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Research Paper

Temporal Resolution Skills in Cochlear Implant Users in Relation to Post Implant Age

Medical Science

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ABSTRACT

Cochlear Implant (CI) is a device that helps adults and children who have severe to profound hearing loss and are not receiving satisfactory benefit from hearing aids or tactile devices to understand speech. Temporal resolution is an auditory temporal processing skill that refers to the minimal time required to segregate or resolve acoustic events. Gap detection is probably the most commonly used measure of temporal resolution. 20 children with cochlear implant in the age range of 7-20 years were included in the study. Gap Detection Threshold was measured at 500Hz, 1K Hz, 2K Hz, 4K Hz in four groups i.e., are cochlear implant recipients with 2, 5, 10 and 15 months of post-operative duration. Significant (p<0.001) difference in gap detection threshold between 2 and 5, 10 and 15 months observed for all frequencies. No significant difference observed between 5 months to 10 and 15 months and between 10 and 15 months for all the test frequencies. Poor temporal resolution is seen in CI because they rely on either temporal or spectral cues. Poorer scores soon after the implants could be due to the training, implant duration or the initial map current levels.

Introduction:

Cochlear Implant (CI) is a technologically advanced medical device that helps adults and children who have severe to profound hearing loss and are not receiving satisfactory benefit from hearing aids or tactile devices to understand speech. It is a neural stimulators, which, when implanted into the cochlea of inner ear, bypass the function of sensory receptors. Minute electrical currents directly stimulate ganglion cells of auditory nerve and are transmitted by the auditory nerve to the auditory cortex, where they are interpreted as sound. CI users have more difficulty in understanding speech sounds than listeners with normal hearing because their ability to discriminate frequency is limited. This limitation may be a problem because different speech sounds are produced by different articulatory gestures, resulting in different spectral envelop peaks. Steady-state values of these spectral peaks or format frequencies provide important information for vowel and consonant identification, as do some types of formant transitions. Poor frequency discrimination can make it difficult to identify formant frequency values, thus making it more difficult to identified speech sounds (Watson 1994). The multichannel CIs are firmly established as effective options for the re/ habilitation of adults and children with bilateral profound hearing impairment (Bethesda, 1995). These implants are designed to take advantage of the tonotopic organization of the cochlea to encode spectral frequency cues. The incoming sound signal is filtered into frequency bands, each corresponding to a given electrode in the electrode array (Kirk, 2000).

Temporal resolution is an auditory temporal processing skill that refers to the minimal time required to segregate or resolve acoustic events (Irwin et al, 1985; Shinn, 2003). This skill plays an important role in speech perception. Poor speech perception is due to the reduced temporal resolving power of the auditory system (Ginzel et al., 1982; Tyler et al., 1982; Price & Simon, 1984; Dreschler & Plomp, 1985; Schneider, 1997). Time, duration, intervals are the major components of temporal resolution. Central processing is important in temporal resolution and specifically in gap detection. Processing of temporal information may occur via monaural and/or binaural inputs. The most common way of investigating monaural temporal processing is by means of gap detection, defined as the ability to detect a brief period of silence between two test signals.

Gap detection is probably the most commonly used measure of temporal resolution. Gap Detection is a hearing test that measures ability to resolve differences in time. Gap detection is likely as popular in method as because it provides a description of temporal resolution based on single threshold; whereas other methods require multiple thresholds estimates. Another advantage is that the gap detection is easy to measure in native listeners, including infants. The gap detection thresholds obtained from native listeners are closed to those obtained from well trained listeners (Werner, Marean, Halpen, Spetner, & Gillenwater, 1992). Gap detection is one of the standard paradigms for measuring auditory temporal resolution (Fitzgibbons and Wightman, 1982; Moore, 1985; Moore and Glasberg, 1988).

The purpose of the present study was to assess the temporal resolution skills in Cochlear Implant (CI) recipients with post operative duration.

Method:

A total number of 20 children with cochlear implant in the age range of 7-20 years were included in the study. The children were divided into four groups. Group – I (n=5) subjects with post CI duration of 2 months, Group – II (n=5) subjects with post CI duration of 5 months, Group III (n=5) subjects with post CI duration of 10 months and Group IV (n=5) post CI duration of 15 months receiving Nucleus 24R device.

Children has recent history of middle ear infection, motor milestones delay, cognitive impairments, behavioral & psychological malfunctions, illness on the day of testing were excluded from the study.

Calibrated diagnostic two channel audiometer (Elkon EDA 3N3 Multi) used to measure Gap detection threshold. Stimulus was delivered through free field to measure gap detection threshold for CI individuals respectively. Stimulus for auditory thresholds for frequencies 500 Hz, 1K Hz, 2K Hz, and 4K Hz was directly delivered through audiometer. Stimulus for gap detection threshold were presented through a diagnostic audiometer, with an input from a personal computer, (Compaq Presario CQ 60) and delivered through a loudspeaker at 45° azimuth from the test ear. Testing was done in a sound treated double room, with the ambient noise levels within permissible limits as recommended by ANSI (1989).

