# VISUAL STIMULI ACTIVATE AUDITORY CORTEX IN THE DEAF

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# PREVIOUS BRAIN IMAGING STUDIES

- Demonstrated responses to tactile and auditory stimuli in the visual cortex of blind subjects.

- Suggesting that removal of one sensory modality leads to neural reorganization of the remaining modalities.

# CURRENT STUDY

- Looking to see if similar 'cross-modal' plasticity occurs in human auditory cortex.

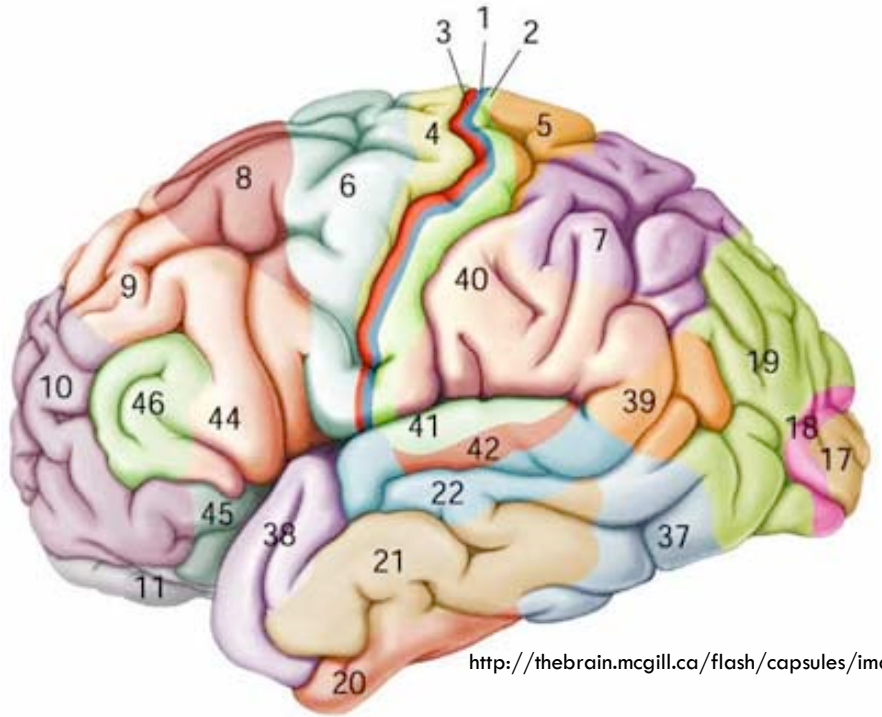
- Used fMRI to measure visually evoked activity in auditory areas of both early-deafened and hearing individuals.

# DEFINITIONS AND BACKGROUD

- **Cross modal plasticity:** is the adaptive reorganization of neurons in the sensory systems.
  - Often occurs after sensory deprivation.

# DEFINITIONS AND BACKGROUD

- **Brodmann areas:** cytoarchitectural organization of the human cortex. Many of the areas Brodmann defined based solely on their neuronal organization.
  - Functional imaging can only identify the approximate localization of brain activation in terms of Brodmann areas since their actual boundaries in any individual brain requires histological examination.
- Area 22 – association auditory areas
  - Superior temporal gyrus
  - Wernicke's area
- Area 41- primary auditory cortex
- Area 42- secondary auditory areas

