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Research Article

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Can we Measure Speech Perception Ability Objectively in Young Children using Cochlear Implant?

Bhimte SL[1*] and Rangasayee R[2]

[1]*Ali Yavar Jaung National Institute for Hearing Handicapped, Nashik University, India*

[2]*Dr. S. R. Chandrasekhar Institute of Speech and Hearing, Bengaluru, India*

[*]**Corresponding author:** Bhimte SL, Ali Yavar Jaung National Institute for Hearing Handicapped, Nashik University, India, Tel: 9769399711; E-mail: aslp_shiv84@yahoo.co.in

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Abstract

Speech perception plays a significant role in the development of speech and language ability in children with hearing loss. There are various speech perception tests with the specific protocol to administer and score. Auditory evoked potential is an objective measure used for assessing hearing acuity in young children. Higher cortical evoked potential test provides an effective indication of the physiological status of auditory cortex. CEAP can be obtained in young children with assistive devices. The present research study aims to investigate whether latency and amplitude of aided cortical evoked potential can predict Speech perception score in cochlear implant users. 52 cochlear implant users and 102 typical children were tested. The mean age for children using cochlear implant was 8.05 years, standard deviation 1.4. The normal hearing group had a mean age of 8.12 years and standard deviation 1.46. Cochlear implant users were having at least 15 active electrodes. Speech stimulus was used with 100 ms duration, 20 ms rise/fall, 20 ms plateau tones. The inter-stimulus interval was kept at 1125 ms. During statistical analysis of data, CEAP P1 latencies and speech perception scores were found to be related. A further regression equation was obtained. The present study reveals speech stimuli can evoke distinct neural response patterns from auditory cortex. The present research study also helps in understanding the neural processing of speech in individuals with hearing impairment using Cochlear implant. Statistical analysis of data CEAP P1 latency and speech perception score regression equation were obtained. The result reveals that speech stimuli can evoke distinct neural response patterns from auditory cortex. CEAP finding support speech perception ability and auditory evoked potential help to the study of neural processing of speech in individuals with the cochlear implant. The evoked potential and speech perception ability has a significant relation between them.

Keywords: Cortical evoked potential; Auditory brainstem response; Speech perception; Cochlear implants; Regression; Evoked potential

Introduction

Hearing is one of the gi ts given by God to every human being, among the ive vital senses-vision, hearing, taste, smell and touch which work in congruence with each other. None of our senses function in absolute isolation from each other "all senses contribute to providing meanings for experience in life, but hearing and vision the distance sense are the most crucial [1]. In young children during the critical period (i.e 0-5 years) of language development, typical children get maturation in all elements which are necessary for becoming efficient communicators in their language. Signi icant hearing impairment can effect child's ability to extract linguistic information from the environment and thus interferes the child's language and speech development.

Various researchers have reported that children with HL had de iciencies in their vocabulary and semantic language development, grammar aspect, concepts and pragmatics aspects in both receptive and expressive language domains [2-5]. According to World Health Organization (WHO) estimates, that 278 million people have disabling hearing impairment worldwide. In India, NSSO reported that 63 million people (6.3%) suffer from signi icant hearing loss [6,7]. e prevalence of hearing impairment seen in Southeast Asia ranges from 4.6% to 8.8% [8].

Generally, speech perception precedes speech production in the process of first language acquisition. In first language acquisition, we can see certain structures may be produced before they are fully comprehended. Speech Perception can be noticed even in very early in life. The minimal speech perception ability in the early months improves with increasing age up to the adult level. Young children show from the early reflexive perception of perceiving one's own sounds, further the child begins to acquire perceptual skills like attending and localizing the sounds emitted by others. According to Boothroyd, much of the impact of sensorineural hearing loss was reflected in the ability of speech perception of the child [9].

