Original Research Paper
Volume - 12 | Issue - 02 | February - 2022 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar
Physiology

A STUDY ON VISUAL MEMORY AMONG CONGENITALLY DEAF CHILDREN

Dr Veena C N*	Associate Professor, Department of Physiology Dr Chandramma Dayananda Sagar Institute of Medical Education and Research Devarkaggalahalli Village, Harohalli Hobli, Kanakapura, Karnataka. *Corresponding Author
Mr Hariharan V	Manager, Research and Development Pearson India Education Private Limited Bangalore, Karnataka.
Dr Rajasekhar P	Professor, Department of Physiology Apollo Institute of Medical sciences and Research Murukambattu, Chitoor district, AndraPradesh.
Dr Vastrad B C	Former Professor and Head, Department of Physiology PES Institute of Medical Sciences and Research Kuppam, Chitoor district, AndraPradesh.
Dr Nandan T M	Professor, Department of Microbiology Sambhram Institute of Medical sciences and Research Kolar Gold Fields, Kolar, Karnataka.

ABSTRACT During early stages of development, the loss of a sensory system can lead to profound neural reorganization, specifically leading to an enhancement of the remaining modalities, a phenomenon termed as cross-modal plasticity. Thus in the absence of hearing, the vision is put under great demand, resulting in use-dependent plasticity pertaining to visual functions. The objective of the current study is to assess visual memory among congenitally deaf children and compare the results with those obtained from normal hearing individuals. The study included 60 congenitally deaf children and 50 normally hearing subjects. 30 subjects from each group with intelligence scores between 25-75 percentile were tested for visual memory. The results of the present study disclosed that deaf individuals were superior to normally hearing subjects with respect to immediate recall and delayed recall. Since deaf individuals demonstrate increased sensitivity to visual stimuli, their visual strengths can be utilized for better communication and academic achievement.

KEYWORDS : Congenitally deaf, Neuronal plasticity, Intelligence, Visual memory, Rey-Osterrieth Complex figure.

INTRODUCTION

Visual and the auditory stimuli primarily influence and control behavior. During early stages of development, the loss of a sensory system can lead to profound neural reorganization, specifically leading to an enhancement of the remaining modalities, a phenomenon termed as cross-modal plasticity. Evidence for cross modal plasticity is predicated on findings that blind individuals are more sensitive and respond better to sound and touch stimuli while deaf individuals are more sensitive to visual stimuli.[1] Although it is generally acceptable, recent findings suggest that cross modal plasticity is rather distinct and only few facets of the residual senses appear to be modulated after early sensory deprivation. With reference to deafness, the available literature specify comparable visual psychophysical thresholds, visual contrast sensitivity, temporal discrimination, temporal resolution.[2] Reorganization due to deafness would occur in the "deprived" parts (e.g. auditory areas) or the non-deprived parts (e.g. visual areas) since the human brain is exceptionally flexible .Also the areas of brain which receives and integrates inputs from various modalities may get greater information from vision.[3] Considering human mind to be distinguished by extensive linguistic inventiveness, deaf people instinctively tend to use visual clues. After early deafness ,visual skills like processing of peri-personal and peripheral space are more likely to be reorganized which would allow deaf individuals to achieve similar performance levels as hearing individuals .[3] In the absence of auditory stimuli, vision is put under great demand, leading to the greater plasticity in visual functions.[4]

Although the most neural connections in humans are shaped during fetal development, neural organization are refined based on sensory information received from the environment around us during childhood as a result of neural activity and synaptic transmission. Since the deaf children must essentially rely on vision to figure out the world to a much greater extent ,they might not show the same level of difficulty for visual images as compared with hearing and considerable evidence suggest that deaf people use visuospatial skills better than their hearing counterparts.[5] However, little is known about which visuo spatial skills might be enhanced due to deafness and what distinct factors associated with deafness might be responsible for such enhancement. Studies by Parasnis and Samar specifically proposed that the arrangement for visual attentional mechanism in deaf people might be different than in hearing people due to their greater dependence on the visual modality for alerting and analyses functions.[6] Enhanced abilities have also been reported for imagery and visual attention.[7, 8,9] Also studies have shown enhanced memory performance for shapes in deaf signers acquired through sign language.[10] However few studies have reported poor memory span in deaf compared to normally hearing .[11] Thus the study was taken up to evaluate and compare visual memory in deaf and normally hearing subjects.

