

# Brain stem auditory evoked potentials in normal and congenitally blind individuals

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## Abstract

**Background:** Understanding the effects of visual loss on remaining senses has been a matter of interest since long. Neuroplasticity in the form of cross-modal plasticity occurs to compensate for the loss of function and to enhance remaining functions in the event of sensory deprivation. In congenitally blind individuals, auditory localization tasks can activate the visual cortex. Studies have shown that blind subjects perform as well or even better than normal controls with auditory stimuli.

**Objectives:** To compare the auditory evoked potentials in congenitally blind individuals with those of normal subjects so as to look for any compensatory increased activity in auditory functions.

**Materials and Methods:** Auditory evoked potentials were recorded in 33 normal subjects and 37 congenitally blind subjects using a single fiber electromyography. Recording was done in both ears by giving clicks into test ear. Latencies, amplitudes, and waveforms were recorded.

**Result:** A significant decrease ( $p < 0.05$ ) in latencies of left I and V wave was seen both ipsilateral and contralateral. One-way ANOVA showed a significant difference in the mean between the two groups.

**Conclusion:** A compensatory neural reorganization may occur in blind individuals which may be influenced by corticofugal connections with the auditory system.

**KEY WORDS:** Auditory evoked potentials, cross-modal plasticity, congenital blindness, latencies

## Introduction

There have been mixed opinions about the enhancement of auditory senses in blind individuals with interest in understanding the effects of visual loss on remaining senses.<sup>[1-4]</sup> Some animal studies have shown that in the absence of vision, sound processing by neurons of auditory cortex is enhanced

and there is expansion of non-visual regions at the expense of formerly visual regions.<sup>[5-7]</sup> Neuroplasticity in the form of cross-modal plasticity occurs to compensate for loss of function and to enhance remaining functions in the event of sensory deprivation.<sup>[8,9]</sup> Studies have also shown that in congenitally blind individuals, auditory localization tasks can activate the visual cortex.<sup>[10]</sup> Some studies on blind subjects have reported that they perform as well or even better than the normal controls when given auditory stimuli.<sup>[11,12]</sup> Brain stem auditory evoked potential (BAEP) is a very small electrical response occurring in the brain within 10 ms of auditory stimulus which allows assessment of integrity of auditory neural pathway. The aim of this study was to compare the auditory evoked potentials (AEPs) in congenitally blind individuals with normal subjects and to see if there is any compensatory increased activity and alterations in auditory functions.

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## Materials and Methods

AEPs were recorded in 33 normal subjects and 37 congenitally blind individuals. Subjects with diseases of auditory system were excluded from the study in both the groups. A single fiber electromyography (Nicolet system) was used for recording auditory potentials and a two channel auditory brain stem response was adopted. The sweep duration was 10 ms with constant current throughout the procedure. Recording was done in both the ears with about 2000 clicks given for recording AEPs in test ear, whereas no click was given in the contra-lateral ear. The wave pattern recorded had five waves (I-V). I wave originated from the peripheral portion of eighth cranial nerve adjacent to cochlea, II wave from cochlear nucleus, III wave from superior olivary nucleus, IV wave from lateral lemniscus, and V wave from inferior colliculus. Latencies of I, III, and V were recorded on ipsilateral and contralateral sides. Amplitudes of I' and V' on ipsi and contralateral sides were also estimated. Interpeak latencies were recorded along with amplitudinal ratio. Electrodes were applied after appropriate preparation of the area on the scalp and were connected to amplifiers set at average control. The channel selector could be operated remotely so as not to disturb the subject. Amplification was done to gain factor of 5,00,000 X which was necessary for the study. The voltages produced by amplifiers were converted to numbers (analog to digital) to enable computer to perform mathematical operations by the A/D converted. Measurements of latency, amplitude, and wave form of wave IV and V were recorded. An informed consent was taken from all the subjects participating in the study and the Institutes Ethics Committee permission was obtained.

### Statistical Analysis

Mean and standard deviation were calculated. One-way ANOVA was used to see the variation between congenitally blind and normal subjects.

## Result

The mean age of normal subjects was  $20.15 \pm 3.85$  years and mean age of congenitally blind individuals was  $22.7 \pm 3.99$  years [Tables 1-5]. Amplitudes of II' ipsilaterally and contralaterally were lower in blind than normal subjects. Applying the one-way ANOVA between blind subjects and normal group, it was found that there was a significant difference in the mean between the two groups in left latency I and V both ipsilaterally and contralaterally.

## Discussion

BAEP is a short latency AEP. It is generated by synchronous firing of neurons along auditory nerve, cochlear nuclei, superior olivary nucleus, lateral lemniscus, and inferior colliculus.<sup>[13-16]</sup>

In this study, BAEPs were used as a mode of evaluation to prove the existence of cross-modal interactions of sensory modalities by comparing congenitally blind individuals with normal people.

