Morphometric analysis of Heschl’s gyrus in hearing impaired and normal hearing infants

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Introduction

• Children with congenital deafness are deprived of auditory stimulation during critical periods of brain and language development
• Lack of auditory stimulation in congenitally deaf individuals may lead to developmental changes in primary auditory cortex
• Studies of primary auditory cortex (Heschl’s gyrus) in deaf adults have found that total volume and gray matter volume in HG is preserved - attributed to neuroplasticity [1,2]
• However, studies have found less white matter in HG and the superior temporal gyrus in deaf compared to hearing adults [2,3]
• Our findings in infants suggest increased grey matter in addition to less white matter in HG in congenitally hearing impaired compared with normal hearing babies.

Method

Participants
43 infants, 8-19 months old
27 = Normal hearing (NH) (M = 12 m/o)
16 = Bilateral hearing impairment (HI) (M = 13 m/o)

NH subjects recruited from the Radiology MRI schedule and passed a hearing test. HI subjects had moderate to profound hearing loss were referred for MRI by Otolologist as part of cochlear implantation evaluation.

MRI Scan
High resolution 3D-T1 weighted images were obtained using a 3T MRI scanner. These scans are acquired using an inversion recovery prepared rapid gradient-echo 3D method and cover the entire brain at a spatial resolution of 1 x 1 x 1 mm. 3D MP-RAGE acquisition parameters are as follows: TR/TE = 2000/2.93 ms, FOV = 21.9x21.9 cm, matrix = 256x256, scan time = 3 minutes and 50 seconds. This was added to the end of clinical imaging while the child was sedated.

Procedure for outlining Heschl’s gyrus
HG defined as the first transverse gyrus of the temporal lobe, most anterior gyrus if more than one [4]. While locating landmarks, the anatomy was viewed concurrently in 2D coronal, axial, and sagittal orientations. Manual regions of interest were traced around HG by three raters in the coronal plane. Heschl’s sulcus and the anterior transverse sulcus were the posterior and anterior boundaries respectively. The roof of STG white matter was the inferior boundary. See example HG ROI in Figs 1 & 2.

ROI

Inter-rater reliability was .95 for the right and .93 for the left hemisphere ROI volumes.

Analysis
Images were segmented using SPM5 [9] in an infant brain template to obtain gray and white matter volumes [5]. T-tests were used to compare left, right, NH, and HI on total ROI, gray, and white matter volume while controlling for age, sex, and total brain volume.

Results

Total ROI volume
Total ROI volume analyses revealed no significant differences between Normal Hearing (NH) and Hearing Impaired (HI) consistent with adult studies. (Table 1)

Gray Matter volume
HI infants exhibited a significantly higher mean percentage of GM within HG compared with the NH infants.

White matter volume
The HG group shows a significantly lower percent WM volume within HG than the NH group.

Discussion

• Total volume of primary auditory cortex appears normal in HI infants, but tissue classification reveals significant differences in both gray and white matter.
• Higher GM and lower WM percent in HG of HI infants characterizes delayed structural development due to auditory deprivation.
• The increased GM may be related to a higher and delayed peak synaptic density as seen in visually deprived animals [6]. In addition, decreased synaptic pruning in HG could contribute to increased GM volume.
• Lower WM percent is consistent with deaf adult studies and studies in visually deprived cats in which fewer myelinated fibers in the primary cortex were observed [2,3,7].

Conclusion

These macroanatomic changes in primary auditory cortex can be combined with other evidence supporting early disruption of normal structural development in congenital deafness. These findings reinforce current trends toward earlier intervention with cochlear implant in congenitally deaf infants [8].

References