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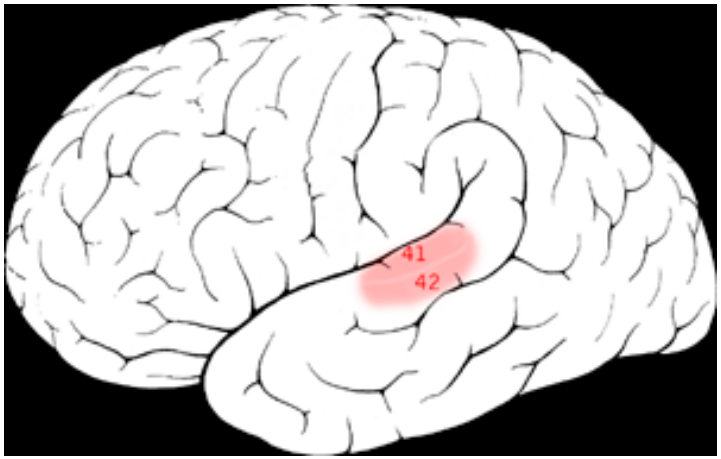
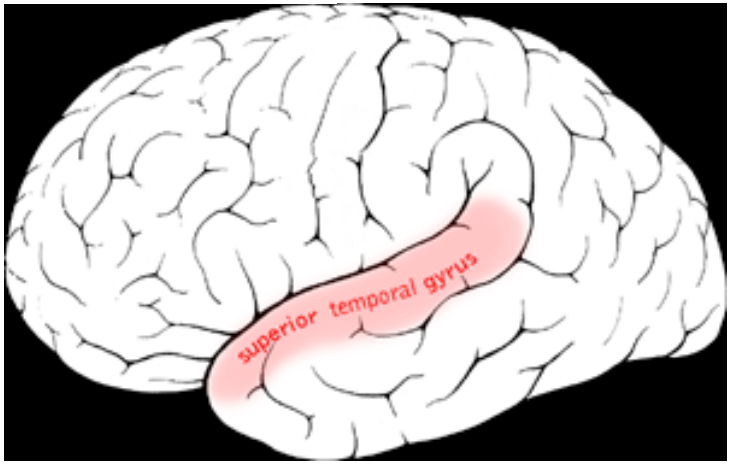


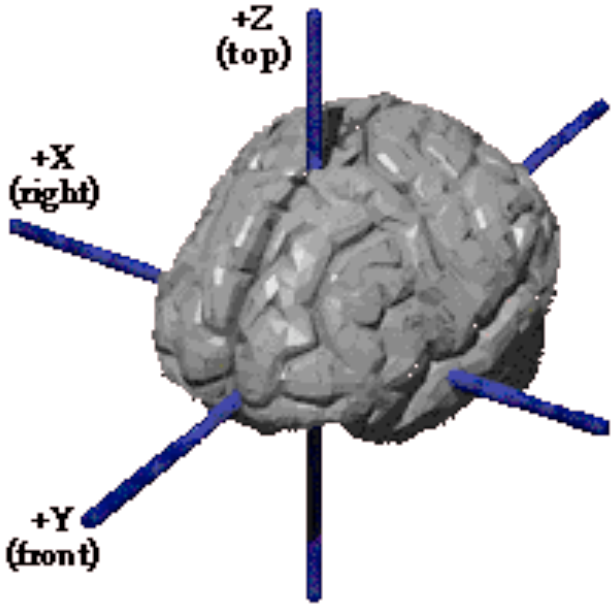

http://en.wikipedia.org/wiki/File:Brodmann_41_42.png




http://en.wikipedia.org/wiki/File:Superior_temporal_gyrus.png

# DEFINITIONS AND BACKGROUD

**Talairach and Tournoux coordinate system:** used to describe the location of brain structures independent from individual differences.