Thus, children with severe to profound degree of hearing loss cannot develop speech as verbal language without an early and intensive stimulation with an appropriate habilitation program. The ability of speech perception of a child with hearing impairment, thus, is depending upon the amount of residual hearing, and how early does the child get intervened and trained during his early years of speech and language development. Children with hearing impairment using the cochlear implant or hearing aids show significant changes in speech perception ability. This speech perception ability plays the significant role in further development of speech and language. There are various speech perception tests available, which has the specific way of administering and score. Auditory evoked potential is the objective measure which mainly used for assessing hearing acuity in young children.

Higher cortical evoked potential can give the effective indication about the children auditory cortical part and functionality. CEAP can be obtained in young children with hearing impairment [10]. Objective tools such as auditory evoked potentials can be used to ensure that infants do have access to the speech signal in the early months. In most of western countries cortical auditory evoked potentials are routinely used by clinicians to estimated hearing sensitivity in adults because the P1, N1, and P2 response thresholds agree very well with audiometric thresholds determined behaviourally reported that cortical potentials were present in 100% of well babies n=17 and in 34 of 35 very low birth-weight babies that they tested at age 2 months [11-13].

Pasman and colleague measured cortical potentials in preterm babies at 35-37 weeks conceptional age. They reported good 95% detectability rates of cortical potential [14]. Auditory cortical evoked potentials have some advantages compared with more commonly used clinical techniques such as the auditory brainstem response. Auditory cortical potential more closely related to perception and can be evoked by complex sounds such as speech [15]. These response characteristics suggest that cortical potentials could be used clinically in the estimation of hearing threshold and also assess speech discrimination and perception. Clinical uses of auditory evoked potentials include threshold estimation and their use as an electrophysiological index of central auditory system development, auditory discrimination and speech perception and the benefits from cochlear implantation, auditory training or amplification.

Cortical auditory evoked potentials obtained in passively alert subjects have a remarkably high correspondence with perceptual threshold [16]. Cortical evoked potential test might be used to determine the integrity of neural encoding for such features and thus contribute to speech perception assessment. Cortical auditory potentials are affected by listening experience and so could be used to measure the effects of aural habilitation. The presence of cortical potentials in children with hearing loss appears to indicate residual hearing abilities [17].

The cochlear implant converts the acoustic form of energy into electrical impulses that directly stimulate the auditory nerve. This stimulation is biphasic pulse trains delivered to the auditory nerve in a specific pattern in the temporal and spectral characteristics of the incoming speech stimulus [18-21]. In the human auditory system, brainstem and cortical auditory regions are responsible for the detection and decoding of complex speech stimulus. Till date, little is known about the auditory cortex response to electrical stimulation by the cochlear implant. These differences in cortical processing may be in part responsible for the wide range of speech perception abilities in individuals with cochlear implants [22].

Cortical Auditory Evoked Potentials (CAEPs) may provide valuable information regarding speech processing at the level of the cortex. CAEPs are measures of the brain's response to sensory stimuli that reflect synchronous neural activity along the auditory centers of the cortical pathway. In the cortical evoked potential test neural responses evoked by speech stimuli, as evidenced by in the CAEP waveforms. At a very simple level, the presence of speech-evoked CAEPs indicates that speech stimuli have been detected [23].

The relation between cortical evoked potential and in the aided cortical responses to speech stimuli could indicate that the underlying neural representation the stimuli. The purpose of the current research investigating the use of aided cortical assessment to evaluate hearing instruments in children isn't-to verify hearing instrument fitting. This could be done by measuring aided CAEP amplitude and latencies values and speech perception score. It is possible that CAEP can be used for objective validation of amplification system. The underline hypothesis is that a hearing aid fitting that causes activation of auditory cortex. Similar and same pathway function can be measured by CAEP elicited by speech stimulus.

This is supported, but by no means proven, by research observations that certain speech sounds produce cortical evoked potential in the normal hearing subject, and compare this finding with disorder population (Hearing aid user and CI user). It is reasonable to expect an optimally fitted hearing aid with good speech perception score to produce a response with normal morphology (shape, amplitude, latency). As previous deprivation to sound is known to cause abnormal latencies, as increasing number of hearing impaired population (i.e. 6%) of the total Indian population [24,25]. Advances in audio logical diagnosis and rehabilitation approach more and more hearing impaired children are being fitted with hearing aids or cochlear implant. To objectively measure speech perception capability through CEAP is very crucial in these HI children. Cortical evoked potential and cortical areas functionality correlate with the speech perception ability; therefore there is a great need in this area to explore evoked potential and its objective measure for assessing speech perception ability.

