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BLIND INDIVIDUALS EXHIBIT BETTER INFORMATION PROCESSING BY THE AUDITORY CORTEX: A COMPARATIVE CASE CONTROL STUDY

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ABSTRACT: BACKGROUND: Totally blind individuals are often considered to be compensated for their visual loss by augmentation in the auditory and tactile perceptions as compared to normal subjects. The objective of the present work was to study the Middle Latency Auditory Evoked Potential (MLAEP) component of the Auditory Evoked Potentials (AEP) in the totally blind and the normal subjects. **METHODS:** MLAEP was recorded in 20 totally blind females and compared with 20 age matched normal females. Latency and amplitude of the waveforms Na, Pa, Nb of MLAEP were measured and analyzed statistically using Student t test. **RESULTS:** The latencies of all the waveforms were significantly reduced in the blind individuals compared to normal subjects. The amplitudes of the waveforms Na, Pa, Nb did not show any significant changes between the two groups. **CONCLUSION:** The present study suggests that the totally blind individuals demonstrate remarkable neuroplastic changes and there is neuro physiological evidence of much better information processing in the auditory system in the totally blind compared to normal subjects.

KEYWORDS: Totally blind, normal sighted, auditory evoked potentials, MLAEP, neuro plastic changes.

INTRODUCTION: The blind individuals are often thought to be compensated for their handicap by developing supranormal abilities in their remaining sensory systems. Studies done in specific electrophysiological recordings have reported plasticity changes in the involved neural tracts and the higher central nervous system in the totally blind in response to blindness and that they depend on the non-visual sensory modalities.^{1,2,3,4,5} Neural plasticity is an important adaptation. It is the capacity of the nervous system to modify its organization by the changing of neurons, their networks and their function by new experiences.⁶ These changes are beneficial and the brain continually responds to changes in stimuli by reorganizing itself. Cross modal plasticity refers to the capacity of the brain to replace the functions of a lost part by another part, the most commonly used form of sensory substitution is Braille reading.^{7,8,9}

Studies have also shown augmentation of the auditory evoked potentials in the totally blind in comparison with the normally sighted.^{2,3,4,5} AEP, a sub class of event related potential, is an electrical manifestation of the brain's response to a physiological or an electrical auditory stimulus, recorded from the scalp. AEPs are classified into early (The first 10 to 15 milliseconds), middle (10 to 80 ms) and late (80 to 750 ms) components.

The present work is undertaken to advance our understanding of MLAEP responses in the blind and the probable plasticity of the auditory system in response to blindness.

MATERIALS AND METHODS: The present study was a comparative study in which 20 totally blind females from blind schools and 20 ages matched normal sighted females from the general population

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were recruited. Ethical clearance was obtained from the institute's ethical committee for human research. Informed written consent was obtained from all subjects.

Female subjects who were aged between 18 to 40 years, in the first week of menstrual cycle, who were congenitally blind or subjects with total blindness (Category-5) for more than 2 years were included in the study. Subjects with other visual defects, other causes of blindness, with history of hearing impairment, other neurological disorders, subjects using drugs like narcotics, stimulants and neurotropic drugs were excluded.

Personal details like menstrual history were procured through history from all the study participants. Subjects were screened for general physical health to rule out any clinical disorder likely to interfere with the study findings. Anthropometric details like weight in kilograms, height and head circumference in centimeters were recorded from all the subjects. All the subjects were also screened for hearing threshold by audiometry. Blind subjects were certified for blindness by an Ophthalmologist through ophthalmologic and funduscopy examinations. The subjects were assigned to two different groups - (A) Normal sighted females and (B) Totally blind females.

AEPs were recorded in a sound proof, semi dark, air conditioned room with subjects comfortably lying down on the bed and awake; subjects were requested to remain calm keeping their eyes closed to avoid electro-oculographic artifacts due to eye movements and improve the concentration and attention to the stimuli presented. AEP Recordings were performed after cleaning the sites with Nuprep EEG & ECG abrasive skin prepping gel and later affixing Ag/AgCl disc electrodes with Ten 20 conductive paste. All electrodes were plugged to a junction box and skin to electrode impedance was kept below 5 KOhm. Electrode placing, nomenclature and methodology of AEP recordings were according to Chiappa.¹⁰

The peak latency of Pa, Na and Nb components of MLAEP were recorded. The acoustic stimulus parameters used for MLAEP acquisition were 1500 alternating condensation and rarefaction click stimuli were delivered at 80 dB sound pressure level monaurally through shielded headphones. Contralateral ear was masked with a white noise of -30 dB. Signals picked up by electrodes were filtered (10 Hz and 200 Hz), amplified, averaged and displayed on the screen of GALILEO NT Evoked Potential Recorder. The different wave form latencies and amplitudes were calculated. Amplitude (μ V) was measured from the peak of one polarity to the immediately following peak of the opposite polarity.