MATERIALS AND METHODS:

The study included 60 congenitally deaf children from school of hearing impaired and 50 normally hearing subjects from Government primary school in a semi urban area who were aged between 10-14 yrs. The written consent from the principal of the concerned schools and institutional ethical clearance was obtained. Students with history of externalizing disorder, emotional disturbance and other psychological disturbances were excluded from the study.

After thorough history taking and detailed examination to rule out systemic and psychiatric illness, Intelligence was tested using Raven's Standard Progressive Matrices (SPM), comprising of 60 problems divided into five sets of 12 each. The subjects were briefed about the procedure of the test, record forms were distributed to the individuals and instructions regarding filling of particulars about themselves was explained. A demo picture related to a sample problem and instructions regarding filling the answer sheet was projected. For deaf individuals instructions regarding the procedure employed for testing intelligence was delivered through sign language by their class teachers along with the sample test. Sufficient time was given for completing the task .SPM scores were obtained after correcting the record forms. Among those included in the study, 30 students from each group with intelligence scores between 25-75 percentile (tested with Raven's progressive matrices) were subjected to testing for visual memory using the Rey-Osterrieth Complex figure.

Rey-Osterrieth Complex Figure:

It is a classic neuropsychological instrument that gauges visuoconstructional abilities and visual memory in both children and adults for a diverse number of conditions from child developmental problems to dementia, trauma and infectious process. The test consists of a complex design with an overall structure and multiple subcomponents within it. For testing, the subject is asked to copy the diagram as shown (figure 1) and later procreate the same from memory as accurately as possible.

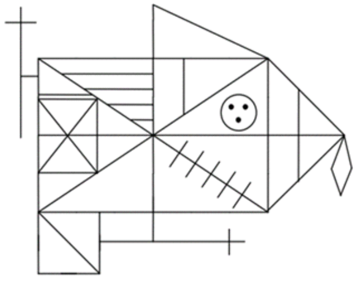


Figure 1- Rey-Osterrieth Complex Figure

To obtain a quantitative value for the accuracy of a subject's drawing, the figure is split into eighteen identifiable units and each units is considered separately and scores are assigned based on the accuracy of its position and the distortion exhibited (figure 2). [12]

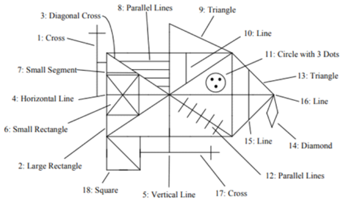


Figure 2- Rey-Osterrieth Complex Figure Scoring

Scoring -

1. For Correct and properly placed -2
2. For correct but poorly placed unit -1
3. For unit which is distorted, incomplete but recognizable and placed properly- 1
4. For unit which is distorted, incomplete but recognizable and placed poorly-1/2
5. Unit which is absent or unrecognisable- 0

Procedure – For administering the test, an 8.5 inch by 11inch card containing the complex figure and a blank paper is distributed to the subject and then the subject is instructed to copy the figure without using rulers to draw lines and then replicate the same from memory after 15min and 30min for immediate and delayed recall respectively.13

RESULTS AND ANALYSIS

The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 11.0. The scores were expressed as means, and differences in the scores between two groups were analyzed using unpaired "t" test. P values<0.05 was considered to be statistically significant and P values <0.01 was considered as highly significant

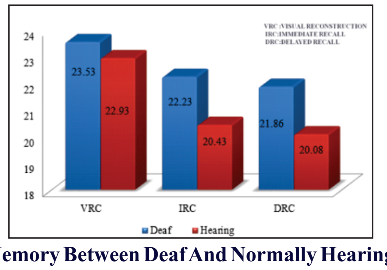
The results of unpaired student t test revealed that there was no significant difference in the mean scores for visual reconstruction ability between deaf and hearing individuals, though deaf children had superior scores .However with respect to immediate recall and delayed recall ,the mean scores of deaf were significantly higher compared to hearing individuals (Table:1, Graph:1)

Table 1: Memory Between Deaf And Normally Hearing Subjects

VARIABLES	DEAF (Mean +SD)	HEARING (Mean +SD)	p VALUE
VRC	23.53 + 1.97	22.93 + 2.09	0.25
IRC	22.23 + 1.97	20.43 + 2.63	0.004*
DRC	21.86 + 2.08	20.08 + 2.82	0.007*

VRC: Visual reconstruction, **IRC:** Immediate recall, **DRC:** Delayed recall

*(P<0.01)-highly significant



Graph 1: Memory Between Deaf And Normally Hearing Subjects

DISCUSSION

Brain reorganization linked with altered sensory experience elucidate the role of neuroplasticity during development. An explanation for this is improved peripheral visual processing reported in individuals with congenital deafness.[14]Cross-modal plasticity refers to neural reorganization that occurs due to sensory deprivation. It is often said that deaf people respond to the visual world much better than their hearing counterparts. Research investigating the visuospatial skills of deaf and hearing individuals has revealed several positive outcomes of using sign language.

