

An MR Volumetric Study of the Motor Hand Region and Insula in Deaf, Hearing, and Hearing-Signing Individuals

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Introduction

We used high-resolution MRI to examine the effects of auditory deprivation and experience with sign language from birth on the gray and white matter volumes in the motor hand region (handknob) of the precentral gyrus and the insula. We predicted that the bimanual requirements of signing would result in differences in handknob anatomy between the hearing non-signers and the deaf/hearing signers.

Subjects

Right Handers—14F, 11M (28.5 yrs, sd 5.4)
Deaf Signers—14F, 11M (23.8 yrs, sd 4.1)
Hearing Signers—10F, 6M (24.3 yrs, sd 4.4)
--Children of Deaf Adults (CODAs)

All subjects were healthy and without neurological or psychiatric disease. Informed consent was obtained from all participants.

Methods

MRI data acquisition:

- GE Signa scanner (1.5T), SPGR 30 TR 26 TE 7 matrix 256x192 FOV 24cm, 3 1-NEX acquisitions, averaged *post hoc* with AIR 3.03
- Coronal slice thickness 1.5-1.6mm; Axial slice thickness 1.0mm
- Final voxel dimensions 0.7 x 0.7 x 1.5

Image analysis:

- BRAINVOX and tal programs (Frank, Damasio, and Grabowski, 1997) were used to trace regions of interest (ROIs)
- ROIs were traced in native space:

- 1) **Without resizing**, the brain was reoriented and resliced with reference to the AC-PC line
- 2) Volumetric ROIs were manually traced on contiguous coronal or axial slices of the brain.
- 3) An automated program (Grabowski et al. 2000) was used to segment the brain into gray matter, white matter and CSF.

A. Handknob Asymmetry Index

| Region and Tissue | Group | | | t-test p-values | | |
|----------------------------|-----------------|-----------------|-----------------|------------------|------------------|---------------|
| | Hearing | Deaf | CODA | Hearing vs. Deaf | Hearing vs. CODA | Deaf vs. CODA |
| Handknob Gray Matter AI | -.139 (.416) | .115 (.401) | .014 (.393) | .033 | ns | ns |
| Handknob White Matter AI | -.536 (.415) | -.245 (.399) | -.181 (.516) | .015 | .020 | ns |
| Precentral Gray Matter AI | .000 (.159) | .008 (.103) | -.034 (.133) | ns | ns | ns |
| Precentral White Matter AI | -.060 (.205) | -.047 (.148) | -.121 (.174) | ns | ns | ns |

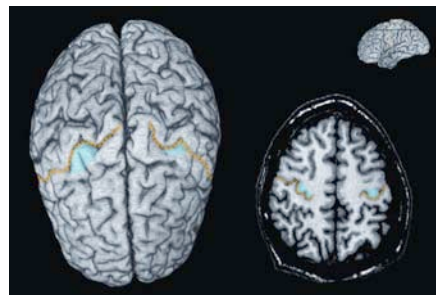
AI: (L-R) / [(L+R)/2]

B. Handknob Volume

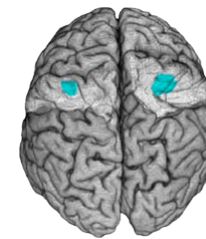
| Ratio | Group | | | t-test p-values | | |
|------------------------------------|------------------|------------------|------------------|------------------|------------------|---------------|
| | Hearing | Deaf | CODA | Hearing vs. Deaf | Hearing vs. CODA | Deaf vs. CODA |
| L Handknob/Precentral Gray Matter | .0375 (.0133) | .0458 (.0163) | .0572 (.0185) | .054 | <.001 | .045 |
| L Handknob/Precentral White Matter | .0355 (.0138) | .0440 (.0173) | .0653 (.0273) | ns | <.001 | .004 |
| R Handknob/Precentral Gray Matter | .0436 (.0166) | .0410 (.0136) | .0553 (.0187) | ns | .043 | .007 |
| R Handknob/Precentral White Matter | .0607 (.0269) | .0551 (.0232) | .0703 (.0266) | ns | ns | ns |

C. Insula Asymmetry Index

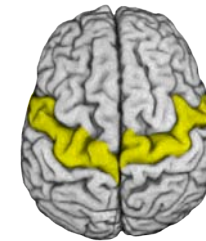
| Region and Tissue | Group | | | t-test p-values | | |
|-------------------|------------------|------------------|------------------|------------------|------------------|---------------|
| | Hearing | Deaf | CODA | Hearing vs. Deaf | Hearing vs. CODA | Deaf vs. CODA |
| Insula GM AI | .0014 (.042) | .0581 (.044) | .0442 (.042) | <.001 | .003 | ns |
| Insula WM AI | -.6799 (.170) | -.8341 (.156) | -.7532 (.308) | .002 | ns | ns |



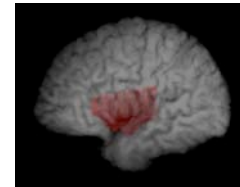
Handknobs in blue



Precentrals in yellow



Insula in red



The handknob (blue) is located in the superior portion of the precentral gyrus. It is buried within the central sulcus and is best visualized in an axial cut through the cerebrum.

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Summary of Results

- 1) For the hand knob region of motor cortex, deaf and hearing signers are less rightwardly asymmetric than hearing non-signers. **[A]**
- 2) The left hemisphere hand knob (gray matter) is largest for hearing signers, followed by deaf signers, and then hearing non-signers. **[B]**
- 3) Insular gray matter exhibits a greater leftward asymmetry for deaf and hearing signers compared non-signers. **[C]**
- 4) Insular white matter shows a rightward asymmetry for all groups, but the asymmetry is greatest for deaf signers. **[C]**

Conclusions

- 1) Asymmetries within motor cortex and the insula can be altered by developmental experience with sign language.
- 2) The leftward shift for signers is not simply due to increased use of the right hand because left-handers and right-handers do not differ in hand knob asymmetry (Allen et al. 2006).
- 3) We hypothesize that top down linguistic control of the hands during language production creates a leftward shift for insular gray matter and the hand knob for ASL signers.

Reference: Allen, J. S., Bruss, J., & Damasio, H., (2006) Rightward volumetric asymmetry in the motor hand region of the brain in right and left-handers. *Am. J. Phys. Anthro.*, Supplement 42, p. 56.