http://www.talairach.org/daemon.html

http://www.cafemuse.com/soundgarden/theory_math/dynamics.htm

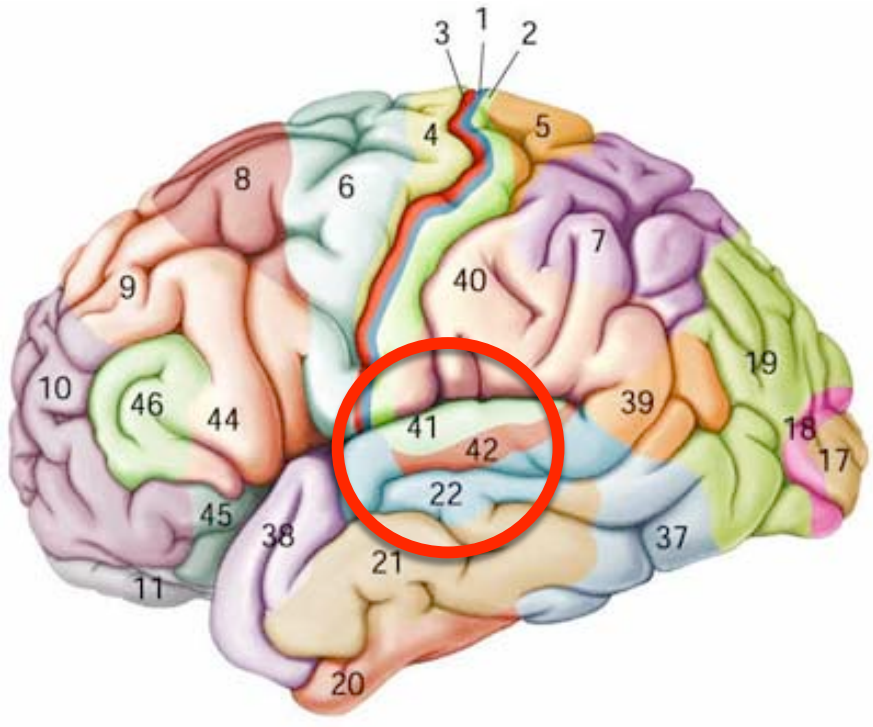
# DEFINITIONS AND BACKGROUD

- **Degrees of Deafness:**
  - Mild – 26-40 dB
  - Moderate – 41-65dB
  - Severe – 65-90dB
  - Profound – 91+dB

| Sound | Decibel Level |
|---|---|
| Threshold of Hearing | 0 |
| Normal Breathing | 10 |
| Leaves Rustling | 20 |
| Empty Theater | 30 |
| Mosquito Buzzing | 40 |
| Quiet Restaurant | 50 |
| Normal Conversation | 60 |
| Traffic | 70 |
| Vacuum Cleaner | 80 |
| Truck Engine | 90 |
| Subway Train | 100 |
| Rock Band | 110 |
| Threshold of pain | 120 |
| Machine Gun | 130 |
| Jet Engine | 140 |

# ESTABLISHING REGIONS OF INTEREST

- Subjects: 6 profoundly deaf and 6 hearing individuals.
- Used fMRI to define the auditory region of interest (ROI) by measuring responses elicited by auditory stimuli (music sequences) in the hearing subjects.