As deaf individuals entirely rely on visual information to communicate effectively by the use of sign language, Rönnberg, Söderfeldt and Risberg (2000) postulated that deaf individuals may have an improved peripheral attention, enhanced spatial cognition, a better memory for faces, better perspective abilities, as a consequence of the early dependence on visual perception.[15] The results of the present study revealed that deaf individuals outnumbered the normally hearing individuals with respect to immediate recall and delayed recall .The reason may be that visual attentional mechanism in deaf people is organized differently compared to hearing individuals as they solely depend on the visual cues for alerting and analyzing functions and recruitment of sensory cortex that has been deprived of its default sensory modality, as well as network-level recruitment of cortices involved in attention.

Recent studies using fMRI displayed a feasible neural pathways for auditory reorganization and correlations of activations of the reorganized cortical areas.[16] Also , Wolff and Thatcher proposed EEG coherence model whose findings suggested more neuronal differentiation over the occipital (visual) regions and greater neuronal differentiation over the right hemisphere in deaf individuals compared to hearing children supporting the findings of the present study.[17]

The findings of the present study is consistent with previous findings by Bellugi et al. (1990) which reported better performance on facial recognition tasks by deaf individuals and findings of Wilson, Bettger et al. whose results revealed variable patterns of performance among deaf individuals when sequences of digits were presented.[18,19]

Contrary to the findings of the present study, the results derived by Parasnis, Samar, Betger, and Sathe showed no significant difference between hearing and deaf children in their ability to recall a series of geometric figures presented via a static sequential pattern and findings of Michelle A that revealed poor performance by deaf children on easily nameable sequencing tasks . 20,21The reasons could be difference in the sensitivity of different parts of the visual system to different aspects of environmental input and individual's strength in recall of information presented to them in a static visuospatial format.

CONCLUSION

Human brain is remarkably flexible. Childhood deafness has variable effects on cognitive development as it is necessary for early access to language, family and educational environments. Since deaf individuals demonstrate enhanced sensitivity to visual stimuli , their visual strengths can be utilized and deficiencies could be compensated so that communication and academic achievement can be enhanced by working out with various presentation strategies that allow deaf students to take advantage of their specific strength for the processing of specific sequential information and memory .

Limitations Of The Study-

The findings of the present study is riveting enough to know the outcomes of neuroplasticity during development. However, our study included a small sample of individuals and was limited to testing only visual memory. Further tests related to neurocognitive development can be employed to study the behavior of deaf individuals to different aspects of memory and cognition.

Acknowledgment:

The authors would like to express their gratitude to the Managing director, boarding school of hearing impaired and Principal of Government primary school for permitting us to conduct the research in their Institution. Mrs ShriVani Ashok & Mrs Bhavya A for their constant support in collecting the data. The faculty members of the boarding school for their guidance on communication. The students of boarding school and the government school for their interest and enthusiasm to participate in the study