The latencies and amplitudes of wave V when stimuli were given to left ear are statistically significantly altered. However, the latencies of V ipsilateral and III ipsilateral and contralateral waves were not altered. This observation was interesting as the stimulus used was a monotonous click which is more akin to a musical sound and is expected to be analyzed thoroughly on the contralateral side in the right hemisphere. This insignificant alteration in V ipsilateral amplitude may be explained by the fact that the V wave corresponds to the analysis of information at the level of inferior colliculus. The processing of auditory information is bilateral but is predominantly contralateral starting from the II wave onward. The other observation is that when a stimulus was given to the right ear, there was no significant alteration found between the groups except I wave latency on ipsilateral and contralateral side. Lack of alterations in other waves may be explained by specialization of cerebral hemispheres to perform different functions like verbal in left hemisphere and music in right hemisphere. Previous studies also have shown that compensatory neural reorganization may occur in blind individuals which may be influenced by corticofugal connections with the auditory system.<sup>[17]</sup>

Significant alterations in latencies of I wave both ipsilateral and contralateral and alteration in amplitude of I wave indicates sharpening of auditory sense modality in blind individuals at first order neuron only as sensitivity maybe increased at the first order neuron.

From this study it may be inferred that specialization of hemispheres occurs like verbal for left and music for right hemisphere. When monotonous click was given to left ear in right handed persons, latencies and amplitudes of five AEPs were significantly altered.

The study also shows that processing of information is much faster in blind than normal individuals as seen from V wave latencies and I-V interpeak latencies. Also, increased amplitude of V wave speaks of more elaborative processing of information in blind than normal individuals.

The study gives information about the compensatory neural reorganization that may occur in blind individuals enhancing the sensitivity of auditory system. However, a larger sample size maybe required to substantiate the findings of this study which is the main limitation.

The information obtained from this study maybe useful in training the congenitally blind individuals to use their other senses, especially auditory, more effectively and efficiently.

## Conclusion

A compensatory neural reorganization may occur in blind individuals which may be influenced by corticofugal connections with the auditory system.

**Table 1:** Left latencies in normal and blind individuals on ipsilateral and contralateral sides

	Left latency I IL*	Left latency I CL**	Left latency III IL*	Left latency III CL**	Left latency V IL*	Left latency V CL**
Normal mean ± SD	1.73 ± .14	1.69 ± .17	3.83 ± .43	3.75 ± 0.48	5.75 ± 0.53	5.7 ± 0.49
Blind mean ± SD	1.6 ± 0.23	1.5 ± 0.24	3.75 ± 0.34	3.67 ± 0.30	5.46 ± 0.31	5.48 ± 0.29

\*IL = ipsilateral, \*\*CL = contralateral.

There was a significant decrease in latencies of left I and V wave both ipsilaterally and contralaterally.

**Table 2:** Right latencies I, III, and V - ipsilateral and contralateral

	Right latency I IL*	Right latency I CL**	Right latency III IL*	Right latency III CL**	Right latency V IL*	Right latency V CL**
Normal mean ± SD	6.9 ± .29	1.73 ± 0.17	3.72 ± 0.38	3.790 ± .59	5.49 ± 0.40	5.63 ± 0.38
Congenitally blind mean ± SD	1.6 ± .19	1.61 ± 0.18	3.65 ± 0.19	3.72 ± 0.27	5.49 ± 0.18	5.62 ± 0.21

\*IL = ipsilateral, \*\*CL = contralateral.

When latencies on right side were compared between normal and blind individuals, there was a decrease in the latencies between the two groups.

**Table 3:** Interpeak latencies, left and right

	Left interpeak latency I-III	Left interpeak latency III-V	Left interpeak latency I-V	Right interpeak latency I-III	Right interpeak latency III-V	Right interpeak latency I-V
Normal	2.07 ± 0.43	2.09 ± 0.46	3.98 ± 0.49	2.01 ± 0.26	1.99 ± 0.41	3.85 ± 0.35
Blind	2.260 ± .41	1.660 ± .36	3.810 ± .38	2.05 ± 0.23	1.83 ± 0.18	3.87 ± 0.32

The interpeak latencies I-III on left and right were higher in congenitally blind individuals compared to normal. The interpeak latencies III-V were lower in blind when compared to normal subjects.

**Table 4 :** Amplitudes II' and VV' left side

	Left amplitude I' IL	Left amplitude I' CL	Left amplitude V V' IL	Left amplitude V V' CL	Left amplitude ratio II':VV'
Normal	187.57 ± 109.41	143.48 ± 58.99	285.90 ± 140.32	231.96 ± 103.44	0.65 ± 0.43
Blind	133.78 ± 71.43	105.67 ± 76.41	282.16 ± 141.38	267.89 ± 122.87	0.5 ± 0.35

\*IL = ipsilateral, \*\*CL = contralateral.

**Table 5 :** Amplitude II' and VV' in normal and blind

	Right amplitude I' IL	Right amplitude I' CL	Right amplitude V V' IL	Right amplitude V V' CL	Right amplitude ratio II':VV'
Normal	153.48 ± 89.35	141.66 ± 70.90	268.33 ± 119.06	258.33 ± 109.67	0.52 ± 0.42
Blind	125.67 ± 80.24	131.48 ± 60.95	277.16 ± 114.10	258.4 ± 90.87	0.56 ± 0.55

\*IL = ipsilateral, \*\*CL = contralateral.

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