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Research article

STUDY OF NEURAL PLASTICITY IN BRAILLE READING VISUALLY CHALLENGED INDIVIDUALS

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ABSTRACT

Background: Neural plasticity includes a wide range of adaptive changes due to loss or absence of a particular sense. Cortical mapping or reorganization is evolutionary conserved mechanism which involves either an unmasking of previously silent connections and/or sprouting of new neural elements. **Aims & Objectives** -To compare the Somatosensory evoked potentials (SSEPs) wave form in normal and visually challenged individuals. **Materials & Methods**: 20 visually challenged males in the age group of 21 -31 yrs were included in the study along with 20 age & sex matched individuals. Subjects were screened for general physical health to rule out any medical disorder, tactile sensibility i.e., sensation of light touch, pressure, tactile localization & discrimination to rule out any delay in the peripheral conduction disorder. Somatosensory evoked potentials were recorded on Nicolet Viking select neuro diagnostic system version 10.0.The placement of electrodes & recording of potentials were done based on methodology in chiappa. Data was subjected to various statistical analyses using SPSS version 17.0 software. N20 & P25 latencies were shorter and amplitudes were larger in visually challenged individuals compared to age & sex matched individuals. **Conclusions:** In visually challenged individuals, decrease in latencies indicate greatly improved of information in the nervous system & increase in amplitudes indicate the extent and synchronization of neural network involved in processing of vision.

Keywords: Neural plasticity, Somatosensory evoked potentials, Cortical mapping, Visually challenged

INTRODUCTION

In humans as well as in many animals, cortical area has enormous capacity for reorganization i.e plastic changes.[1] The present study was undertaken to study the cross modal interactions of sensory modalities in visually challenged individuals for the exploration of neural plasticity using somatosensory evoked potentials. In our central nervous system perception is modulated due to the redundant informational inputs from more than one sensory organ. In blind individuals Occipital cortex that is deprived of its normal inputs is invaded by inputs from other modalities supporting the concept of cross-modal plasticity.[2-5]

Specific electrophysiological recordings & functional imaging studies of visually challenged individuals have depicted that touch modality is not only sharpened in these individuals but also plays a major role in their perception.Various animal models have been used to study the changes occur both at the cellular & synaptic level i.e activity based competition between the differential sensory inputs.[6]

The molecular mechanism underlying neural plasticity is probably due to unmasking of connections or the up-regulation of synaptic efficacy.[7] As we all know that the thalamus is considered as the gateway for the sensory information reaching the cortex, the reorganization can occur at this level or at the level of polymodal association areas.[8]

Specific somatosensory & auditory evoked potentials have demonstrated that cross-modal plasticity develops in visually challenged individuals due to their dependence on tactile & auditory information.[9- 12] In blind Braille readers there was structural & functional cortical reorganization along with relevant changes in the behavior & perceptual capacities as demonstrated by imaging studies.

METHODS

20 visually challenged individuals were recruited from Govt. hostel for blind boys, Dilsukhnagar area, Hyderabad & study was conducted at the Electrophysiology lab, Upgraded Department of Physiology, Osmania Medical College, Koti, Hyd., during Dec.2009 to Dec.2011. 20 Age & Sex matched controls were also included in the study. Subjects with history of nervous system disorders, usage of antidepressants, narcotic drugs, CNS stimulants were not included in the study. Subjects with late onset of blindness due to other medical reasons were excluded from the study. Subjects were screened for general physical health to rule out any medical disorder, tactile sensibility i.e sensation of light touch, pressure, tactile localization & discrimination to rule out any delay in the peripheral conduction disorder. Prior to study, ethical guidelines were followed; consent was taken, after the subjects were told about the aims & objectives of the study.

Procedure : This study was conducted on patients using **3-channel with normal averaging technique.**[13] The procedure was explained to the patient and consent taken.Patient was asked to sit comfortably on a chair and instructed to gently close his/her eyes while relaxing all the head and neck muscles during the recording. Patient is asked to count the number of stimuli so as to get proper recordings. Electrodes of the 3 channels were placed on the patient at appropriate sites after it's proper abrasion. Placement of electrodes & recording of potentials were done in accordance with the methodology in Chiappa.[13]

Surface EEG electrodes are used. Frontol electrode [Fz] is used as the reference in most montages.

Active recording electrodes are placed as follows:

1. 1st channel: Over the contralateral C3'/C4' scalp region (2cm posterior to C3 or C4)
2. 2nd channel: Over the C5/C2 cervical spinous process (referred to as C5S or C2S and located relative to the prominent C7 spinous process with the neck flexed.
3. 3rd channel: At Erb's point (2-3 cm above clavicle in the angle between it and posterior border of the clavicular head of the Sternocleidomastoid muscle ipsilaterally.
4. Inactive recording electrodes of the 3 channels were placed on Fz position on the scalp.
5. Ground electrode: is placed between the stimulating and the recording electrodes relatively close to the former. We have used a band around the forearm.
6. Stimulation electrode: using surface disk electrodes placed between the tendons of palmaris longus and flexor carpi radialis, i.e., at the supinated wrist, **median nerve** was stimulated. Stimuli of 0.2-0.3 msec duration are given at 4-7 Hz. The intensity of the current was adjusted till a visible twitch was produced.

