Disparity of Non-verbal Language Learning

Identical Rate of Acquisition, Neurological Adaptations, and Cognitive Development

Science 100 Capstone Poster by Bethel Sileshi

Introduction

Language involves input, thought and output: a process of receiving, interpreting and responding in order to communicate.

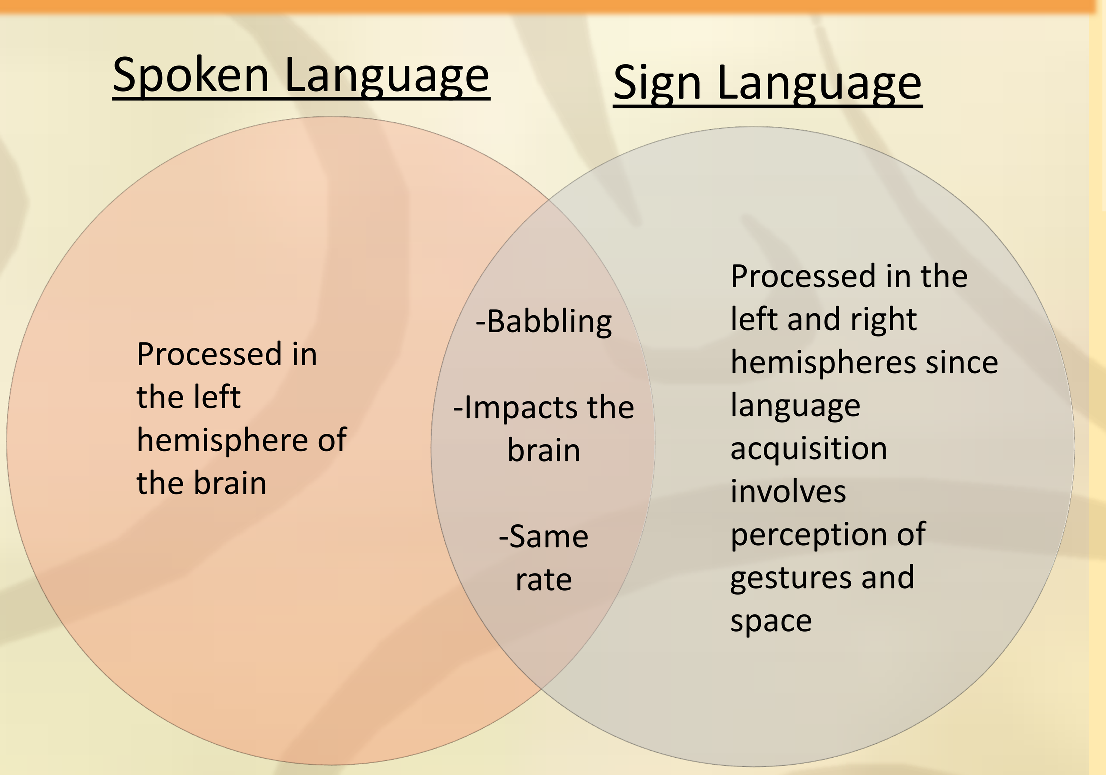
Infants learn any language at the same rate, including American Sign Language, ASL, or Langue des Signes Québécoise, LSQ)

People born with severe (70–89 dB loss) or profound (>90 dB loss) hearing loss are referred to as deaf and despite deafness, they can still have a strong foundation in language

However,

the process of language acquisition causes different neurological adaptations in the brains of hearing and deaf subjects which creates different cognitive outcomes in the deaf population: it hinders academic achievement, slightly affects IQ test performance and improves visuospatial abilities.

Similarities in Language Learning



Differences in Language Learning

Areas within the left and right hemispheres of the brain are analysed by various methods including scalp topography, functional magnetic resonance imaging (fMRI), and volumetric analysis.

Scalp Topography

In an experiment, 17 hearing subjects and 10 congenitally deaf subjects were presented with nouns and verbs while connected to an array of scalp electrodes. The resulting scalp topography identified areas of different brain activity (Figure 1).

