Constricting and Validating Hindi Monosyllabic Speech Perception Test Material for Hearing Impaired Children

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Abstract: The current study aimed to compare speech perception score of children with Hearing impairment using CI and HA. The Hindi speech perception test was designed for children aged between two to six years-old. A total of 226 normal hearing children consisting four groups from 2 years to 6 years participated as normative sample. Test items were selected on the basis of familiarity & frequent consonants occurred in daily uses. Test consists of each set of 40 pictorial stimuli which scored 2 for auditory response, 1 for auditory and visual cues, zero for no response even after auditory and visual stimulation. Similarly in experimental groups, 30 subjects with HI using HA were recruited with mean age 8.083 years consisting of 13 female and 17 male. Other group comprises of 30 subjects with HI using CI with mean age 8.231 years and consisting of 14 female & 16 male. Both the group had exposure to aural –oral therapy for at least 3 years. After't' tail test analysis it was seen that both the group had statistically significant difference in speech perception score. Subjects with CI showed significant higher score in speech perception ability. This research article further discussed the HA technical short coming over CI.

Keywords: Speech perception test, Normal hearing, Hindi, mono syllabic, HA users, CI users.

INTRODUCTION

Speech perception tests are widely used in audiology to measure the auditory perceptual capability of the hearing-impaired population [1-3]. Measurement of speech perception, together with other procedures, allows audiologists and special educator to assess the benefits of hearing aid and/or cochlear implant usage and to determine the needs for cochlear implant in children and adults [4-7]. In current scenario in the view of cochlear implant, many Indian states are expending on cochlear implant and post rehabilitation management of children with hearing impairment [8]. Special educator and audiologist play important role in the management of children with hearing aids or cochlear implant in various way. Their role such as to guide, counsel & support parents & caregivers as the primary models for spoken language development & to help them understand the impact of deafness and impaired hearing on the entire life [9-11]. To help children integrate listening into their development of communication & social skills. To support child's auditory-verbal development through one to one teaching, to continuously assess & evaluate child's development in the above areas & through diagnostic, intervention and modify the program when needed. Appropriate Speech perception test tool may not only help to check listening level but also provide continuous assessment & evaluation, diagnostic intervention, modification of the program that need to change [4, 11, 12]. Children with hearing impairment who show limited benefit with HA and CI require quantified speech perception ability regularly. Therefore speech perception test is very crucial in rehabilitation process of hearing impaired. Speech perception tests are also help in setting goals in aural rehabilitation [13, 14]. In young children assessing listening skill require to modification because they don't have same level of language and vocabulary which adult has, therefore test items should be picturable and stimulus item should be within child vocabulary [14-17]. In Indian scenario, speech perception in children is difficult to assess due to a scarcity of age-appropriate measures and multi-lingual exposure to child. For assessment of speech perception currently we rely on western countries test tool are used by Indian audiologist and educator. There are few scales which are clinically used such as Ling Developmental Scales [15]. This scale uses different phonemes to capture auditory, speech, and linguistic developmental milestones in infants and toddlers with hearing loss. Similarly the Infant-Toddler: Meaningful Auditory Integration Scale [7] (IT-MAIS), evaluates the child's speech perception ability such as alert to sound, and derive meaning from sound is probably the most widely used scale for the assessing young hearing impaired child. The recently developed Checklist of Auditory Communication Skills [4] represents an expanded and more comprehensive scale by which to document auditory skill development in children with significant hearing loss. In western countries there are comprehensive standard test available such as

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Northwestern University-Children's Perception of Speech [19] (NU-CHIPS), Early Speech Perception (ESP) Test, and the Pediatric Speech Intelligibility (PSI) Test [20]. All three measures are closed-set identification tasks and require picturing-pointing responses.