Data-sheet was made using Microsoft word & excel sheets.Statistical analysis was done using PASW 18.0 (SPSS Inc.Chicago,USA)

RESULTS

This Comparative study consisted of 20 congenitally blind males (Group A) and 20 normal sighted individuals(Group B)

The mean pattern of latency of SEP-N20 after wrist stimulation was found to be significant I.e P value = 0.000 (<0.0001) for right side & P-value = 0.001 (<0.005) for left wrist.The mean pattern of latency of SEP-P25 after wrist stimulation was found to be significant i.e. P value =0.000(<0.0001) & p=0.022(<0.05).The mean pattern of latencies of N9& N13, inter-peak latencies of SEP's did not show significant difference (P > 0.05) between the two groups.(TABLE –I)

Table 1: Statistical analysis of mean pattern of latencies on wrist stimulation

MEAN PATTERN OF LATENCIES	WRIST	GROUP A	GROUP B	P-VALUE
N9	RIGHT	9.25±0.62	9.48±0.68	0.274
	LEFT	9.17±0.69	8.89±0.64	0.270
N13	RIGHT	12.54±0.39	12.68±0.78	0.463
	LEFT	12.54±0.43	12.49±0.53	0.725
N20	RIGHT	17.5±0.58	18.49±0.7	0.000
	LEFT	17.8±0.53	18.54±0.79	0.001
P25	RIGHT	20.63±0.53	21.69±1.08	0.000
	LEFT	21.03±1.08	21.81±1.0	0.022
N9-N13	RIGHT	3.41±0.62	3.47±1.06	0.83
	LEFT	3.58±0.84	3.22±0.77	0.168
N9-N20	RIGHT	8.07±0.22	8.20±0.19	0.105
	LEFT	8.69±0.81	8.88±0.72	0.438
N13-N20	RIGHT	5.31±0.52	5.33±0.39	0.894
	LEFT	5.19±0.25	5.28±0.34	0.406

Table 2: Statistical analysis of mean pattern of Amplitude on wrist stimulation

MEAN PATTERN OF AMPLITUDE	WRIST	GROUP A	GROUP B	P-VALUE
N9	RIGHT	2.12±2.44	1.9±1.73	0.778
	LEFT	1.90±1.57	1.67±1.77	0.667
N13	RIGHT	0.87±0.55	0.91±0.66	0.834
	LEFT	0.79±0.73	0.41±0.68	0.092
N20	RIGHT	4.82±1.36	2.74±0.95	0.000
	LEFT	4.2±2.5	2.76±0.83	0.004
P25	RIGHT	1.24±0.68	0.77±0.52	0.021
	LEFT	1.28±0.56	1.14±0.62	0.452

The mean pattern of amplitude of SEP-N20 after wrist stimulation was found to be significant i.e

P- value = 0.000 (<0.0001) for right side & P-value = 0.004 (<0.005) for left wrist. The mean pattern of amplitude of SEP-P25 after wrist stimulation was found to be significant i.e. P value =0.021(<0.05) for right side .The mean pattern of amplitudes of N9& N13 SEP's did not show significant difference (P > 0.05) between the two groups.(TABLE-II)

DISCUSSION

This study compares the latencies and amplitudes of SEP's in normal and congenitally blind individuals thereby giving an insight into the sharpening of other sensory modalities in the absence of vision.

The present study throws light on the efficiency and rapidity of neural processing of information in congenitally blind subjects.

Following SEP parameters were recorded - N20, P25, N13, N9 latencies and amplitude; N9-N13, N9-N20, N13-N20 inter-peak latencies and N20-P25 amplitude in blind and was compared with that of age-matched normal controls using the independent sample't' test.

The congenitally blind individuals use more than one finger for Braille reading;index middle & ring finger. Hence the median nerve was stimulated in the wrist to get a cumulative record of the reading fingers. Somatosensory evoked potentials like other evoked potentials are path-specific electrical signals are produced in the areas of signal processing which correspond to the synaptic junctions of various neurons and they give good temporal resolution in milliseconds domain.N20 & P25 Latencies were decreased and N20 & p25 amplitudes increased in the congenitally blind when compared to same group in the congenitally blind individuals,there were highly

significant differences in N20 & P25 Latencies & amplitudes stimulation on right side than the left side. According to previous studies done by Alvaro et al & Dayanand G et al;there was increase in amplitude of N20 Potential & the increase was more on the right/dominant side[14]

In another comparative study SEPs were recorded in 10 blind & 15 control subjects & data revealed that there were significant increase in N20 & P22 SEP'S on right-sided stimulation suggesting activity dependant alteration in spatio-temporal components of signal processing[15]

In a PET study to decipher the cross-modal plasticity in the visually challenged individuals by electro-tactile stimulation of tongue,results have shown that the occipital area is part of a neural network for discriminating touch sensations along with posterior parietal cortex as there was increase in regional blod flow(rRBF) in the occipital cortex & that the increase was related to the performance of particular task[16]

In another functional magnetic resonance imaging study 12 congenitally and early-onset blind subjects were studied with fMRI reading & results reveal that there was activation of the primary sensory area along with polymodal association areas[17]

Studies in congenitally blind Braille readers have shown that there was reorganization of tactile & auditory tracts to the central retinal targets both at the sub-cortical & cortical levels.[18-20]

Another brain -imaging study demonstrated that there is difference in pattern of activation of visual cortex in late and congenitally blind subjects. Early blind subjects when compared to late blind have better tactile & auditory sensibility as demonstrated by event related potentials recorded over the posterior cortical areas.[21-22]

CONCLUSIONS

In congenitally blind individuals, decrease in N20 & P25 latencies indicate greatly improved processing of information in the nervous system; increase in N20 & P25 amplitudes indicate the extent and synchronization of neural network involved in processing of information for a wider Neural network could be due to changes in the local connectivity as several local mechanisms have been proposed, including sprouting, unmasking of silent synapses and/or changes in the modulatory effects of lateral connections.

In accordance with the principles of lateral inhibition; the tactile & auditory modalities also exert the modulatory effects on perception of visual modality both at the sub-cortical & cortical level.

Thus it can be formulated that in the spatio-temporal framework the demarcation between uni-modal & polymodal association areas can undergo re-organization i.e plastic changes both at gross & at molecular level.

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