These maps have the same scale and display a current sink in the left hemisphere of the hearing subjects. As shown by the black arrows, the current sink over the anterior temporal region is missing in the deaf subjects.

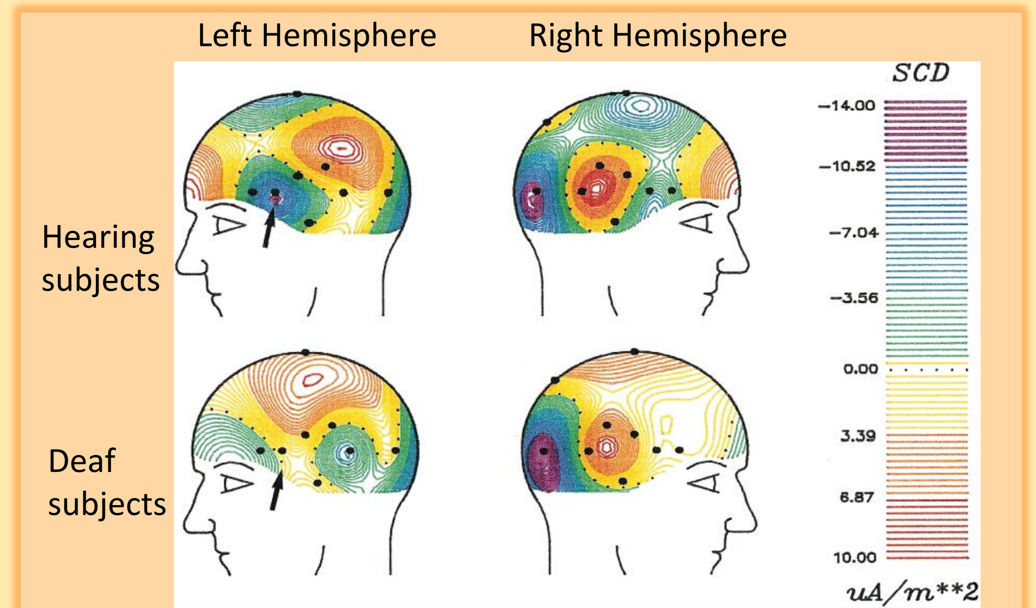


Figure 1. Scalp topography of current densities

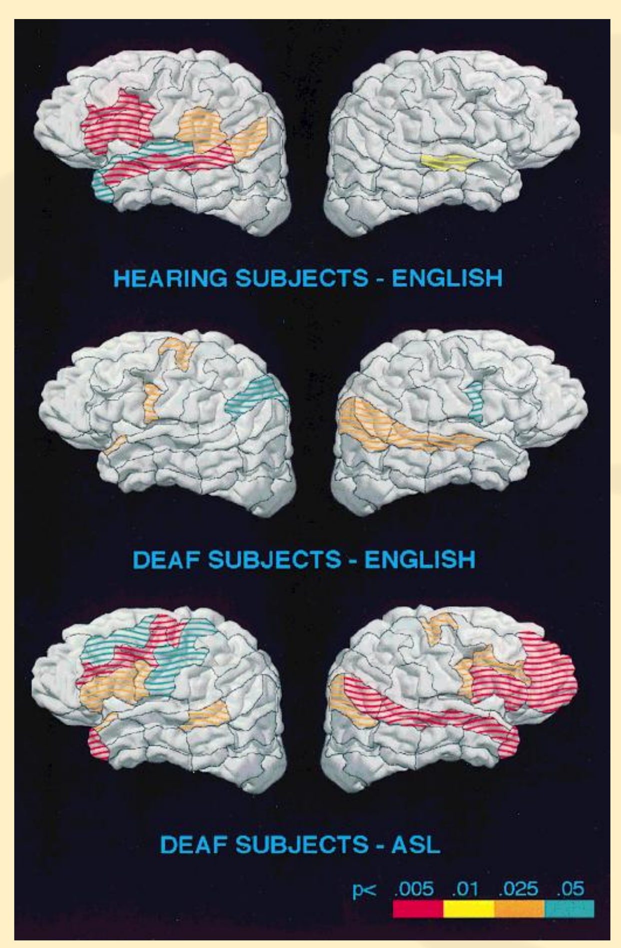


Figure 2. Cortical areas showing blood oxygenation on fMRI

Functional Magnetic Resonance Imaging (fMRI)

