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Research Article

# Development of Hindi Test of Speech Perception (HTSP) for Children Using Hearing Aids and Cochlear Implants

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## Abstract

### Rationale

The purpose of this study was to develop and assess the psychometric properties of the Hindi Test of Speech Perception (HTSP), which is intended for use with children with hearing impairment.

### Methods

The HTSP test was administered to 43 Hindi-speaking children, aged 6-8 years, with severe-to-profound hearing loss. Twenty-two were bilateral hearing aid users and 21 were unilateral cochlear implant users. Test stimuli included a total of 78 words that could be displayed as pictures. Pictorial representations of the words were distributed (2 picture plates each) across 3 subtests to assess pattern perception, bi-syllabic word identification, and monosyllabic word identification.

### Results

The children who wore a cochlear implant performed significantly better than the children who wore bilateral hearing aids. The HTSP demonstrated high test-retest reliability, item reliability and split-half reliability.

### Conclusion

Both the stimuli and task demands were deemed appropriate for testing speech perception of children with hearing impairment who are native speakers of the Hindi language.

## Introduction

Many children with hearing loss rely on amplification for effective (re)habilitation. As such, it is important to verify and validate that they are receiving maximum benefit with hearing aids, cochlear implants and other auditory devices (Madell, 2011). Speech understanding cannot be predicted from aided pure tone thresholds alone. Hence, administering an effective and reliable speech perception test to determine how well children receive, discriminate and recognize speech sounds, is important when working with a pediatric population. Speech perception tests have been used to assign children to different educational groups and to compare the benefits of different sensory aids. Somers (1991) reported better speech perception abilities in children using cochlear implants than those using hearing aids by evaluating 68 children with pre-lingual profoundly hearing impairment. The evaluation was based on five speech perception measures including: pattern perception, spondee and monosyllabic word identification, and closed and open-set speech recognition tasks. Similar studies have been completed by Bittencourt, Torre, Bento, Tsuji and Brito (2012), Kishon-Rabin et al. (2000), Mildner, Sindija and Zrinski (2006), Ranjan (2006), and Svirsky and Meyer (1999).

An issue with many speech perception tests is that they have a substantive language loads that can be problematic when testing children with limited language skills, such as the Bench-Kowal-Bamford Sentences test (Bench, Kowal & Bamford, 1979) and the Hearing in Noise Test (Nilsson, Soli & Sullivan, 1994). In contrast, tests like the Auditory Numbers Test (Erber, 1980) and the Environmental Sounds Test (Norton & Berliner, 1977) have limited language loads. Consequently, auditory perceptual tests vary in the populations targeted, as well as in the way results can be applied to different groups. For children it is important that test materials be age and developmentally appropriate, and in most cases it is important that the content be familiar. However, most published standardized test materials for speech perception testing in children have been developed in western countries with the stimuli are largely based on English.

The Indian subcontinent consists of a number of separate linguistic communities, each of which share a common culture and need to communicate. The people of India speak many languages and dialects. Hindi is a widely spoken language and is the mother tongue of approximately 41% of the Indian population (Census of India, 2001). Hindi speaking patients, therefore, account for a significant portion of the clinical population in audiology clinics across the country. However, a review of the available literature shows a dearth of Hindi-based speech perception assessment materials, particularly when considering materials for young children with severe to profound hearing loss. The lack of appropriate test materials demonstrates an immediate need for the development of language-appropriate tools. Test development is a time consuming and multifactorial process but it can be advanced quickly if the new test is based on the framework of an already existing and widely used tool with known psychometric properties.

The Early Speech Perception (ESP; Moog & Geers, 1990) is an English-based test developed for children who have profound hearing loss and limited auditory and verbal skills. It is simple, quick and easy to administer. Moreover, the perceptual, linguistic and response demands are reduced so it can be used with children who have poor or emerging skills. The ESP test provides valuable information about basic auditory perceptual processing of speech patterns, and monosyllabic and spondee words within a closed set. It has already been translated to other Indian languages, e.g., Marathi (Savarkar, 1999), and Malayalam (Jijo, 2008), so there is a precedence for developing a Hindi version. This achievement would substantially augment the clinical assessment tools available for use in hearing clinics that serve pediatric populations within India.