- Auditory stimuli were found to activate regions in both right and left auditory cortex including Brodmann's areas 41, 42, 22.
- The right auditory ROI was larger than the left ROI (26.1$cm^3$ compared to 14.5$cm^3$) probably because of the asymmetry in processing music in the brain.

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http://thebrain.mcgill.ca/flash/capsules/images/outil_jaune05_img02.jpg

# ESTABLISHING REGIONS OF INTEREST

- 6 profoundly deaf and 6 individuals.
- Used fMRI to define the auditory region of interest (ROIs) by measuring responses elicited by auditory stimuli (music sequences) in the hearing subjects.
- Auditory stimuli were found to activate regions in both right and left auditory cortex including Brodmann's areas 41, 42, 22.
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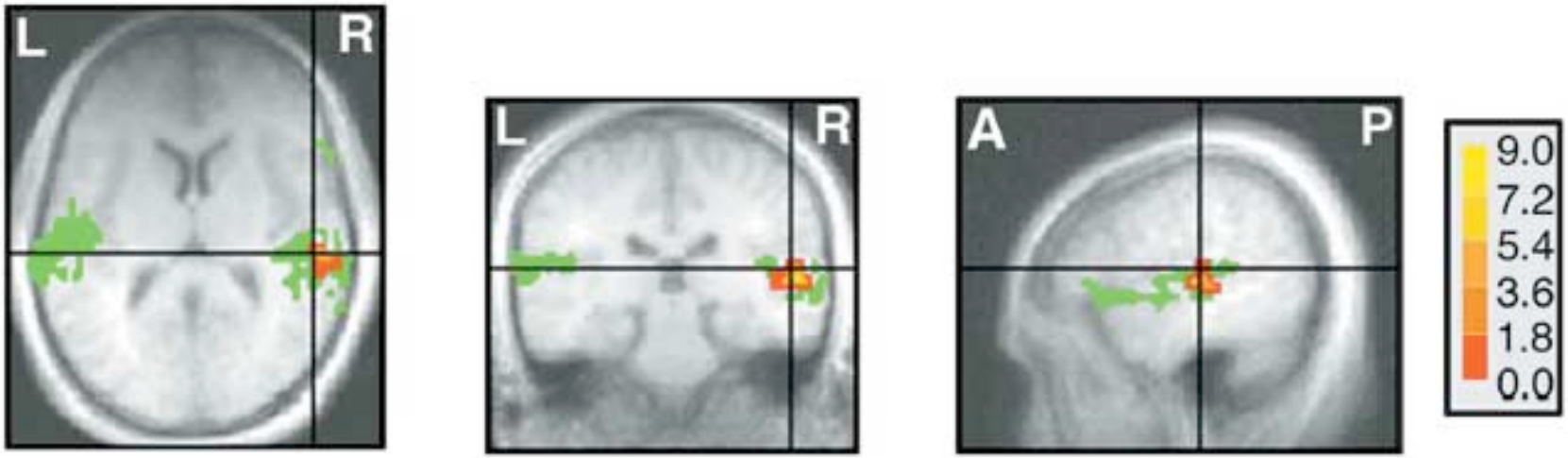