Figure 2 shows blood flow measured by fMRI in the active brain, as an indirect measure of neural activity. This data suggests that neural systems mediate language because there is significant activation of the left hemisphere when normal hearing adults and deaf adults read their native languages. There are alterations in these neural systems as a consequence of deafness and the acquisition of sign language.

The greatest difference in the brains occurs around Broca's area, in the anterior temporal region. Recent studies have shown that Broca's area plays a role in processing hand actions and facial gestures as well as motor speech-production. While language processing and sentence formation may be impaired in deaf people, their brains show Broca's area to be activated when they are presented with either English or sign language sentences therefore it has been hypothesized that Broca's area is reorganized as a consequence of deafness.

Volumetric Analysis

Reorganization in the brain can also be investigated using volumetric analysis of grey and white matter: white matter is the tissue through which messages pass between different areas of gray matter. Another study examining structural differences between 14 native signing deaf individual and 16 matched hearing controls, hypothesized hypertrophy (non-tumorous enlargements) in Broca's area as well as the motor and language cortices.

No significant volumetric differences were detected at the lobar level (Figure 3); however Broca's area, the cerebellum and the splenium (posterior end of the corpus callosum) were enlarged in deaf people (Figure 4). Since sign language is primarily observed by the visual cortex and travels to associated cortices for higher-level analysis, it is understandable that areas associated with motor and language cortices would be enlarged.