Methodology

Subject selection criteria were kept as following

No other medical history and associated disability such as autism, CP, ADHD etc., normal middle ear condition, average intelligence children/average scholastic performance, children with hearing impairment using cochlear implant having experience greater than 2 years have taken in the research study. In cochlear implant, subjects must have at least 15 active electrodes [26]. Behavioural screening test tool for CAPD most applicable test item used to rule out possible CAPD component. Informed Consent was obtained from the parent before testing.

Instrument

Welch ad Allyn hand held clinical otoscope was used for visual examination of the external ear canal and tympanic membrane. The AC 40 interacoustic dual channel clinical audiometer (Version 2) was used for pure tone testing (ANSI S 3X-1978). Tymponometry and Refexometry were measured by GSI Tympstar Clinical Impendance audiometer. To rule out the possibility of auditory dysynchrony GSI Audio Screener was used to screen with TEOAE in all subjects. Similarly, I.H.S 3.36 Smart EP clinical instrument was used for recording auditory evoked potential. Speech perception ability was measured Marathi, Hindi adapted version early speech perception test. Detail demographic data was collected. Pure tone thresholds were acquired from 250 to 8000 Hz via air conduction, and when clinically appropriate, bone conduction thresholds were also acquired from 250 to 4000 Hz, using modified Hughson and Westlake procedure. Tympanometry and acoustic reflexes were recorded to rule out middle ear pathology. Tympanometry test was carried out using 226 Hz probe tone at 85 dB SPL, and the acoustic reflex test was done at the tone of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz ipsilaterally and contra laterally [27]. Transient evoked Otoacoustic emissions (TEOAE) were measured using click stimuli at 85 dB SPL in both ears. All the testing was performed in recommended test environment and with the standardized test protocol. Subjects were seated in a reclining wooden chair in an electrically shielded and acoustically treated room (ANSI 3X 76). Silver chloride electrodes (AgCl) were placed at the recording sites, after cleaning those sites with an abrasive gel (NeuroPrep). Electroencephalography (EEG) paste and the surgical adhesive tape were used to hold the electrodes firmly in place. In essence, standard and well-accepted auditory evoked potential protocols were used throughout all cortical potential acquisitions. Clients were asked to remain quietly seated with minimum body movement accompanied the parent. It was ensured that all possible other electric instruments such mobile, I pad etc. not to bring inside the testing chamber. CI was insured that were working properly and matching with the necessary standard [28]. It was also ensured that CI at most comfortable level. For both the test i.e. cortical evoked potential and speech perception test duration was 60 minutes each.

Following test parameters were used which was suggested by Purdy for aided caep testing in children with hearing impairment [15-26].

Stimuli 30-100 ms speech sound/ba/20 ms rise/fall, 20 ms plateau tones (/ba/was developed according to suggested parameter).

Stimulus level: 70 dB nHL.

Inter-stimulus interval 1125 ms.

Transducer: Mode of stimulation was used TDH 39 earphone. The microphone of speech processor or hearing aids was directly placed (10 cm) on the TDH 39 earphone.

EEG filter high pass 1 Hz low pass 30 Hz or 100 Hz online, 30 Hz offline digital filter.

Recording time window 100 ms pre-stimulus baseline 600 ms post-stimulus.

Artifact rejection trials exceeding ± 100 to 150 mv.

Number of trials: 300.

Number of repeats at least two.

EEG channels vertex Cz-mastoid.

With two recording channels, one was used for recording auditory evoked potentials channel A and the other was used for recording ocular movements and blinking channel B.

The channel A: Active electrode was placed on CZ, connected to the preamplifier input positive and the reference electrode was placed on the test ear lobule A2, connected to the input negative. The ground electrode was placed on the FPz, connected to the ground position.

