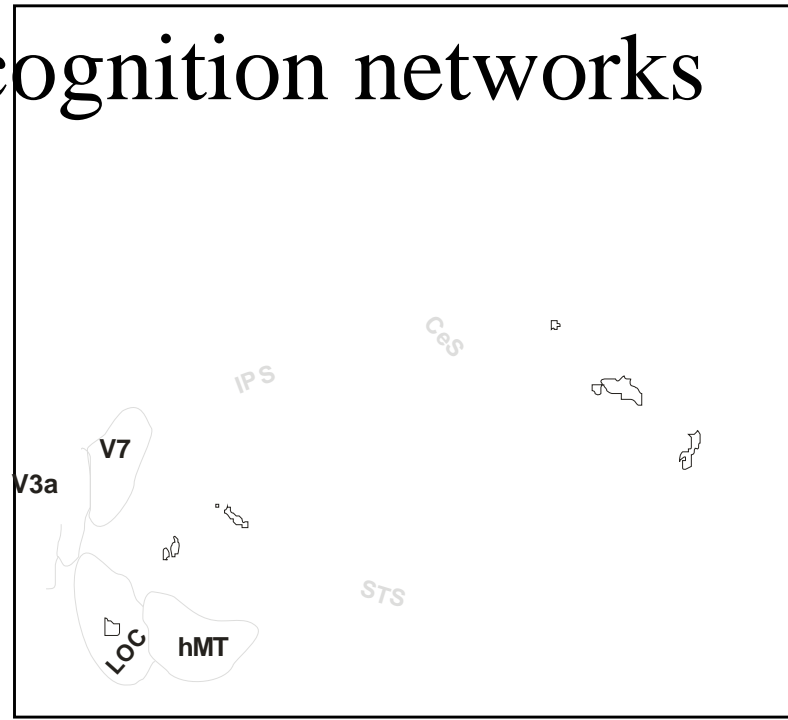
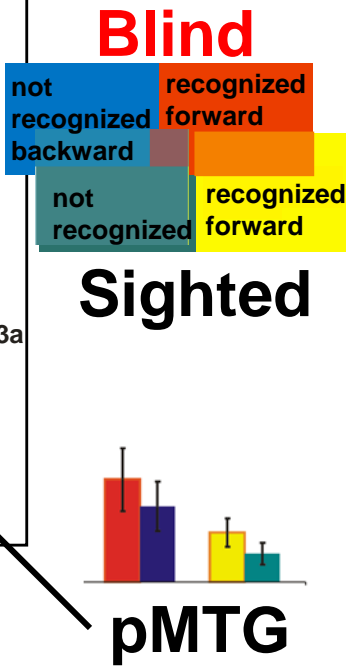
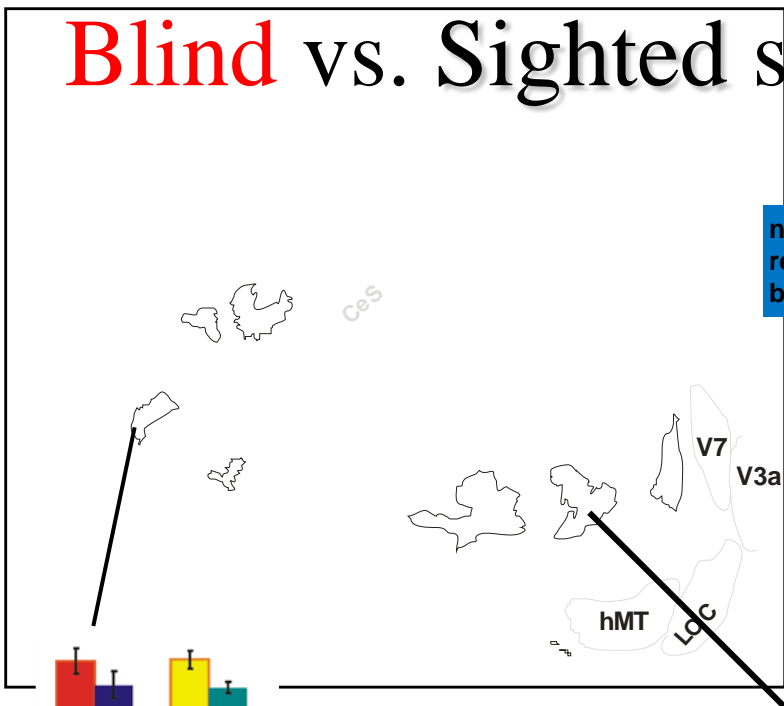
parahippocampus