The present study primarily aimed to develop a Hindi Test of Speech Perception (HTSP) based on the ESP framework that would be appropriate for children with severe to profound hearing impairment in the age range of 6 to 8 years. Because most children diagnosed with a hearing loss in India are fitted with either bilateral hearing aids or a unilateral cochlear implant, the study also aimed to compare the HTSP results between children using hearing aids and those using cochlear implants as a measure of test validity. This was important because earlier studies had indicated significant differences in performance on speech perception tasks for children wearing hearing aids compared to those fitted with cochlear implants. Children with severe-to-profound hearing loss tend to receive one of these two treatment options and itis important that standard procedures and norms be developed for both groups.

The protocol for the study was approved by the Ethics Committee of Ali Yavar Jung National Institute for the Hearing Handicapped. All procedures were in strict adherence to the protocol.

## Methods

### Materials

#### Hindi Test of Speech Perception (HTSP) Structure

The HTSP was structured after the standard version of the ESP, which assesses closed-set perception of single words through listening alone. The ESP is comprised of 3 hierarchical subtests – pattern perception (12 items), spondee identification (12 items) and monosyllable identification (12 items). It depicts target words using 12 pictures per plate (1 for each subtest). Scores on ESP fall into 1 of 4 categories of speech perception: no pattern perception, pattern perception, some word identification and consistent word identification.

However, unlike English, true spondee words do not exist in any Indian language including Hindi (Sreedhar, Venkatesh, Nagaraja, & Srinivasan, 2011). So for the purposes of developing this Hindi version of the test, Subtest 2 (spondee identification) was changed to bi-syllabic word identification. The final HTSP consists of 3 subtests: pattern perception, bi-syllabic word identification and monosyllabic word identification. Similar to the ESP, the word identification tasks of the HTSP were constructed as closed-set tasks.

### Test Development

#### Material Selection

For Subtest 1, a set of 60 words with differing numbers of syllables was generated. Similarly, 60 bi-syllabic words were selected for Subtest 2 and 50 monosyllabic words beginning with /b/ and /p/ consonants were randomly selected for Subtest 3. Words were chosen with the intention that they would be familiar to children between the ages of 6 to 8 years who also were diagnosed with a hearing loss. The words also had to be easily represented with pictures across all 3 subtests. For this purpose, stimulus words were collected from Hindi books used in schools for children with hearing loss and written for children aged 6 to 8 years. The stimulus words for each subtest were chosen carefully, taking into consideration factors such as the requirements of each subtest, characteristics of the Hindi language, the vocabulary of the children to be tested and the pictorial representation of the words. All of the pictures depicted commonly used objects. A total of 170 words comprised the initial list.

**Appropriateness of Test Material**

To recruit appropriate subjects, hospitals, special schools and cochlear implant centers were contacted by the research staff. Out of those contacts, 10 responded (2 hospitals, 6 special schools and 2 cochlear implant centers) and provided permission to recruit through their site. The schools used Hindi as the language of instruction and also claimed to follow an oral-aural instructional approach. The sites provided a list of children fitting the inclusion criteria and only those children were invited to participate in the study.

To select the requisite number of stimuli for each subtest, the preliminary set of words was presented to parents (8 mothers and 2 fathers) of the 10 children (5 bilateral hearing aid users and 5 cochlear implant users). The parents were asked to rate each word as 'very familiar', 'somewhat familiar' or 'not familiar'. The words assigned the category 'very familiar' were those commonly used by the children in routine communication. The words described as 'somewhat familiar' were those that children knew but did not use commonly in routine communication, and 'not familiar' words were those the children did not know. Only the words that were rated as 'very familiar' by all parents were considered for use in the test. The parents also provided suggestions to use alternative words given their child's language learning experience (e.g., /ʧʌʃma/ for /ænʌk/, /viman/ for /hʌvaiʤʌhaz/, and /motʌr/ for /gadi/). Some English words like ball, pen, bat, bus, and bag also were included because they fell into the 'very familiar' category and are commonly used by Indian children. This intermediate list was then given to four speech-language pathologists with experience working with pediatric cochlear implant users. It also was reviewed by 2 Hindi language teachers at the primary-school level. Based on the feedback from parents, personal observations and professionals, the list was finalized. Out of the original list, 69 words were selected as test items and 9 were selected to served as practice items.