RESULTS: Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean $\pm$ SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. Student t test (Two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis). Effect size of blindness has been computed. SPSS 15 was used for statistical analysis of the data and Microsoft Word and Excel was used to generate tables and graphs.

The two groups were similar in terms of the basic characteristics as shown in Table 1.

The mean latency of MLAEP waveforms Na, Pa, Nb in the blind and normal subjects is shown in Table-2. The mean pattern of absolute latencies of MLAEP waveforms Na, Pa, Nb from right and left ears showed significant difference between the two groups with the blind individuals having a decreased latency period compared to the normal subjects (Table-2). The amplitudes of the

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waveforms Na, Pa, Nb did not show any significant changes between the two groups (Table 3). The effect size showed variable relationship among the two groups for MLAEP latencies.

Basic variables	Group A	Group B	P value
Age in years	24.33±6.29	26.05±6.59	0.409
Height in cm	157.80±4.58	156.65±5.79	0.490
Weight kg	54.55±8.14	56.60±7.94	0.425
Head circumference cm	30.75±1.11	30.60±1.19	0.683
Table 1: Basic characteristics of subjects studied			

MLEP-Latency in ms	Group A	Group B	P value	Effect size
RIGHT SIDE				
Na	26.02±1.73	22.78±1.86	t=5.715;p<0.001**	1.77
Pa	33.06±3.31	28.7±4.22	t=3.643;p=0.001**	1.13
Nb	38.81±3.69	35.99±3.36	t=2.522;p=0.016*	0.78
LEFT SIDE				
Na	26.48±2.08	23.64±2.28	t=4.105;p<0.001**	1.27
Pa	32.79±3.54	30.12±4.28	t=2.153;p=0.038*	0.67
Nb	40.53±3.47	38.64±4.03	t=1.594;p=0.119	0.49
Table 2: Comparison of MLAEP LATENCY between the two groups				

* Significance at 5% ** Significance at 1%

MLAEP-Amplitude (Microvolt)	Group A	Group B	P value	Effect size
RIGHT SIDE				
Na	0.79±0.62	0.68±0.36	t=0.663;p=0.511	0.21
Pa	0.61±0.43	0.51±0.38	t=0.771;p=0.446	0.24
Nb	0.71±0.45	0.47±0.33	t=1.886;p=0.067	0.58
LEFT SIDE				
Na	0.80±0.52	0.71±0.42	t=0.565;p=0.575	0.18
Pa	0.49±0.43	0.44±0.40	t=0.397;p=0.693	0.12
Nb	0.73±0.50	0.58±0.46	t=0.965;p=0.341	0.30
Table 3: Comparison of MLAEP AMPLITUDE between the two groups				

DISCUSSION: Blind individuals have to rely on non-visual information to a greater extent than the sighted to efficiently interact with the external environment and consequently exhibit superior skills in their spared modalities. In the present study among the blind we found the following results which were in agreement with our hypothesis that there is neuro physiological evidence of much better

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information processing in the auditory system in totally blind compared to the normally sighted subjects. The mean pattern of absolute latencies of MLAEPs (Na, Pa, and Nb) showed significant decrease in the blind when compared to the normal subjects. This implies that there is facilitation of processing of auditory information at the level of the die cephalic and the superior temporal cortex (Heschl's gyrus) which are known to be the generators of the middle latency waveforms.¹¹

This finding is in agreement with previous studies, where they found that the peak latencies of both the Pa and Nb waves was significantly shorter in the congenitally blind compared to the normal sighted subjects.^{12,13}

The mean pattern of amplitude of MLAEPs (Na, Pa, Nb) did not show any significant difference between the two groups, except for Nb wave where it showed some significance which is in contrast to the study which showed that the peak amplitude of the Pa wave recorded from the occipital area of the congenitally blind individuals was significantly less than that of the normal sighted subjects, recorded from the same site.¹² It appears that in the blind subjects' changes in the generators of the middle latency auditory evoked potentials are mainly related to latency rather than to the scalp distribution of these components.

To conclude, the present study provides evidence of neuro plasticity in the form of decreased latencies of MLAEP in the visually deprived, suggestive of much better information processing in the auditory system. This finding can guide future studies of the cellular and molecular mechanisms important in neuro plasticity. Additionally, in the long run, they may contribute to the design of educational and rehabilitative programs for the blind.

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