Development of test material:

Broad band noise was generated using Adobe Audition software version 1.0, which was then filtered using band pass filter to generate noise track of high pass and low pass bands respectively based on the lower and upper frequencies of the electrodes in the nucleus cochlear implants. Three Interval Forced Choice (3-IFC) methods were used in developing the test material. In 3-IFC each set of stimulus consists three stimuli, each stimulus recorded for two seconds duration. One second gap was introduced between the stimuli. Three seconds gap was introduced between each set of the stimulus. The subject was instructed to listen to the set of three noise stimuli, one of the three stimuli

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contain a gap of varying duration. Subjects made a note where the gap was identified in each of test set of stimuli. Before the actual test sets, three practice sets were given to train the subjects. The children were demonstrated audio-visually to understand the test procedure. Descriptive statistics were done to see the mean scores and SDs for each group of children. T-test was done to see group differences.

Result:

Gap Detection Threshold was measured at 500Hz, 1K Hz, 2K Hz, 4K Hz in four groups i.e., are cochlear implant recipients with 2, 5, 10 and 15 months of post-operative duration with the age range of 7-20 years.

Mean and Standard deviation were calculated to evaluate the gap detection thresholds within CI groups at frequencies 500 Hz, 1 KHz, 2 KHz & 4 KHz. The Mean for Group I were 19.6ms, 20.8ms, 22.8ms & 23.2ms, for Group II were 12.8ms, 14.8ms, 14.4ms & 15.2ms, for Group III were 10.8ms, 12.4ms, 12.8ms & 13.2ms and for Group IV were 11.2ms, 12.4ms, 12.8ms & 12.8ms for 500 Hz, 1 KHz, 2 KHz & 4 KHz respectively. Standard deviation varied from 0.8 to 1.67ms in all frequencies in all groups.

	Cochlear Implant Recipients							
	Group I		Group II		Group III		Group IV	
Frequency	Mean	SD	Mean	SD	Mean	SD	Mean	SD
500 Hz	19.6	1.67	12.8	1.09	10.8	1.09	11.2	1.09
1K Hz	20.8	1.09	14.8	1.09	12.4	0.89	12.4	0.89
2K Hz	22.8	1.09	14.4	0.89	12.8	1.09	12.8	1.09
4K Hz	23.2	1.09	15.2	1.09	13.2	1.09	12.8	1.09

Table 1: shows the Mean and Standard deviation of scores obtained from Gap detection threshold test, for CI group individuals with respect to post operative duration.

Frequency	Pairs	T	Sig
500Hz	2 to 5 months	6.66	0.003
	2 to 10 months	11	0
	2 to 15 months	21	0
	5 to 10 months	3.16	0.034
	5 to 15 months	2.13	0.099
	10 to 15 months	-1	0.374
1K Hz	2 to 5 months	9.48	0.001
	2 to 10 months	11.22	0
	2 to 15 months	11.22	0
	5 to 10 months	6	0.004
	5 to 15 months	6	0.004
2K Hz	2 to 5 months	11.22	0
	2 to 10 months	15.81	0
	5 to 10 months	2.13	0.099
	5 to 15 months	2.13	0.099
	10 to 15 months	0	1
4K Hz	2 to 5 months	12.64	0
	2 to 10 months	15.81	0
	2 to 15 months	26	0
	5 to 10 months	2.23	0.089
	5 to 15 months	3.2	0.033
	10 to 15 months	1	0.374

Table 2: Results of t test of scores obtained from subjects of CI at all frequency.

It was observe that for all the test frequencies there was significant ($p<0.001$) difference in gap detection threshold between 2 and 5, 10 and 15 months post operative duration in cochlear implant recipient group. There was no significant difference between 5 months to 10 and 15 months and between 10 and 15 months for all the test frequencies.

Discussion:

Poor temporal resolution is seen in CI because they rely on either temporal or spectral cues. Temporal processing is dependent on the number of neurons engaged in process as well as the channels or filters in the cochlea. Cochlear Implant signal processing is done primarily on the envelop of the signal, the fine structure were not processed in the implants. So the temporal resolution is poor in cochlear implant. More over normal cochlea has 28 independent filters, where as a cochlear implant have not more than 22 filters. So the information delivered by CI to the auditory system is degraded , despite poor gap detection thresholds the speech and language abilities of the cochlear Implantees are comparable to the normal's. Based on the results we can say that temporal resolution is very poor soon after the surgery (post operative duration 2 months). After five months of cochlear implantation temporal resolution gets saturated. Gap detection thresholds vary depending upon the duration and age at implant was done. Poorer scores soon after the implants could be due to the training, implant duration or the initial map current levels. Our results are in accordance to the observation made by Tong et al., (1988) study. The implication of this study is to assess the temporal resolution in CI with relation to post implant duration & implementation of therapy at the time of progressive temporal resolution which will help children to learn more rapidly.

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