The channel B: Active electrode was placed on the non-test ear supra-orbital position, connected to the preamplifier input positive and the reference electrode was placed on the non-test ear infra-orbital position connected to input negative [29]. Artifact rejection level was adjusted in channel B to include the ocular movement amplitude and blinking in each subject. Subtracting the ocular artifact: CAP was recorded in channel A, ocular movement and blink were simultaneously recorded in channel B. A subtraction process was applied wherein the ocular movement recording was subtracted from the auditory potential recording (response A-B). An auditory evoked potential recording resulted, which eliminated any interference from ocular movement artifacts. Similarly, all subjects were informed to minimize eye blink as much as possible.

Amplitude marking

Late auditory evoked waveforms are occurring within 50-300 ms after the acoustic stimulation to the ears. The peak potentials in the waveforms are denoted as P1, N1, P2, and N2 having identified the auditory evoked potential, amplitude was established as the difference between the 0.0 UV point and the maximum positive value [30,31]. The p1/n1 potential was marked, and amplitude was calculated based on the difference between negative and following positive peak vice versa. Peak picking was done by two independent observers who had 5 years clinical experienced in auditory evoked potential.

Set up

The speech stimuli were presented at 70 dB SPL (as measured at the client's head) which approximates normal conversational level. The presentation was via a loudspeaker placed at a 45 azimuth degree angle to the side of the cochlear implant. The speaker was then positioned on the same side for the matched children with normal hearing. The evoked potential recordings were collected using the comfortable chair in a sound-attenuated room at the training centre. The children with Hearing impairment using cochlear implants ensured their instrument was set to their regular normal settings and any noise reduction functions were deactivated. However, residual hearing of contralateral ear was not blocked out. The child was allowed to watch a silent cartoon on the tablet screen. McArthur et al. reported that the presence of low-level or silent mobile and tablet did not significantly impact on the P1-N1-P2 waveform. This arrangement helped to keep the child engaged without interfering with the stimulus.

Speech Perception Test Analysis

Speech perception score was measured by using early speech perception test [32]. The test was adapted in Hindi and Marathi language. Speech perception test was having three components first 12 items were for assessing pattern perception in which mono-syllable, bi-syllable and tri-syllable words were kept. The test second part consists of 12 items bi-syllable words, and last section having 12 monosyllable word items.

Procedure of administration

The test was presented in a quiet room with minimum or no visual and audible distractions. Adequate lighting conditions in the test room to facilitate good visibility of picture plates. The test was administered with live voice. Stimuli were presented via the auditory channel. Seating arrangement: child and tester were seated next to each other with the tester's chair slightly behind that of child's chair to avoid any visual cues. Tester was seated on the side of the better hearing ear in case of hearing aid users, whereas on the implanted side for cochlear implanted users [33,34].

Pattern perception

A word is counted correct for pattern perception if a word with the same stress pattern is selected. For example, if the word was given/ gubaaraa/and the child pointed to the picture of the/Almari/, the response would be counted as correct for pattern perception. The word need not be correctly identified to be scored as correct since identification of temporal pattern is all that is being evaluated. Each word is presented twice, so a perfect score is 24 words correctly categorized. Responses were marked on part of the response sheet that has been printed with bold outlined boxes to illustrate words of similar category. This makes it easy to score, as words contained within the bold outlined boxes are considered correct for pattern perception. A child who scores at least 17 out of 24 meets the criteria to qualify for the administration of the spondee/ bi-syllable test identification subtest.

BI-syllable sub-test: spondee/bi-syllable identification sub-test

The spondee identification subtest evaluates word recognition ability of profoundly hearing-impaired children who demonstrate the ability to perceive durational patterns in words (i.e., they scored at least 17 correct out of 24 on the pattern perception subtest). The 12 spondee/bi-syllable with widely differing vowels and consonants that comprise. The words were like medhak, hiran etc. in Hindi version of the test. The words were presented auditory-only in random sequence until each word has been presented twice. The child was expected to point to the picture representing the spoken word.