REFERENCES

1. Dye MW, Baril DE, Bavelier D. Which aspects of visual attention are changed by deafness? The case of the Attentional Network Test. Neuropsychologia. 2007 Apr 9;45(8):1801-11. doi: 10.1016/j.neuropsychologia.2006.12.019. Epub 2007 Jan 10. PMID: 17291549; PMCID: PMC2885017.
2. Hauser PC, Dye MW, Boutla M et al . Deafness and visual enumeration: not all aspects of attention are modified by deafness. Brain Res. 2007 Jun 11;1153:178-87. doi: 10.1016/j.brainres.2007.03.065. Epub 2007 Mar 28. PMID: 17467671; PMCID: PMC1934506.
3. Bavelier, D., Brozinsky, C., Tomann, A et al . Impact of early cerebral organization for motion processing. Journal of Neuroscience. 2001; 21(22): 8931-8942.
4. Peter C. Hauser, Matthew W. G. Dye, Mrim Boutla, C.et al. Deafness and visual enumeration Not all aspects of attention are modified by deafness Brain Res. 2007 Jun 11; 1153: 178– 187.Published online2007,Mar 28. doi: 10.1016/j.brainres.2007.03.065 6.
5. Douglas P. Sladen, Anne Marie Tharpe, Daniel H.et al. Visual Attention in Deaf and Normal Hearing Adults: Effects of Stimulus Compatibility Journal of Speech, Language, and Hearing Research, December 2005;Vol. 48:1529-1537.doi:10.1044/1092- 4388(2005/106)
6. Parasnis I, Samar VJ, BettegerJG et al. Does deafness lead to enhancement of visual spatial cognition in children? Negative evidence from the deaf non signers .J Deaf Stud Deaf Educ.1:2 Spring145-152
7. Emmorey, K., Kosslyn, S.M., and Bellugi, U. Visual imagery and visual-spatial language: Enhanced imagery abilities in deaf and hearing ASL signers. Cognition, 1993; 46: 139-181.
8. Parasnis, I & Samar, Vincent. Parafoveal attention in congenitally deaf and hearing young adult. Brain and cognition. 1985; 4:313-27. 10.1016/0278-2626(85)90024-7.
9. Neville HJ, Lawson D. Attention to central and peripheral visual space in a movement detection task. Separate effects of auditory deprivation and acquisition of a visual language. Brain Res. 1987 Mar 10; 405(2):284-94. doi: 10.1016/0006-8993(87)90297-6. PMID: 3567606.
10. Allegra Cattani, John Clibbens, Timothy J Perfect. Visual memory for shapes in deaf signers and nonsigners and in hearing signers and nonsigners: atypical lateralization and enhancement. Neuropsychology 2007 ; 21(1) : 114-121. PubMed: 17201534
11. Pintner, Rudolf, Paterson, Donald G. A comparison of deaf and hearing children in visual memory for digits. Journal of Experimental Psychology. Feb 1917; Vol 2(1):76-88
12. Canham, Richard & Smith, Stephen & Tyrrell et al. Automated Scoring of a Neuropsychological Test: The Rey Osterrieth Complex Figure. Conference Proceedings of the EUROMICRO. 2000;2. 2406-2413. 10.1109/EURMIC.2000.874519.
13. Shobini L.Rao, D.K Subbakrishna,K. Gopukumar. NIMHANS neuropsychology battery Manual.2004, pg 191-192
14. Scott, Gregory & Karns, Christina & Dow et al. Enhanced peripheral visual processing in congenitally deaf humans is supported by multiple brain regions, including primary auditory cortex. Frontiers in human neuroscience. 2014; 8:177. 10.3389/fnhum.2014.00177.
15. Rönnberg, Jerker & Söderfeldt, Birgitta & Risberg, Jarl. (2001). The cognitive neuroscience of signed language. Acta psychologica. 105. 237-54. 10.1016/S0001-6918(00)00063-9.
16. Mochum Que,Xinjian Jiang,Chunyang Yi,Peng Gui et al. Language and Sensory Neural Plasticity in the Superior Temporal Cortex of the Deaf.Neural Plasticity.2018; Article ID 9456891, 17pages, 2018. http//doi.org/10.1155/2018/9456891
17. Thatcher, Robert & North, D & Biver, C. EEG and intelligence: Relations between EEG coherence, EEG phase delay and power. Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology.2014; 116:2129-41. 10.1016/j.clinph.2005.04.026.
18. U. Bellugi, L. O'Grady, D. Lillo-Martin, M. O'Grady Hynes et al. Enhancement of Spatial Cognition in Deaf Children. From Gesture to Language in Hearing and Deaf Children, 1990, Volume 27 ISBN : 978-3-642-74861-5
19. Wilson, M., Bettger, J. G., Niculae, I., & Klima, E. S. Modality of language shapes working memory: Evidence from digit span and spatial span in ASL signers. Journal of Deaf Studies and Deaf Education.1997;2:150-160.
20. Parasnis I, Samar VJ, Bettger JG, & Sathe K Does deafness lead to enhancement of visual spatial cognition in children? Negative evidence from deaf nonsigners. Journal of Deaf Studies and Deaf Education. 1996; 1:146–152.
21. Gremp MA, Deocampo JA, Walk AM, Conway CM. Visual sequential processing and language ability in children who are deaf or hard of hearing. J Child Lang. 2019; 46(4):785-799. doi:10.1017/S0305000918000569