**Preparation of Picture Plates**

Like the ESP, the HTSP was developed to contain three subtests with 2 picture test plates per subtest. The first subtest targeted pattern perception. Each of its 2 test-plates contained 12 pictures (4 monosyllabic, 4 bi-syllabic and 4 multisyllabic) that were totally randomized on an A3 sized page (as shown in Appendix A). The second subtest assessed bi-syllabic word identification and included 24 words evenly divided across 2 picture plates. The third subtest assessed monosyllabic word identification. The single-syllable words contained different vowels but the same initial consonant in a consonant-vowel-consonant (cvc) syllable construction. The restricted number of phonemes limited the content and linguistic context for word retrieval. One set of 12 words was depicted on the first plate and started with /b/, whereas a set of 9 words was depicted on the second plate and started with /p/. The pictures for the plates were natural photographs of objects. Seventy two images were retrieved from Internet sources and 3 were photographed. The chosen pictures were then presented to 5 children (aged 6 to 8 years) with pre-lingual severe-to-profound hearing impairment. They were asked to name each picture. Pictures not correctly identified by 4 of the children were replaced as stimuli. After selection of the final set of pictures, the test plates were prepared and tested for their appropriateness by four 6 to 8 year old children with severe-to-profound hearing loss. The children were seated in a sound-treated room with the picture plates in front of them. The words were presented via monitored live voice at 70 dB HL in auditory mode only by a male speaker. This testing was conducted to verify the familiarity and non-ambiguity of the pictures, and to determine that the children could attend to test plates having a large number of pictures (i.e., 12 words/pictures). The inter-stimulus interval was kept to 6 seconds to allow sufficient time for the children to respond and for the tester to record the responses.

**Recording the Acoustic Test Materials**

For the purpose of recording the speech material, a native Hindi speaker was selected from among four adult native speakers (two males and two females) based on trial recordings (containing ten Hindi words) which were judged by five experienced listeners (who were audiologists and speech-language pathologists) on the basis of voice projection, diction, quality and clarity. The speaker chosen for recording the test material was a 23 year old male from the state of Bihar in northern India.

For the final recordings the speaker was instructed to limit the variation in his intonation, and to use equal stress and uniform loudness (monotonous) across the word list. Practice items were provided prior to the recording the final list. The words were then recorded in a professional recording studio by a sound engineer using Nuendo Version 4.0. They were saved as a single wave file. The individual words were extracted and edited using the Adobe Audition version 3.0 software (2007). They were normalized to -3 dB, and saved as separate wave files. The words were then assembled with an inter-stimulus interval of 6 sec. A calibration tone of 1000Hz was created, with a Root Mean Square (RMS) equal to that of the words so that the gain of the audiometer could be adjusted prior to testing.

### Participants

The children who participated in the study were aged 6-8 years, raised in a primarily Hindi speaking environment and previously diagnosed with a pre-lingual severe-to-profound hearing loss. They ranged in backgrounds from the low to middle socio-economic class. The children were recruited from the local special schools for children with hearing impairment, hospitals, cochlear implant centers and from patients coming to the AYJNIHH Institute for services. They were appropriately fitted with either trimmer digital or digitally programmable behind-the-ear hearing aids bilaterally or a unilateral cochlear implant and had consistently used their devices for a minimum of 2 years prior to the study. The mean number of years that hearing instruments were worn was 2.97 (*range* = 2-6 years) for the children fitted with bilateral hearing aids and 2.72 (*range* = 2-6 years) for the children wearing cochlear implants. Age of implantation varied from 13 months to 4 years, and age of digital hearing aid fitting varied from 12 months to 5 years. Prior usage of a body-level hearing aid was not considered. The children also needed to demonstrate aided pure-tone average thresholds (500, 1000 & 2000 Hz) of 60 dB HL or better (lower) in at least one ear. Children with abnormal otoscopic findings at the time of testing (e.g., perforated tympanic membrane or middle ear infections), multiple impairments, and/or multilingual backgrounds were excluded from the study. A total of 61 children were enrolled in the study but 18 were excluded because of active middle ear infections during the time of testing, or because they were completely dependent on visual cues and could not perform the tasks with consistency. A total of 43 children completed the study. For comparison they were separated into two groups – the hearing aid group and the cochlear implant group. The groups are described in Table 1.