Scoring

The score sheets for the word identification subtests having A1, A2, and AV in three spaces for responses. For each word one for the audio-visual response in the column headed by AV, and two for the listening or auditory-only condition headed by A-l and A-2. A plus (+) can be given if the word was correctly identified, a minus (-) if the word was incorrectly identified. A perfect score on this test is 24 words correctly identified. A child who correctly identifies 8 out of 24 words demonstrates sufficient word recognition skill for conducting speech perception category 3.

Monosyllable identification subtest

The closed sets of monosyllabic words were designed to provide a more challenging test of word recognition ability. Twelve quite similar words are included in this set identification of the words requires finer vowel discriminations than was required in the spondee/bi-syllable set. The administration procedures were the same as those just described for the spondee identification subtest. /p/, /b/ phoneme was used for the Marathi language which having the different vowel in combination. Similarly, /t/, /k/ phoneme were used for Hindi language [35].

Scoring: Responses to the monosyllable identification subtest were recorded and scored same as the spondee/bi-syllabic identification subtest.

Results and Discussion

As speech perception ability is the important indicator of normal speech and language development. It is difficult to measure in young children with amplification devices. Therefore, current research study measures speech induced cortical evoked potential in children using CI. Similarly, to find out there was any correlation with aided cortical evoked potential amplitude and latency with speech perception score. The research study sample consisted of two groups. Experimental groups were composed of children with hearing impairment using cochlear Implant. Other group composed of children with normal hearing as a control group.

52 subjects were recruited in CI users group having means age 8.55 with SD 1.49. 102 subject were recruited in Control group was having means age 8.19 with SD 1.59. To study relationship between speeches induced aided cortical potential and speech perception ability of CI users.

Cochlear implant users

To study the relationship between speeches induced aided cortical potential P1 latency and speech perception ability in children using CI. Aided speech evoked Cortical potential latency P1 and speech perception score of cochlear implant users were analysed in correlation test.

From Table 1 speech perception score having the inverse relationship with Aided speech evoked Cortical potential latency P1 i.e. -0.69. Considering correlation value one can say 0.7 is the strong relationship i.e. latency of p1 and speech perception strongly related.

Correlations				Spearman's rho		
		Cortical potential CIp1	Speech perception CI		Cortical potential CIp1	Speech perception CI
Cortical potential CI p1	Pearson Correlation	1	-0.699**	Correlation Coefficient	1	-0.605**
	Sig. (2-tailed)		0.000	Sig. (2-tailed)		0.000
	N	52	52	N	52	52
Speech perception score CI	Pearson Correlation	-0.699**	1	Correlation Coefficient	-0.605**	1
	Sig. (2-tailed)	0.000		Sig. (2-tailed)	0.000	
	N	52	52	N	52	52

Table 1: Statistical correlation test result of Aided speech evoked Cortical potential latency P1 and speech perception score of cochlear implant users [**Correlation is significant at the 0.01 level (2-tailed)].

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Cochlear implant users

The model summary table reports the strength of the relationship between the model and the dependent variable i.e. speech perception score. R, the multiple correlation coefficients, (how well the regression line approximates the real data) is the linear correlation between the observed and model-predicted values of the dependent variable (Table 2). Its large value indicates a strong relationship (0.77). R Square (0.59) is a statistical measure of how close the data are to the fitted regression line. The coefficient of determination is the squared value of the multiple correlation coefficients. R square value is the important measure in current example 60% chance to correctly predict speech perception score with cortical potential P1 latency.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.774a	0.598	0.59	17.50362

Table 2: Showing value model summary with R (multiple correlation coefficients) and R-square of regression analysis.

ANOVAs						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22816.582	1	22816.582	74.472	0.000a
	Residual	15318.838	50	306.377		
	Total	38135.42	51			

Table 3: Showing ANOVA test result of the acceptability of the model from a statistical perspective.

The ANOVA table tests the acceptability of the model from a statistical perspective (Table 3). The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance. The ANOVA table is a useful test of the model's ability to explain any variation in the dependent variable (i.e. speech perception), it does not directly address the strength of that relationship. Here the P<0.000 which is less than 0.05 and indicates that overall the regression model statistically significantly predicts the outcome variable (i.e. it is a good fit for the data) (Figure 1).