In India, Hindi is the native language of most people living in Delhi, Uttar Pradesh, Uttarakhand, Chhattisgarh, Himachal Pradesh, Chandigarh, Bihar, Jharkhand, Madhya Pradesh, Haryana, and Rajasthan state [21]. Hindi is one of the official languages of India. In the 2001 Indian census, 258 million (258,000,000) people in India reported Hindi to be their native language. In India according to PWD act [22] 1995, monosyllabic word score is mandatory to certify hearing impairment. Similarly various state government and central government in India has started fitment of cochlear implant free of cost under various schemes such as ADIP [23]. Therefore the numbers of CI users have increased across different state. Therefore the current study aimed to construct Hindi speech perception test and administer over subject using CI and HA to check similarity and difference of speech perception between these two groups.

MATERIALS AND METHODS

The Development of the Tests

In India developing speech perception tests for children is challenging due to the limitation of vocabularies and language exposure (Multilingual). It is important to make sure that test items are within the vocabulary that are mastered by the tested children and the response task should be age-appropriate to ensure correct interpretations [2, 24-26]. A number of important factors must be taken into consideration when assessing speech perception in children. These include a combination of child, task, tester, and environmental influences on test outcomes 27. Child factors include the state of the child during testing, such as their attentiveness to the task. Moreover, children must demonstrate the requisite motor skills to perform the response task being asked of them (e.g., head turn, manipulation of objects, picture pointing, pushing a button), as well as the phonological, receptive and expressive language skills needed to participate in speech perception testing [27]. Tester and environmental factors include the audiologist's aptitude to work with the pediatric hearing-impaired population, the general feel of the facility, and caregiver attitudes and behaviors. In the present study, to ensure that the test items are age-appropriate, the items were selected from vocabularies. Besides, the response task for all tests are picture-pointing and the format used are closed-set. This was to ensure that the children's performance in the tests was not affected by the limitation of their expressive language. There were other considerations taken into account in the selection of test items. The present study tried to cover all the important consonants and vowels in Hind/Marathi, based on the frequency of occurrence of consonant [28].

Subjects

Subjects were Hindi speaking children who speak only Hindi as their mother tongue, recruited from several kindergartens around Mumbai and different part of Hindi belt. All subjects had normal hearing, speech, vision and physical development as reported by their parents and teachers. Details audiological testing was conducted assess normal hearing skills. The number of participants and subject age groups were different for each phase of the study.

Phase One: Familiarity Check and Item Selection

In the first phase of the study, the Hindi word list forms which are picturable, were taken from KG junior and senior Hindi Book. Same word list were given to 65 parents or caregivers of children aged 1-2 years to 2- 3 years monosyllabic word to mark familiarity was done in three point rating scale to check whether words are within the vocabulary of these children. Similarly to avoid parental bias same subject reception was assessed by researcher on individual basis. 56 Children age range of 2-3 years were tested with picture identification task. One test plate was containing 3 distraction pictures with one target picture to assess reception. The mean score and standard deviation was calculated by statistical method. The test was administered in a quiet room with minimum or no visual and audible distractions. Adequate lighting conditions in the test room was used to facilitate good visibility of picture plates. 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. Finally test stimulus items were formed by considering both score i.e. parent familiarity checked score and receptive vocabulary assessment scores. Most familiar words were selected to form final forty test items.

Second Phase: Pilot Study

A pilot study was conducted in the second phase which involved 25 children between two to six years of age.

Last Phase

The last phase, which was the field testing study for 226 children of the newly developed material Tests. 226 children aged between three to six years old, participated. There were 226 children in each age group: 2 years to 2 year 11 month, 3 years to 3 years 11 months (3 – 3.11), 4 years to 4 years 11 months (4 – 4.11), 5 years to 5 years -6 years.

Procedure

All test items were field-tested on 226 subjects from each age group. The stimuli were presented using live voice and in auditory mode. Subjects were requested to point the corresponding picture card of the test item after each presentation of the stimulus. Even though the formal instruction of the test was for subjects to point correct picture card, verbal responses were also accepted. Repetition of stimulus-presentation during the test was not allowed. A few practice trials were given to ensure that subjects understood the test procedure and the required responses. All test item result were tested and the scores of the subjects were recorded.