### Preliminary Testing

Informed consent was obtained from the parents for their children's participation in the study. A case history was completed to assist with appropriate participant inclusion. An otoscopic examination also was completed to rule out cerumen build-up, ear discharge, or any apparent external or middle ear abnormality. Immittance testing was completed using a standard 226 Hz probe tone to rule out middle ear abnormality, middle ear pathology and to ensure that all the children had normal tympanograms (GSI Tympstar Middle Ear Analyzer, Grason-Stadler, Inc). Acoustic reflex threshold screens at 500, 1000, 2000 and 4000 Hz also were completed to ensure absent acoustic reflexes. Behavioural pure-tone thresholds were obtained in a sound-treated room with noise levels within permissible limits, as per American National Standards Institute (American National Standards Institute, 1991). The thresholds were obtained with a diagnostic audiometer (Voyager 522, Madsen Electronics) with TDH 49 earphones and a Radioear B-71 bone vibrator (American National Standards Institute, 1989). The pure-tone air-conduction (AC) thresholds were determined for octave frequencies from 250 to 8000 Hz and for bone-conduction (BC) at octave frequencies from 250 to 4000 Hz using the modified Hughson and Westlake procedure (American Speech-Language Hearing Association, 1978). Behavioral aided and CI-assisted thresholds were obtained in the sound field using a two-room sound-treated booth and a diagnostic audiometer (Interacoustics AD229). These sound-field thresholds were obtained for octave frequencies from 250 Hz to 4000 Hz using warble tones (to avoid standing waves) and also for speech detection, speech noise and the Ling sounds test (Ling, 1976). The testing was done separately for both ears with hearing aids or cochlear implant turned on. Frequency specific aided testing was completed using the modified Hughson and Westlake procedure.

**Table 1. Description of children in hearing aid and cochlear implant groups.**

| Group | Age Range (yrs.) | *N* | Sex | Average PTA (dB HL) | | Average Aided/Implant Assisted PTA (dB HL) | |
|---|---|---|---|---|---|---|---|
| | | | | Right | Left | Right | Left |
| Hearing Aid Users | 6 - 8 (*M* = 6.74) | 22 | Male = 12 Female = 10 | >99 (80 to >118) | >98 (85 to >113) | 61 (40 to 86) | 55 (43 to 63) |
| Cochlear Implant Users | 6 - 8 (*M* = 6.75) | 21 | Male = 15 Female = 6 | >109 (90 to >120) | >110 (97 to >120) | 41 (30 to 55) | ----- |

## Test Procedures

### Test Administration and Scoring

The acoustic stimuli of the HTSP test were routed from a laptop computer through a diagnostic audiometer (Interacoustics Diagnostic Audiometer, AD229) for sound-field presentation. Each child was seated in a chair in a sound-treated booth with loudspeakers placed at 45 and 315 degrees azimuth at a distance of 1 meter. For children using hearing aids, the speaker on the side of the ear with the better aided thresholds was used during stimulus presentation. For children with cochlear implants, the speaker on the side of the implanted ear was used to present the stimuli. Stimuli were presented at 70 dB HL to increase the likelihood of audibility by the children with the more severe thresholds.

The children were provided with the following instructions: "You will hear words from the loudspeaker and will be shown pictures in front of you. Listen carefully to the words that are said and point to the respective picture." A practice plate of 6 words was used to determine if the children heard/understood the instructions and could perform the HTSP tasks.

### Response Format and Scoring

As previously indicated, the test used a closed-set format in which children were required to select one of the given response alternatives. Each child was required to respond by pointing to the correct picture on the picture plate that corresponded to the target word he/she heard. The children's responses were recorded by an examiner on a score sheet sitting inside the booth. For Subtest 1 (pattern perception) a score of 1 was given for correct word identification, 0.5 was given for identifying the correct pattern and 0 was assigned to incorrect responses. For the Subtests 2 and 3 correct responses received a score of 1 and incorrect responses received a score of 0. The highest possible total correct score for the test was 36. The total time taken for the entire procedure (including preliminary tests) was approximately 45 minutes per child. The administration time for the HTSP was approximately 15-20 minutes.