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	179.302	9.202		19.484	0
	speeCI	-1.447	0.168	-0.774	-8.63	0

Table 4: Showing regression equation line's standardized, unstandardized coefficients with equation constant.

The coefficients table provides necessary information to predict speech perception ability from the cortical potential (Table 4). As well as determine whether cortical potential contributes statistically significant to the model (Table 5). Furthermore, we can use the values in the unstandardized coefficients column as shown above (i.e. 179.302). To represent the equation as: Equation of regression Y=a+b × X+e

Residuals Statistics					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	75.1256	138.7888	1.03E+02	21.15145	52
Residual	-5.92136E1	32.04280	0	17.33117	52
Std. Predicted Value	-1.304	1.706	0	1.00	52
Std. Residual	-3.383	1.831	0	0.99	52

Table 5: Showing regression line predictive value, standard predicted value and standard residual.

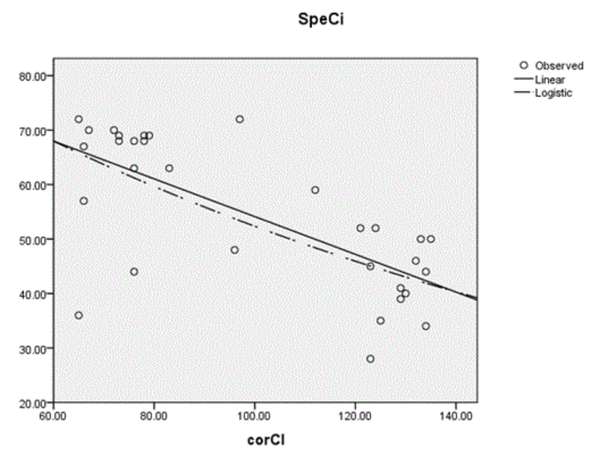

Figure 1: Showing plot point of logistic, linear line model with standard deviation of cortical potential P1 latencies and speech perception score.

The coefficients table provides necessary information to predict speech perception ability from the cortical potential. As well as determine whether cortical potential contributes statistically significant to the model. Furthermore, we can use the values in the unstandardized coefficients column as shown above (i.e. 88.67).

To represent the equation as: Equation of regression Y=a+b × X+e

Speech perception=179.302+ (-1.447) cortical potential +e

Y=dependent variable (speech perception ability)

a=intercept variable

b=regression coefficient

X=independent variable (cortical potential)

e=error

Regression coefficients represent the mean changes in the response variable for one unit of change in the predictor variable while holding other predictors in the model constant.

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This statistical control that regression provides is important because it isolates the role of one variable from all of the others in the model. In the current research, equation shows the coefficient for the cortical potential latency 179.302.

Current regression line equation Y=179.302+(-1.447) cortical potential +e.

From this -1.447 each additional cortical potential latency value increases effect speech perception ability. "e" the error is the difference between a predicted value of Y (i.e. speech perception ability) for a given case and actual value of Y foe a given case (-Y).

e=Y predicated~actual Y

Example:

Cortical potential latency=85 ms

Current regression line equation Y=179.302+(-1.44) cortical potential +e

Y (i.e. Speech perception score)=179.302+(-1.44) 85

=179.302+(-122.4)

=nearly 57.3 Score.