- Figure 1
  - ROIs are averaged across all deaf and hearing participants after transforming individual anatomies into standard Talairach and Tournoux coordinate space.
  - Green- ROI's in the auditory cortex.

# MOTION STIMULUS

- A moving dot pattern was presented to each participant in either the right or left visual field on alternate trials.

- Visually evoked activity within the right and left ROIs was computed by correlating fMRI signal amplitude in individual ROI.

# MOTION STIMULUS

- Visually evoked activity significantly differed between deaf and hearing subjects in the right auditory ROI.
  - Differences in the left auditory appeared but were much smaller and not significant.
- Within the main effect on the right ROI, the visual stimulus caused significant activation in deaf subjects.
- NO significant activation occurred in hearing subjects.

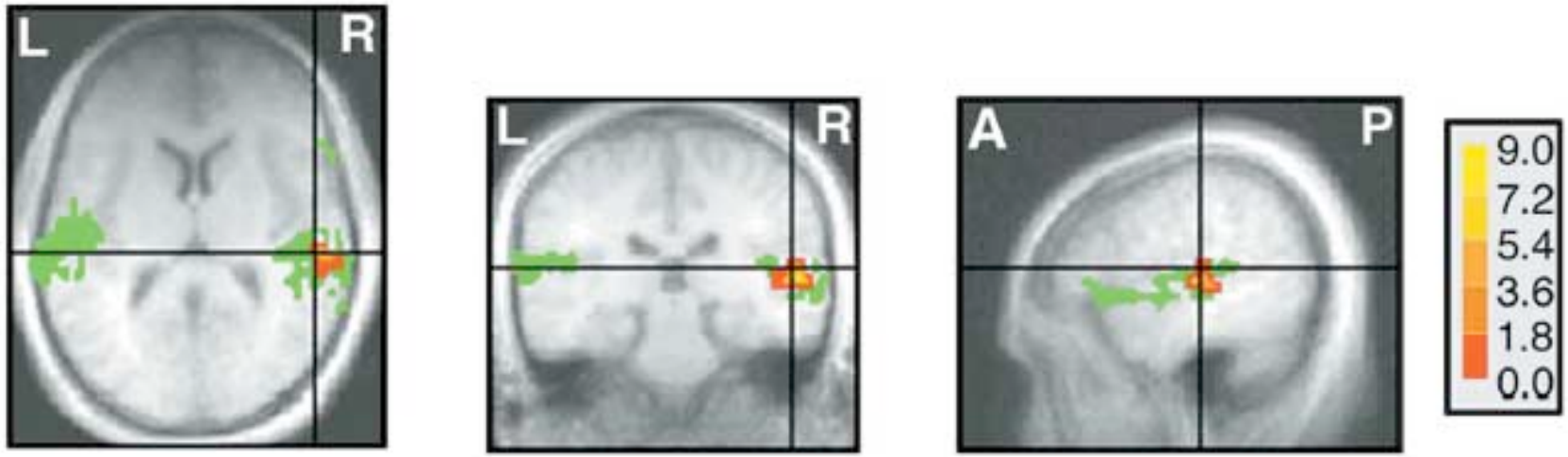