### Retest Evaluation

To assess test-retest reliability, the HTSP was re-administered to 8 children (4 children from each group) who were selected randomly. The retest occurred 4 weeks after the first administration.

## Statistical Analysis

A one-Sample Kolmogorov-Smirnov test was applied to the HTSP results to assess normality of all three subtests as well as the total score. The tests were not significant ($p > .05$) for any subtest or the total score, so the HTSP results were considered to be normally distributed. As a result, parametric statistical tests were used. The SPSS statistical package (version 16.0) was used for data analysis, and a $p$-value of < .05 was considered the criterion for statistical significance. Item reliability was obtained by computing a Cronbach's Alpha. Split -half reliability was obtained by computing Spearman-Brown and Guttman Split-Half Coefficients. For correlation measures, a Pearson's Product-Moment Correlation was performed. Averages and standard deviations between groups were compared with a Student $t$-test.

## Results

The HTSP demonstrated high item reliability with a Crombach Alpha of .929. Split-Half Reliability was measured using an even-odd method and produced a Spearman-Brown Coefficient of .892 and a Guttman Split-Half Coefficient of .892.

A Pearson Product-Moment Correlation was used to assess the relationship between the aided/CI-assisted pure-tone average for the better ear and the scores on the three

**Table 2. Pearson's Product-Moment Correlations (r) between the ear with the better aided/CI-assisted PTA and the HTSP scores.**

| Test | *N* | Correlation (*r*) | *p*-value |
|---|---|---|---|
| 1 | 43 | -.361 | .018** |
| 2 | 43 | -.467 | .002** |
| 3 | 43 | -.391 | .0001** |
| Total Score | 43 | -.446 | .003** |

Note: $^*p$<.05; $^{**}p$<.01

**Table 3. Scores obtained by the children on the HTSP. The maximum total score obtained was 35 and the minimum score was 2.5.**

| Subtest | *N* | *Minimum* | *Maximum* | *Mean* | *Standard Deviation* |
|---|---|---|---|---|---|
| 1 | 43 | 1.50 | 12.00 | 7.51 | 3.04 |
| 2 | 43 | 0.00 | 12.00 | 5.81 | 3.74 |
| 3 | 43 | 0.00 | 12.00 | 5.00 | 3.10 |
| Total Score | 43 | 2.50 | 35.00 | 18.33 | 9.09 |

subtests and the Total Score. As shown in Table 2, strong correlations were found between better-ear pure-tone averages and scores obtained on HTSP. subtests and the total score. As shown in Table 2, strong correlations were found between better-ear pure-tone averages and scores obtained on the HTSP.

Figure 1, shows the total score for each individual child in the two groups. The group differences (hearing aid vs. cochlear implant) per subtest were assessed with *t*-tests and the results indicated that the children using cochlear implants produced higher scores than did the children wearing hearing aids (Table 4).

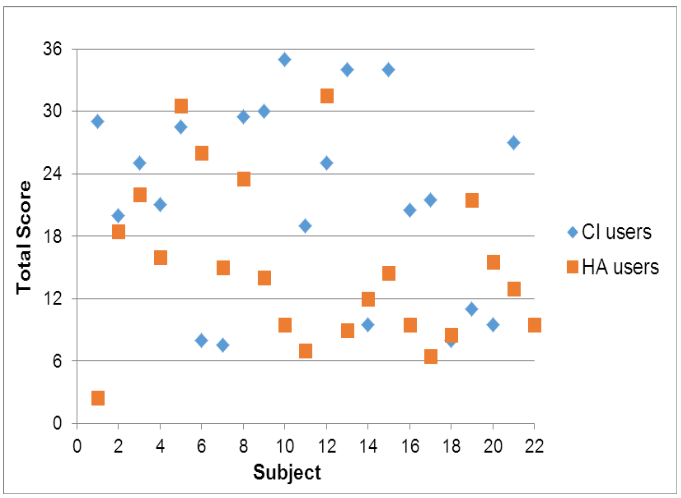


**Figure 1. Scatter gram showing Total Scores obtained by both groups (Cochlear Implant and Hearing Aid users) on the HTSP.**