Reliability of Test Results

Test – retest reliability: To obtain information on test-retest 56 subjects were retested by the same tester after four weeks of the field test sessions.

Inter - rater test reliability; To find out inter-test reliability, 56 subjects were retested by a different tester. Both testers were qualified audiologist and had experience & 6 years in field of audiological management & native Hindi speakers. The testers were briefed on the testing and scoring procedures.

Content Validity

Before field testing Content validity were obtained. All test items were collected from experienced group of panelists that consisted of five audiologist and speech therapist, postgraduate audiology student and five postgraduate speech sciences students. All members of the panel were native Hindi speakers and received Hindi education in primary and secondary schools. The members had experiences in administering speech tests and had basic knowledge on language development. Content validity was performed prior to the field study.

Tests Composition

In this 40 monosyllabic word which has single syllable stress such as aam, ful etc were used to check speech perception.

Scoring and Administering Criteria

In first step, the target words are presented by providing auditory information only. The child is expected to point the picture representing the spoken word. Child does correctly auditory the score of 2 is given for each of the correct response

In the second step, If the child is not able to perceive the target word through auditory information the target word is then presented by providing both auditory and visual information cues like lip, tongue and jaw movements & score of 1 for each correct response. The visual cues act as supplementary information for the words which are not perceived auditory. No response given by the children with both auditory and visual cue was scored as 0.

Experimental Group

60 children participated in the study & were placed in two groups based on the amplification device i.e. HA & CI. In group one, 30 subject with hearing aids users and remaining 30 subject formed other group using cochlear implants.

Subject Selection Criteria

Duration of therapy post implantation/post hearing fitment: minimum of 2 years.

Both the group had exposure to aural – oral therapy for at least 2 years.

Adequately as ascertained by daily listening checks child should use HA / CI throughout day.

Subjects were using appropriate binaural behind the ear hearing aids which were functioning

Children with congenital deafness who fell in age range 5 to 13 years.

Table 1: Showing Demographic Details of both Experimental the Group HA & CI

Sr. No	HA/CI user chronological age	hearing age	Female / male	Attending regular school aural – oral mode	Type of technology/ Type of speech processor	Aural-oral Speech therapy
30 HA	8.083	2.721	13fc/ 17mc	All	11 analog / 19 digital hearing aids	All
30 CI	8.231	2.94	14fc /16 mc	All	7 Body level / 23 BTE processor	All

Table 2: Showing Detail Demographic Information of Experimental Group (i.e.HA/ CI)