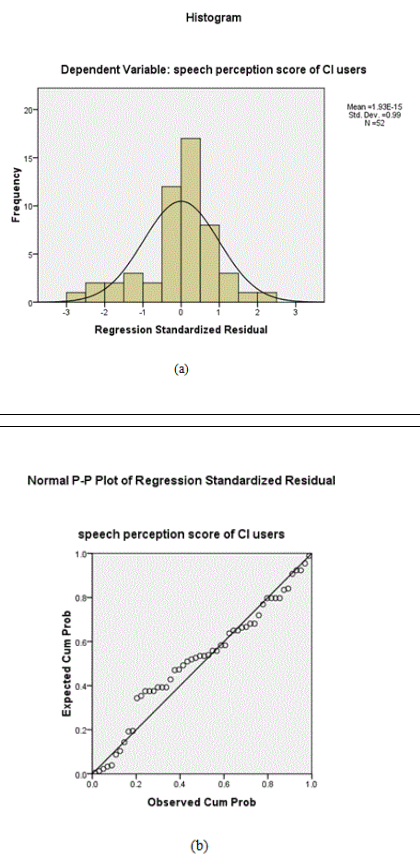

Figure 2 (a,b): A histogram or P-P plot of the residuals will help you to check the assumption of normality of the error term.

The curve fit chart gives you a quick visual assessment of the fit of each model to the observed values. From this plot, it appears that the logistic, linear model better follows the shape of the data (Figure 2).

Important regression equation

Current regression line equation Y=179.302+ (-1.447) aided cortical potential P1 latency +e (cochlear implant users R square Value 60%)

There were few important points, when we use the regression equation, do not use values for the independent variable that are outside the range of value to create the equation. That is called extrapolation and it can produce unreasonable estimates. In this research study independent variable i.e. cortical potential was measured latencies of 90-120 ms for P1. Therefore, only use values inside that range to estimate statistical grades. Using values outside that range (less than 90 or greater than 120 ms for P1 latency) is problematic.

Discussion

CI users

Statically analysis of Pearson correlation test result indicated that -0.699 for latency and speech perception and 0.431 for amplitude and speech perception score. This value indicates that latency of aided cortical potential and speech perception has inversely related. Ponton et al. investigated review of studies on the effects of auditory deprivation due to profound hearing loss and cochlear implant use on the maturation of the cortical evoked potential in children. They also studied the age-related changes in the cortical evoked potential. Results show that although the morphology of the cortical potential is substantially altered by the absence of a normal P (1) and N1 peak. The cortical evoked potential is robustly present in a group of implanted children who have good spoken language perception through their device.

Ponton et al. reported that neuromaturation affects the cortical potential waveform and latency value significantly [36]. The present research study also reported prolong waveform and altered amplitude seen in children with poor speech perception score. Purdy et al. did the research study on children using HA and CI and their behavioural measure. The result of the study indicates that behavioural measures such as speech perception scores do show improvements after cochlear implantation [37]. Purdy et al. concluded that after implantation changes in the central auditory system seen with an improvement of speech perception ability. These studies indicate that improvements in speech perception ability were related to changes in the central auditory system, particularly at the cortical level.

Cortical evoked potential robustness and latency changes seen with impairment of behavioural speech perception score. These finding also reported in the present research study, suggesting good performer of speech perception test showed the significant robust waveform of cortical potential. One of the similar studies did by Tremblay et al. on the subject were implanted and undergoing therapy. They aimed to find out whether the P1-N1-P2 complex reflects training-induced changes in neural activity of auditory system associated with improved voice-onset-time (VOT) perception. They concluded that as perception improved, P1-N1-P2 amplitude increased. These changes in waveform morphology are thought to reflect increases in neural synchrony as well as strengthened neural connections associated with improved speech perception [38]. Auditory training effects auditory cortex area could be more actively changes and that reflected in cortical evoked potential change. Kelly et al. they determined the relationship between auditory cortical evoked potential measures and speech perception ability in experienced adults cochlear implant users and compared to the group of age and sex-matched control group.

Their finding was supported that auditory evoked potentials are related to speech perception ability and provide objective measures of central auditory processing differences across experienced CI user [39]. Comparing cochlear implant group with control group there was the statistical significant difference observed in cortical potential. Cochlear implant group overall P1, N1 amplitudes for the CI group was smaller to the normal hearing group. This difference was especially pronounced for P1 and N1 amplitudes, for which there was a large difference between normal and CI amplitudes. In the present research study both the experimental group having the strong relationship of aided speech perception score and cortical potential P1 latency. This discrepancy could possibly be caused by the characteristics of the CI speech processor. A similar study was done by Purdy et al. They, studied children with CI and normal hearing control subject cortical potential and discrimination ability.