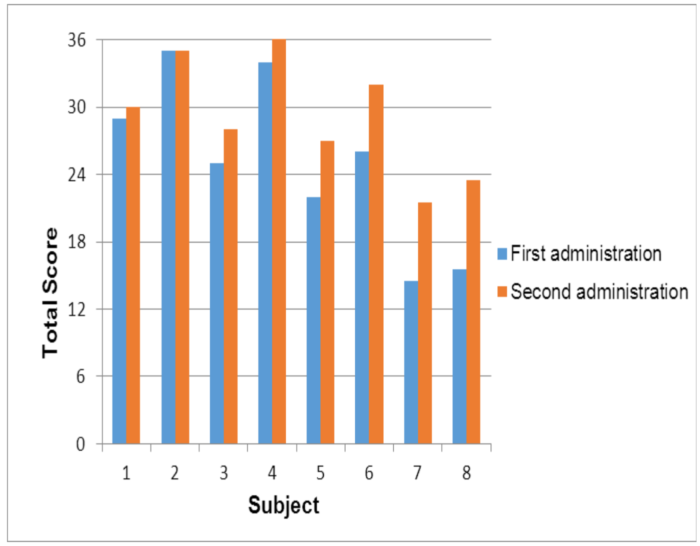


**Figure 2. Total scores obtained by 8 subjects on first and second administration of HTSP (test-retest).**

## Discussion

The major objective of the study was to develop a reliable Hindi-based speech perception test that could be used with children aged 6 - 8 years who have severe-to-profound hearing loss. This objective was largely met.

The Hindi Test of Speech Perception (HTSP) is the first test of its type to be constructed in a recorded form for Hindi-speaking children with hearing impairment. The three subtests of HTSP, pattern perception, bi-syllabic word identification and monosyllabic word identification, parallel the standard form of the ESP except for Subtest 2, which was modified because spondaic words are not present in Hindi.

**Table 4. Comparison of cochlear implant users and hearing aid users on the HTSP.**

| Test | Cochlear Implant Users (*N*=21) | | | Hearing Aid Users (*N*=22) | | | *df* | *t* | *p* |
|---|---|---|---|---|---|---|---|---|---|
| | *Mean* | *Range* | *SD* | *Mean* | *Range* | *SD* | | | |
| 1 | 8.45 | 2.5-12 | 3.11 | 6.61 | 1.5-11.5 | 2.73 | 41 | 2.223 | .027* |
| 2 | 7.00 | 1-12 | 4.12 | 4.68 | 0-10 | 3.01 | 41 | 2.148 | .028* |
| 3 | 6.10 | 1-11 | 2.91 | 3.95 | 0-11 | 2.97 | 41 | 2.444 | .013* |
| Total | 21.54 | 7.2-35 | 9.38 | 15.25 | 2.5-31.5 | 7.82 | 41 | 2.483 | .013* |

*Note.* *p <.05, 2-tailed

**Table 5. Comparison between the total and subtest scores obtained from 8 of the children (4 per group) between first and second administrations of the HTSP. Significant differences were seen between the administrations.**

| Sub-test | Test (*N*=8) | | Retest (*N*=8) | | *df* | *t* | *p*-value (2 tailed) |
|---|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | | | |
| 1 | 10.0 | 1.71 | 9.88 | 1.9 | 7 | 0.403 | .699 |
| 2 | 8.5 | 3.07 | 8.5 | 2.5 | 7 | 0.000 | .999 |
| 3 | 6.63 | 3.58 | 7.13 | 3.4 | 7 | 1.871 | .104 |
| Total Score | 25.13 | 7.63 | 25.5 | 7.5 | 7 | 1.528 | .170 |

**Table 6. Pearson's Product-Moment Correlations between the test and retest. These correlations were high and significantly different from 0.**

| Subtest | Correlation (*r*) | *p*-value |
|---|---|---|
| 1 | .766 | .013* |
| 2 | .965 | .0001** |
| 3 | .978 | .00003** |
| Total Score | .996 | .00001** |
| *Note.* *$p<.05$; **$p<.01$ | | |

The HTSP is simple and takes into account the various levels of speech perception. Like the ESP, the test was constructed to allow categorization of children according to level of speech perception, i.e., no pattern perception, pattern perception, some word identification and consistent word identification. It should be noted, however, that categorization validity and fidelity were not assessed in this study.