Sr. No	HA user chronological age	hearing age	Type of technology	Aural-oral Speech therapy	CI user chronological age	Hearing age	Speech therapy	Type of speech processor
1	7y/ fc	2 1/2y	Digital	Yes	7y/fc	3 1/2y	Yes	BL
2	6 1/2y mc	3y	Digital	Yes	8y/mc	3y	Yes	BTE
3	8y/fc	2 1/2y	Digital	Yes	7y/m	2 1/2y	Yes	BTE
4	7y/fc	3y	Digital	Yes	6 1/2 /m	3y	Yes	BTE
5	9y/fc	2 1/2 y	Digital	Yes	6y/fc	3 1/2y	Yes	BTE
6	7y/ fc	3y	Digital	Yes	6y/fc	2y	Yes	BTE
7	10 1/2y mc	3 1/2Y	Digital	Yes	7y/fc	3 1/2y	Yes	BTE
8	8y /fc	3y	analog	Yes	11y/fc	2 1/2y	Yes	BL
9	9y /mc	2 1/2y	Digital	Yes	8y/mc	3 1/2y	Yes	BL
10	9 1/2y mc	3 1/2y	Digital	Yes	7y/mc	3 y	Yes	BTE
11	10y /mc	2y	analog	Yes	8y/mc	3y	Yes	BTE
12	7 1/2y/ fc	2 1/2y	Digital	Yes	7y/mc	3 1/2Y	Yes	BTE
13	10y /mc	2 1/2y	Digital	Yes	8y/fc	2 1/2y	Yes	BTE
14	11y /mc	3 1/2y	Digital	Yes	10y/m	2 1/2y	Yes	BTE
15	8 1/2y mc	2y	Digital	Yes	8y/mc	3 y	Yes	BTE
16	7 y mc	1 1/2y	Digital	Yes	11y/fc	4 y	Yes	BL
17	8 1/2y mc	2 y	analog	Yes	8y/mc	3y	Yes	BTE
18	6y mc	2 1/2y	analog	Yes	7y/mc	2 1/2y	Yes	BTE
19	7 1/2y fc	3 1/2 y	analog	Yes	11y/fc	3 1/2y	Yes	BTE
20	7y/ fc	3y	analog	Yes	8y/mc	2 y	Yes	BTE
21	8 y/ fc	2 1/2y	Digital	Yes	11y/fc	3 1/2y	Yes	BL
22	10y/ fc	3 y	Digital	Yes	9y/mc	2y	Yes	BTE
23	8 1/2y fc	2 1/2y	Digital	Yes	10y/mc	3 1/2y	Yes	BTE
24	7 y/ mc	1 y	analog	Yes	9y/fc	4 y	Yes	BTE
25	8 1/2y mc	2 1/2y	analog	Yes	10y/mc	2 1/2y	Yes	BTE
26	6y/ mc	3 1/2y	Digital	Yes	8y/mc	3 1/2y	Yes	BTE
27	7y/mc	3y	Digital	Yes	6y/fc	2y	Yes	BTE
28	7y/fc	2 1/2y	analog	Yes	8y/mc	2 1/2y	Yes	BL
29	8 y/mc	2 y	analog	Yes	7y/fc	2 1/2y	Yes	BL
30	8y/mc	3 1/2y	analog	Yes	8y/mc	3y	Yes	BTE

Data Analysis

Data analysis was done in two stage first formation of normative value of test, reliability and contained validity formation. For this purpose ANOVA test was used to analyze the difference in test scores among different age groups, genders. Spearman Correlation was used to analyze the correlation of the scores of the test and those of the repeated test in the test-retest reliability.

In second part of experimental group were statistical analyzed by comparing using t tail test at level of significance of 0.05 levels.

Formation of Normative Data

Subjects

Table 3: Showing Mean and SD of Age in Months Across Different Age Range

Sr. No	Age	Means (months)	SD
1	2-2 years 11 month	32.767	2.7699
2	3-3 years 11 month	44.69	2.922
3	4-4 years 11 month	57.482	2.894
4	5-6 years	67.917	2.434

Content Validity

Before field testing all of the members of the panel (100%) rated the test item. Some panel members suggested that certain items were difficult for the three-year-olds. The test items were modified based on the panel's comments.

Descriptive Analyses

To find out statistical significant difference between different age group ANOVA tests was used.

After ANOVAs Test it can be seen that mean score obtained by different age group have statically significant difference except 4 years to 4years 11month and five years to six year age range.

In the age range 4 years to 4years 11month and five years to six year age range all subject got maximum score which leads to ceiling score i.e. 80. Therefore in ANOVA test both the age group were not having statically significant difference.

Normative score of speech perception test.

From the table it can be seen speech perception score is increasing with the age at 5- 6 years means ceiling score obtained that is 80.