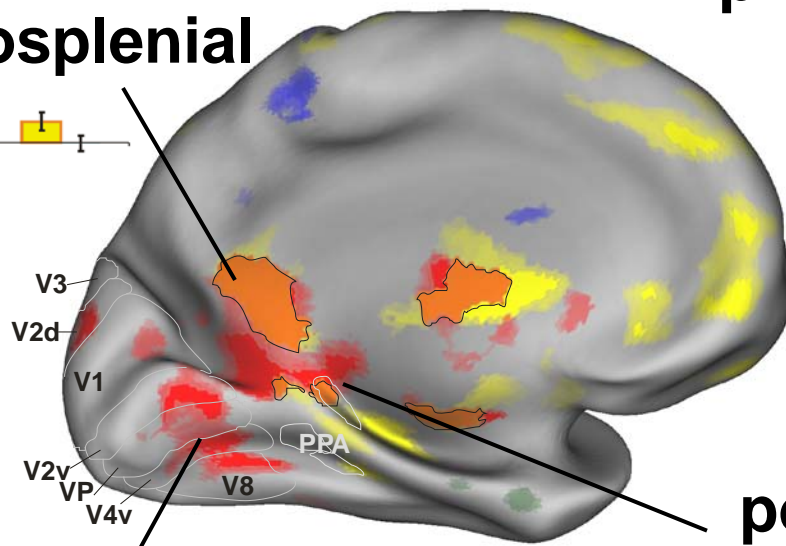
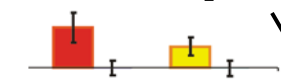
medial occipital