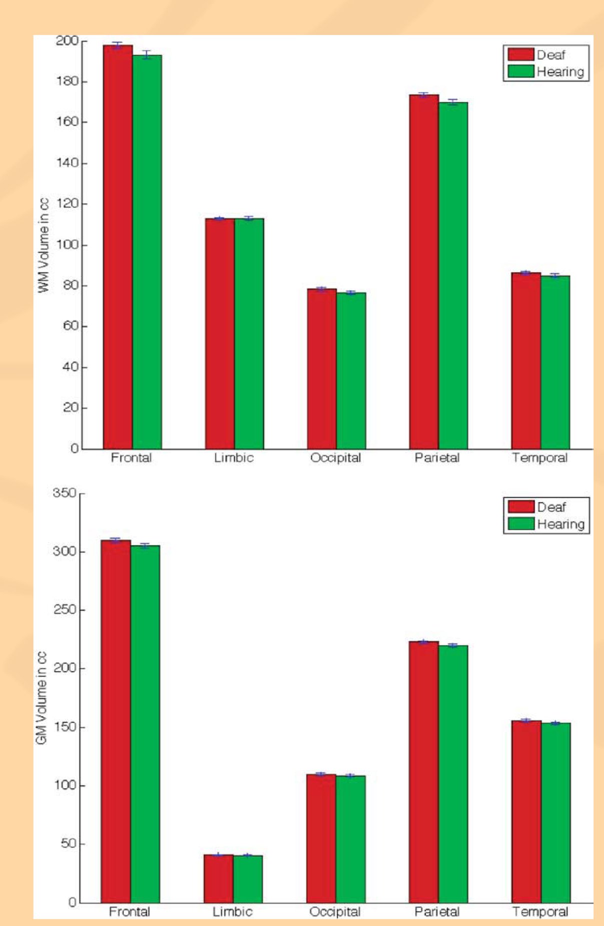


Figure 3. Volumetric differences in white and grey matter in the brain

Cognitive Outcomes

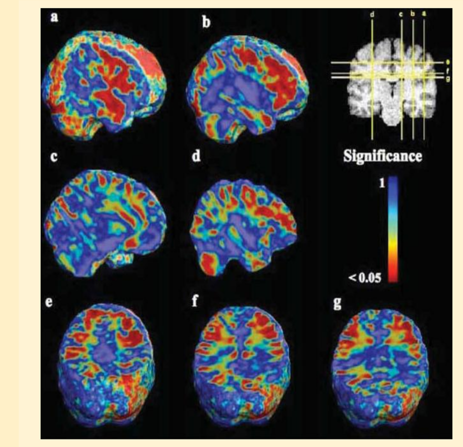


Figure 4. Hypertrophy (red areas) in white matter

Cognitive development is the overarching term describing the complex and logical thought processes of developing children. Comparing hearing and deaf children in academic achievement, performance on standardized intelligence tests and visual–spatial skills, will be the basis for identifying differences in cognitive outcomes.

Academic Achievement

A recent national study, the Stanford Achievement Test Series (established by The Gallaudet Research Institute), found that

- In Math: 80% of deaf students attained scores in the lowest quartile of the general population
- In Reading: <10% of deaf students were at/above grade level

This disparity suggests that children with hearing loss have difficulty in the reading and mathematical areas of academic achievement.

IQ Test Performance

The academic performance measured by an IQ test indicates whether the lower academic achievement of the deaf population compared to the hearing population is as a result of a lower IQ. According to the office of Demographic Studies at Gallaudet University, the mean nonverbal IQ is 100 for both the general hearing and deaf populations. The equal IQ suggests that deafness does not impact IQ.

Visual-Spatial Skills

The theory that deaf children perform better than hearing children on visual tasks as a result of their increased visual acuity was proven by the Benton Test of Facial Recognition: participants presented with a photo of an individual are asked to match the face to one of six simultaneously-presented faces. All sign language users, whether deaf or hearing, performed more accurately therefore using sign language sharpens visual-spatial abilities.

Conclusion

The human brain is remarkably flexible and can adapt to a loss of one sensory input by allocating more resources to use other input (i.e. visual sources) at hand. These adaptations impact areas of cognitive development in deaf children, but considering they display similar IQ performance as the hearing population, there is the potential for eventual progress into adult life.

References

*[Figure 1, Figure 2] Leporé N, Vachon P, Leporé F, Chou Y, Voss P, Brun C, Lee A, Toga A, Thompson P. 2010. 3D Mapping of Brain Differences in Native Signing Congenitally and Prelingually Deaf Subjects. Human Brain Mapping (**Edition**) [Internet]. [**Last Updated**, cited 2014 March 25] 31:970–978 . Available from: http://21cif.com/tools/citation/cse/citeWizard_cse_1.0.html

*[Figure 3, Figure 4] Neville HJ, Mills DL. 1997. Epigenesis of Language. Mental Retardation and Developmental Disabilities Research Reviews [Internet]. [cited 2014 March 25] 3: 282–292. Available from: http://www.researchgate.net/publication/228416919_Epigenesis _of_language

Mayberry RI. 2002. Cognitive development in deaf children: the interface of language and perception in neuropsychology. Handbook of Neuropsychology (2) [Internet]. [cited 2014 Feb 19] 8. Available from: http://www.academia.edu/4946633/Cognitive_development_in_deaf_children_the_interface_of_language_and_perception_in_neuropsychology

Petitto LA, Marentette P. 1991. Babbling in the manual mode: Evidence for the ontogeny of language. Science [Internet]. [**Last Updated**, cited 2014 Mar 28] 251:1483-1496. Available from: http://www.academia.edu/332984/Petitto_L.A._and_Marentette_P._1991_._Babbling_in_the_manual_mode_Evidence_for_the_otogeny_of_language_Reprinted_from_Science_vol._252_pages_1483-1496

Vishton P. 2013. Effects That Language Has on Cognitive Development [Internet]. Demand Media, Inc. [cited 2014 Feb 25]. Available from: http://www.livestrong.com/article/93181-effects-language-cognitive-development/

*Figures are extracted from reference