Reliability of test score between two tester

The same speech perception test was administered by two different testers. Both the testers had equal level of experience in the field of audiology and speech therapy. Speech perception score was subjected to statistical analysis by Pearson Correlation test. Result of the Pearson Correlation test indicated that score of

Table 4: Showing ANOVA Comparison of Speech Perception Score Across the Different Age Range

(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
3y-3y.11m	-4.45877*	.28198	.000	-5.2517	-3.6659
4y-4y.11m	-6.80640*	.27436	.000	-7.5779	-6.0349
5y-5y.11m	-7.08775*	.31649	.000	-7.9777	-6.1978
2y-2y.11m	4.45877*	.28198	.000	3.6659	5.2517
4y-4y.11m	-2.34763*	.27711	.000	-3.1269	-1.5684
5y-5y.11m	-2.62898*	.31888	.000	-3.5257	-1.7323
2y-2y.11m	6.80640*	.27436	.000	6.0349	7.5779
3y-3y.11m	2.34763*	.27711	.000	1.5684	3.1269
5y-5y.11m	-.28135	.31216	.846	-1.1591	.5964
2y-2y.11m	7.08775	.31649	.000	6.1978	7.9777
3y-3y.11m	2.62898	.31888	.000	1.7323	3.5257
4y-4y.11m	.28135	.31216	.846	-.5964	1.1591

Table 5: Showing the Normative Value of Speech Perception Score Across each Age Group

		Range	Minimum	Maximum	Mean	Std. Deviation
Monosyllabic	2y-2y.11m	24.00	36.00	60.00	49.34	7.40034
	3y-3y.11m	12.00	48.00	73.00	60.32	8.63095
	4y-4y.11m	16.00	64.00	80.00	74.5	4.72056
	5y-6 years	4.00	76.00	80.00	78.33	3.57704

Table 6: Showing Pearson Correlation Test Result of when Test Done by Two Different Tester

Subtest		Inter test reliability checked	
		Score	Score
Monosyllabic	Pearson Correlation	1	.764**
Between two tester	Pearson Correlation	.764**	1

0.764, which shows that score of test is highly correlated and reliable [29].

Reliability of test score between test – retest by the same tester

Table 7: Showing Pearson Correlation Test Result of when same Test Administer after Month

Sub-test		Score	Score
Monosyl	Pearson Correlation	1	.834**
Re Monosyl	Pearson Correlation	.834**	1

When the same subjects were re-tested after a month correlation were obtained by Pearson Correlation test.

The speech perception score were obtained by the same tester after one month of duration. Result of the Pearson Correlation test indicated score of 0.83, which shows that score of test is highly correlated and reliable [29].

Analysis of Experimental Group

Further same test were administered over both the experimental group i.e. HA users and CI users. To find out statistical significance between both these groups, 't' tail was used.

The obtained speech perception score from both the groups were subjected to analysis means; SD and Std. error means were calculated

Table 8: Showing Speech Perception Test Score of CI and HA Users Means, SD, std Error Mean Values

Group	N	Mean	Std. Deviation	Std. Error Mean
CI	30	61.4000	13.30958	2.42999
HA	30	49.8000	14.20879	2.59416

The table shows higher mean score on monosyllable identification in children using cochlear i.e. 61.4 than for children who were suing HA (i.e. 49.8). This indicated better performance on the monosyllable identification task by the group of children using cochlear implant than children using HA.

In order to determine the statistical significant difference in speech perception score between the two groups, independent't' tail test was used.

As shown table the p value obtained is 0.009. This value is highly statically significant indicating that the performance of children with CI was indeed superior to that of children using HA.

DISCUSSION

Children with hearing loss, including severe to profound loss, benefit from the hearing aids (HA) or CI [30]. In some children when degree of hearing loss is very high with limited residual, and utility of HA become question mark, such patient are believed to be best candidate for cochlear implant. Electronically due to technological limitations of HA on the part of amplifier,

Table 8: Showing the t Test Value and Level of Significance for the Speech Perception of Children Using CI and HA

t tail test	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
CI / HA	2.70	58	.009	9.60000	3.55450	2.48489	16.71511