medial occipital

Blind vs. Sighted sound recognition networks

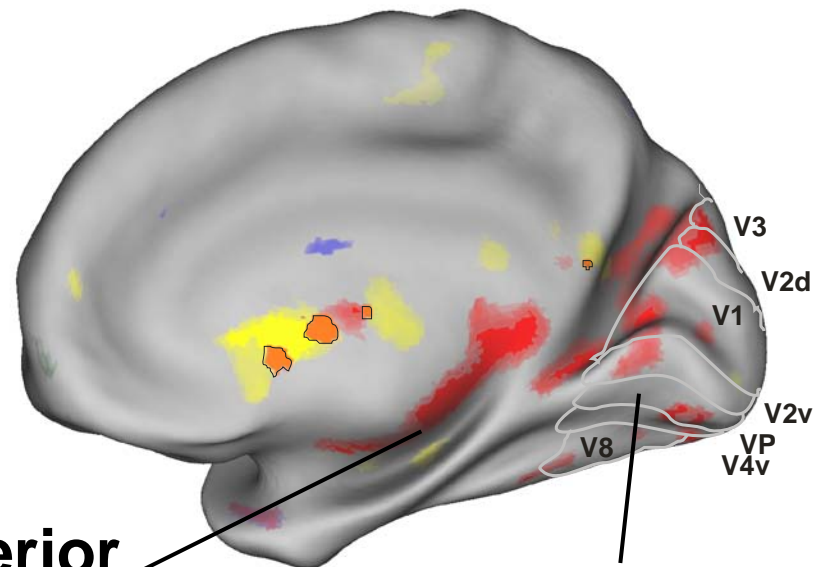


retrosplenial



medial occipital

posterior parahippocampus



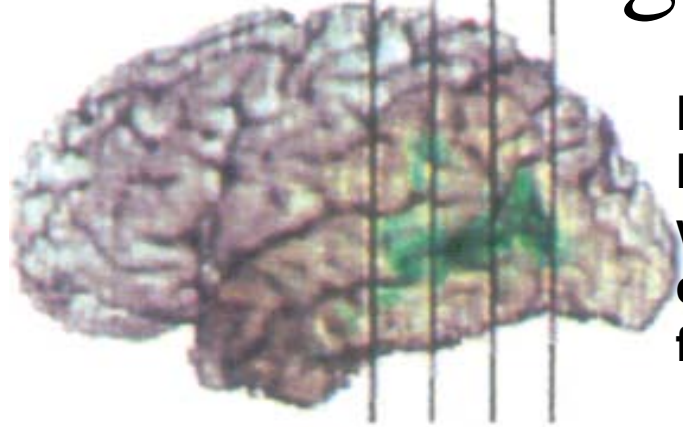
medial occipital

Conclusions #2

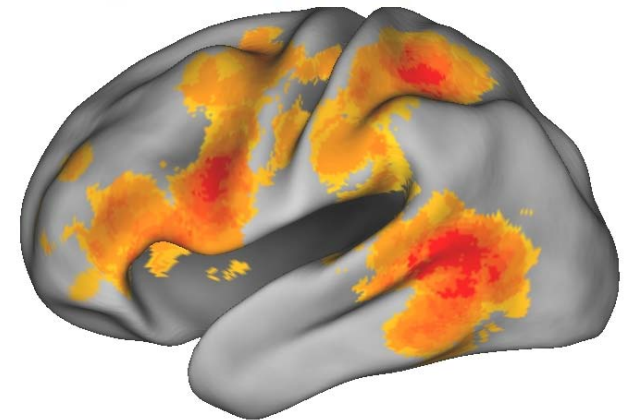
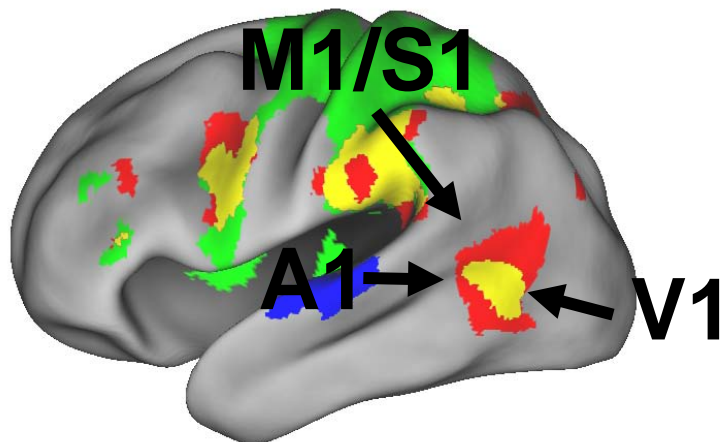
(also see poster #NS-07)

- Blind group similarly activated **pMTG** bilaterally
 - Not visual imagery *per se*
 - Representations of dynamic action sequences (audio, visual or both).
 - Temporal reference frame
- **Retrosplenial** and **parahippocampal** activation was consistent with processing situational relationships depicted by the real-world acoustic events.
 - Expansion of these regions in the blind suggest that cortical plasticity or re-organization may be driven by these higher-level representations.

Cortical organization for language



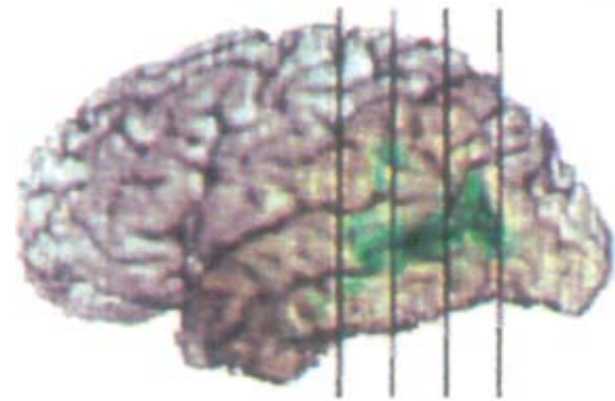
Lesions here
lead to
word-form
deficiencies
for Tools



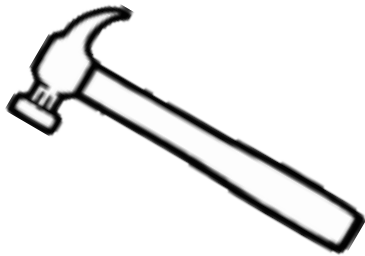
- pMTG/STS may be optimally located and “wired” for intermodal sensory integration.
 - hence, word-form knowledge for tools (and other dynamic action objects) ideally located in pMTG to minimize “wiring” and fiber tracts.

Introduction: Why study tool sound processing?

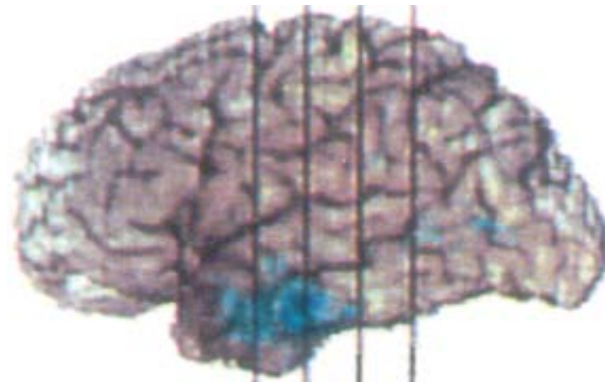
1. Human lesion studies indicate that word-form knowledge for the object category “**tools**” versus “**animals**” or “**people**” are processed along partially separate cortical pathways in the left temporal lobe.



Tools



**posterior
temporal**



Animals



**middle
temporal**



Persons



(from Damasio et al., 1996)