**Figure 1. Visual stimuli activate auditory cortex in the deaf. Shown is an anatomical scan averaged across all deaf and hearing subjects. Auditory regions of interest (ROIs, green regions) and voxels activating differentially in deaf versus hearing subjects in response to the visual motion stimulus (colors defined in scale bar) are shown on axial (left), coronal (middle) and sagittal (right) sections of an averaged anatomical brain, transformed into the standard stereotaxic space of Talairach and Tournoux. The area of visual responsiveness falls within Brodmann's areas 41, 42 and 22 in the right auditory ROI. Crosshairs highlight a voxel within the area of main effect that maps to Brodmann's area 41 (primary auditory cortex). Scale bar indicates the functional intensity (FIT) value, or magnitude of activation. L, left; R, right; A, anterior; P, posterior side of brain.**

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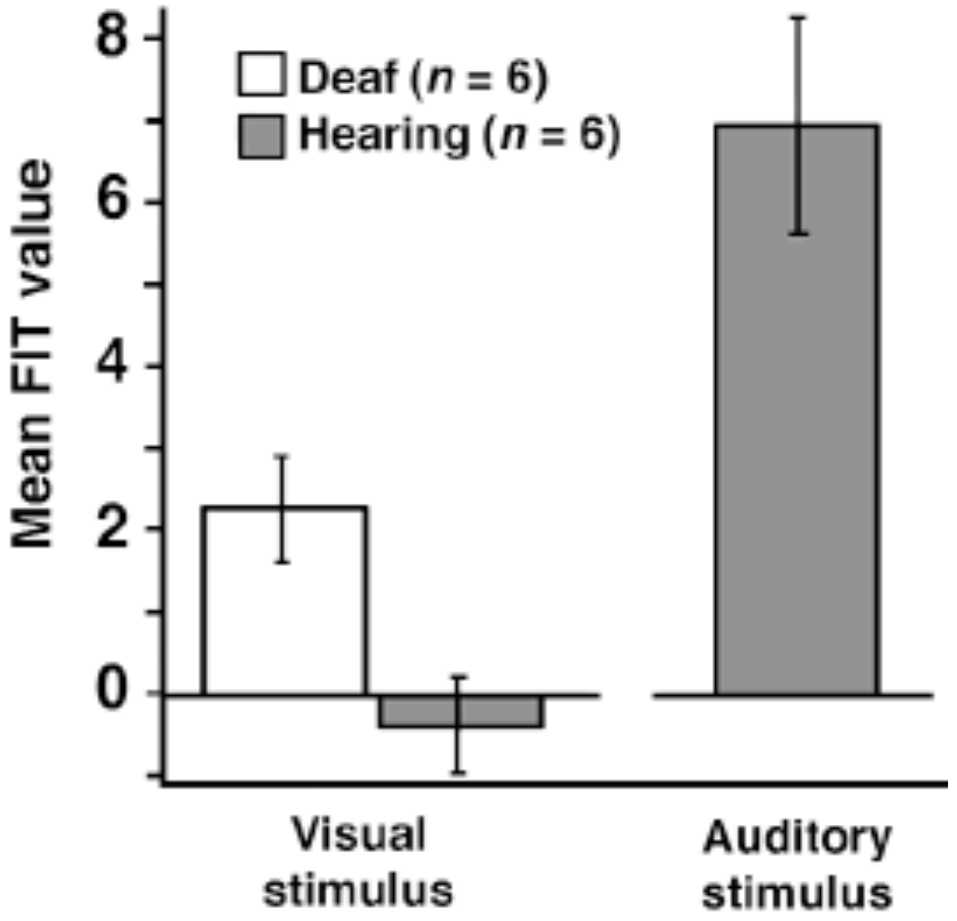
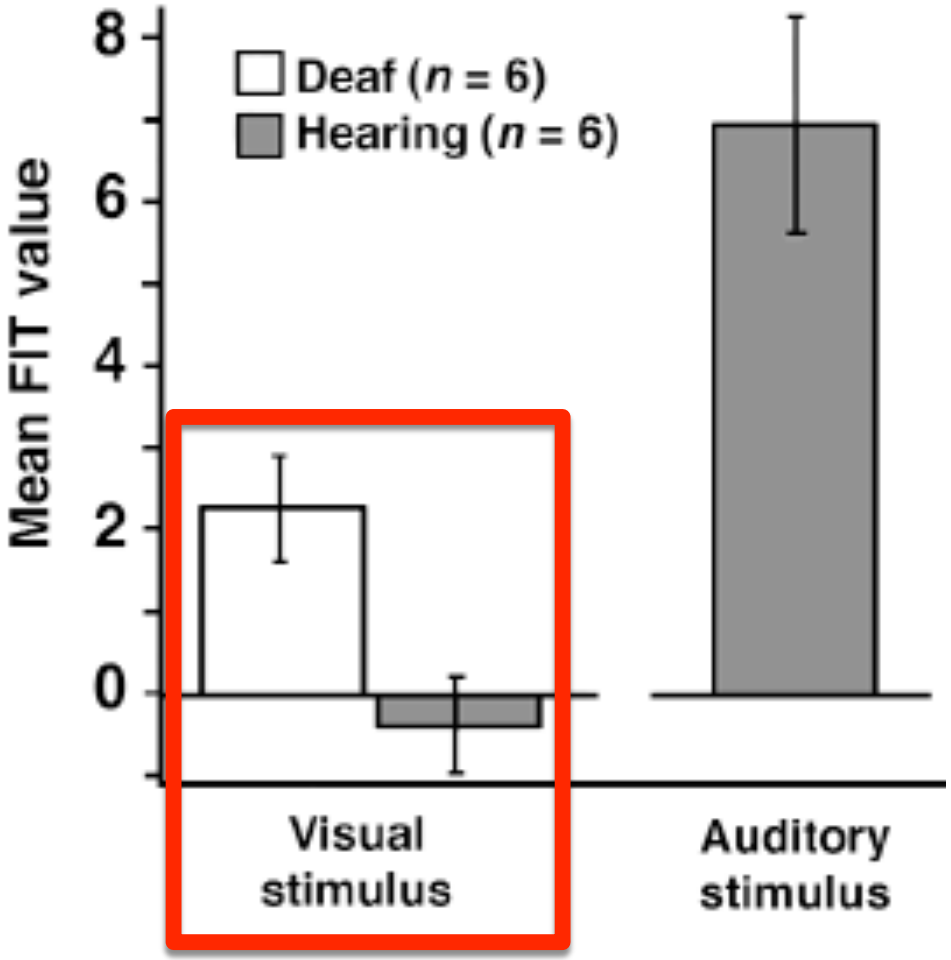