hearing aids have been found to be ineffectual in amplifying frequencies roughly above 3 kHz. Thus children having a sloping configuration of audiogram and having hearing loss of severe degree at higher frequencies might not benefit from the conventional hearing aids. The important speech sounds that are present at characteristic frequency and an under amplification of such frequencies would lead to a loss of information of the speech sounds typical to those frequencies. The speech signal contains information about the fundamental frequency, the first formant F 1, and sometimes (depending on the vowel and the speaker) the second formant F2. The presence of fundamental frequency indicates the presence of voiced sounds (e.g., vowels), and therefore one could discriminate between voiced (vowels) and unvoiced sounds (majority of consonants). Changes in fundamental frequency also gives information about sentence prosody, i.e., one should be able to tell whether a sentence is a statement or a question. An individual could also discriminate between certain vowels which differ in F 1 frequency, i.e., vowels /i, u/ and /a, ae/. Finally, assuming that the temporal details in the waveform are preserved the individual should be able to discriminate among the consonant sets /s, f, 0, f/, /b, d, g, p, t, k/ and |w, r, 1, j/ which have different waveform characteristics [31].

HA requires a better controlled and optimized setting to pick up speech and language. Opportunity for better speech and language development for the children using hearing aids was, however is not possible in the natural environment due to limitation in it components. On the basis of our research study findings it was concluded that monosyllables even when coming at top of the hierarchy of speech perception task are performed better by the CI users than the HA user. Cochlear implants functioning directly stimulate the auditory cochlear nerve fibers and by passes the defective hair cells. Frequency spectrum covered by CI depends upon the number of active function electrodes and its location in the cochlea (i.e. basal part electrode for high frequency and apical part of electrode for low frequency). Recent advancement in CI can enable better perception and discrimination of speech sounds of the environment [32]. The performance of CI evolution depends on age and the duration of deafness. Many research study have reported better outcomes of CI when subjects are fitted at critical age i.e. 0-3 years. Current research finding matches with previous research study by Svirsky and Meyer [33] applied the PB-K test in 297 children using CI or HA. In the children, aged between 6 and 12 years, the average score of the CI-implanted group improved by 6.3% in 18 months, and children with HA users group showed significant lower scores. Mildner [30] *et al* 2006 reported in transverse research study to compare children using CI and those using HA. They also found significant speech perception score of 82.8% and 60.4% in the CI and HA users, respectively [34] investigated preverbal conversation in 27 subjects with CI and HA. Their research study indicated that CI help to promote similar development of pre-verbal behavior in children with profound hearing loss that was not produced with regular HA. Osberger [35] *et al* 1998 assessed 30 children above 5 years old. Speech perception ability was measured with 3 tests (Early Speech Perception (ESP), Glendonald Auditory Screening Procedure (GASP), Phonetically Balanced Kindergarten Test (PB-Ktest)) before CI implantation and HA use and at 3 and 6 months after the fitment of CI / HA. All test results finding indicate better responses for the CI user group. Above all research indicated that cochlear implant could promote profound deaf children from below to above the critical level of hearing. Investigation supports the view that the performance of speech perception of those children who were using hearing aids with the period of time. Also with the passage of time, the language abilities in the children using cochlear implants nearly reached that of their typical hearing peers when these groups of children using CI were classified for their performance they could be put under the category of children having consistent word identification [36] Reason for CI's better outcome may be results of highly modified electrode insertion which help to stimulate low and high frequency area in the cochlea, receiver design, speech encoding strategies and speech processor design. This technological advancement results in patient with CI speech perception performance has expanded. Two

further possible point may be due to training approach in HA and CI after fitment. Alum [37] 1996 reported that therapist often have greater expectation for children with CI than HA. Further HA provide limited frequency range information than CI, which provide larger spectrum information i.e. 8 number of channel electrode stimulation are sufficient to stimulate major speech frequency spectrum [37].

FINAL COMMENTS

With the implementation of newborn hearing screenings and early identification of hearing loss across the country, there is increased interest in measures to assess the speech perception abilities of children. Hindi speech perception test was developed in this study to quantify the ability of Hindi speech sound perception in the age range between three to six-years old. The present research study in accordance with previous reviews finding, it is possible to conclude that CI conferred greater benefits compared to conventional HA for the speech perception. Therefore it will help for acquisition of linguistic and communicative skills in patients with prelingual deafness.

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