The discrimination tasks consisted of pairs of natural syllables that differed by one of the following phonetic contrasts in terms of vowel place, voicing, vowel height, and place of articulation. Results of the study indicated that the cortical evoked potential was comparable in CI recipients and NH controls when the acoustic cues to the perception of the phonetic contrast were accessible. The reduction in accessibility to the essential temporal and/or spectral cues, CI recipients shown delayed (prolonged cortical evoked potential latency) and less synchronous (reduced amplitude) central speech-sound processing compared to normal hearing controls [40]. Kraus et al. reviewed previous research studies and concluded the following points. An audiologist can use the cortical evoked potential measure as the P1-N1-P2 complex as a diagnostic tool in aided and unaided conditions.

This complex is traditionally comprised of slow components ranging from 50 to 300 ms in time evoked. The peaks of the complex reflect synchronous neural activation of the central auditory system in response to spectral and temporal cues. Research suggests that spectrally different speech sounds are encoded differently at the auditory cortical level. The obligatory components of auditory cortical potentials (P1, N1, P2 and N2) have a systematic developmental time-course [13,41,42]. Cortical responses changes with age, adulthood the cortical response is mainly seen by the N1-P2 complex, but in childhood the P1 and N2 components dominate the response [43]. The P1 component of cortical potential serves as a central auditory developmental marker. Likewise, the N2 amplitude reduces, whereas the N1 component becomes more prominent with development [44]. Furthermore, the P1 and N2 components may reflect different aspects of signal processing, with P1 encoding the acoustic features of sound, such as frequency and timing [45]. Therefore present research study analysed P1 peak latency and amplitude of cortical potential. The P1-N1-P2 response has the potential to provide information related to both detection and discrimination of aided speech sounds [39]. Henkin et al. used auditory cortical potential and the simultaneously obtained behavioural measures (performance accuracy and reaction time) speech perception in post lingual adult cochlear implant (CI) recipients and in normal-hearing (NH) controls.

The results of study cortical potential indicated the difficulties imposed on the impaired central auditory system of CI recipients especially when elicited by speech contrasts that required processing of brief temporal-spectral cues. These findings supports to the research present study cortical potential as a sensitive auditory neural index of cortical processing that may provide information regarding accessibility and neural encoding of distinct acoustic-phonetic cues in CI recipients [42]. Therefore we tried to predict speech perception ability with the help of objective evoked potential.

Prediction of speech perception ability by using speech induced auditory cortical potential values

In children with hearing impairment measuring speech perception abilities are very crucial for audiologist and speech therapist. Most of the time both these professional find very difficult due to subjectivity, young age of subjects, limited test material etc. The current research data were subjected to regression test to predict speech perception ability by using objective measured cortical potential latencies. Following equations were obtained with the coefficient of determination i.e. R square 60%, for CI users. Current regression line equation Y=179.302+(-1.447) aided cortical potential P1 latency +e (cochlear implant users R square Value 60%).

Cortical auditory evoked potentials have some advantages compared with more commonly used techniques because they are more closely tied to perception and can be evoked by complex sounds such as speech [40]. Current research study concludes that response characteristics suggest that these potentials could be used clinically in the estimation of threshold and also assess speech discrimination and perception. Clinical uses of cortical potential an electrophysiological index of auditory system development, auditory discrimination and speech perception, and the benefits from cochlear implantation, auditory training, or amplification. Cortical auditory evoked potentials obtained in passively alert subjects have a remarkably high correspondence with perceptual threshold [41]. Cortical evoked potential test can be used to determine the integrity of neural encoding for such features and thus contribute to speech perception assessment. Cortical auditory potentials are affected by listening experience and so could be used to gauge the effects of aural habitation. The presence of cortical potentials in children with hearing loss appears to indicate residual hearing abilities. Cortical evoked potential and cortical areas functionality correlate with the speech perception ability. Current research results are very important which helps us to predict speech perception ability with the cortical potential.

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