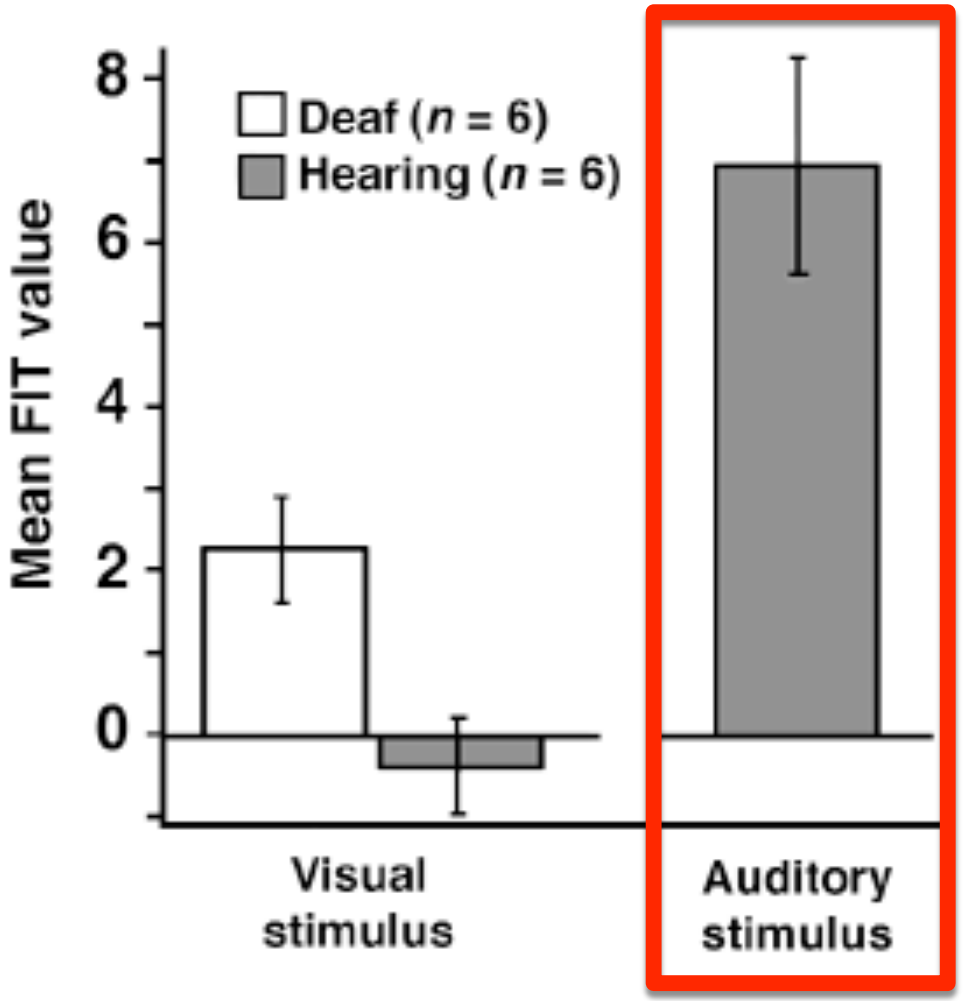
# MOTION STIMULUS

- Within the main effect on the right ROI, the visual stimulus caused significant activation in deaf subjects.
- Mean FIT value: 2.26 ±1.37
- NO significant activation occurred in hearing subjects.
- Mean FIT value: -0.31 ±1.30



# MOTION STIMULUS

- For comparison auditory stimulus was presented to the hearing subjects and resulted in  and a mean FIT value of 6.90± 2.65 in the ROI.



# IGNORING THE MOTION STIMULUS

- Subjects were instructed to ignore the motion stimulus and instead perform a dimming task on a fixation spot.
- fMRI responses showed deaf and hearing subjects differing significantly in the region of the right auditory ROI (mapping onto area 42).
- Deaf subjects exhibited significant activation in this region (FIT coefficient, $2.85 \pm 2.91$, $p=0.031$)
- NO significant activation for hearing subjects (FIT coefficient, $0.175 \pm 1.43$, $p=.78$)
- Consistent with the tendency for sensory areas to activate less strongly to ignored than attended stimuli.

# IN SUMMARY: Previous Studies

- PREVIOUS STUDIES
- fMRI and PET studies suggest that the auditory ROIs used in this study were found to be involved in visual language processing in both deaf and hearing subjects.
- Brodmann's area 42 and 22 are activated during sign language in deaf subjects and during silent lip reading task in hearing subjects.
- Brodmann's area 42 and 22 were also implicated in other nonlinguistic visual tasks in deaf subjects.
- Problems with previous studies include poor spatial resolution.

# IN SUMMARY

- Using fMRI demonstrated the recruitment of the auditory cortex in the deaf for the processing of purely visual stimuli.
- The cross-modal plasticity appeared predominantly in the right auditory cortex.
- Used a moving visual stimuli so the hemispheric asymmetry may simply reflect predisposition for motion processing in the right auditory cortex.
  - The right auditory cortex is specialized for processing auditory motion. Thus, the right auditory cortex in the deaf may come to serve motion processing in the visual modality.
- The brain has a robust ability to reorganize in response to the removal of input early in development from one sensory modality.

# QUESTIONS?