The HTSP included recorded speech stimuli presented from a computer and routed through an audiometer to maintain consistency in presentation (Carhart, 1965; Kreul, Bell & Nixon, 1969). Zheng et al. (2009) used a recorded administration procedure during the development of the Mandarin Early Speech Perception test for 2 - 5 year old developmentally normal children. It was observed that the recorded test also could be used with children who successfully wore hearing aids and cochlear implants.

Like the ESP, the HTSP was constructed as a closed-set task. Oyer and Doudna (1970) commented that most open-set tests are not appropriate for young pediatric populations because they carry higher perceptual, linguistic and memory demands than closed-set tests. Thus, for children who cannot be tested with open-set speech materials, the HTSP is a viable speech perception assessment procedure.

The HTSP required picture pointing responses. Many children with hearing loss are at risk for language and speech production problems, so the use of nonverbal response modes, such as picture pointing or the use of manipulatives is considered as a good option. As a consequence, many speech perception tests for pediatric populations (e.g., Word Intelligibility by Picture Identification test; Ross & Lerman, 1989), especially children with hearing loss and other special needs, use closed set stimuli and picture pointing responses. All the children in the current study (6 - 8 year old target population) with severe-to-profound hearing loss were able to respond by pointing.

Reliability refers to the consistency with which the items on the test yield comparable indices of the abilities being assessed. Internal consistency refers to the extent to which different items within the same category measure the same skills. Internal consistency was evaluated by computing a Cronbach's coefficient alpha and the results indicated that the HTSP has high internal consistency. The HTSP also demonstrated high split-half reliability at levels comparable with other related studies (Savarkar, 1999).

Speech perception testing is used by professionals to track the benefit of hearing aids, cochlear implants, FM devices or any combination of technology (Madell, 2011). For most listeners, the better the aided threshold, the better the performance on speech perception tests (Parkinson, Newell, Byrne & Plant, 1996). The correlation measures in the present study also showed a strong correlation between the average aided thresholds and performance on the HTSP — lower aided average (better hearing) related to higher scores on the test. This result supported the validity of the HTSP.

When children using hearing aids were compared to those using cochlear implants, it was found that children using a cochlear implant performed significantly better than children using hearing aids. Similar results were reported by Somers (1991) and Ranjan (2006). Kishon-Rabin et al. (2000) also reported higher scores on an ESP test adapted to the Hebrew language by cochlear implant users as compared to hearing aid users. Finding this same pattern of results in the current study provides further support for the validity of the HTSP.

The scores obtained by the children in this study were highest for the pattern perception task (Subtest 1) and lowest for the monosyllabic word identification task (Subtest 3), a pattern obtained by Savarkar (1999) and consistent with pattern cues being relatively easy to perceive. The children had more difficulty with identification of monosyllabic words in isolation.

To assess the performance consistency of the HTSP, the test was administered on two different occasions to 8 children. The results from the 2 administrations were not significantly different and the correlations for the subtests and the Total Score were high. Because of financial constraints the re-test included a limited number of children. Thus, this measure is statistically less powerful and reliability results might be obtained if a larger and more diverse group of children were included. The recorded ESP (Moog & Geers, 1990) was tested and retested on 27 children and produced test-retest reliability of 0.84 to 0.93.

## Conclusions

### Strengths

The current study provided evidence that a recorded test of Hindi speech perception can be appropriately administered to children aged 6 – 8 years who have severe-to-profound hearing impairment and use hearing aids or cochlear implants. This study also supported the view that children using cochlear implants tend to perform better that those fitted with hearing aids, although a selection bias or other type of cohort bias is a concern in these types of comparisons.

### Limitations

Test-retest reliability of the HTSP could not be fully established. It should be assessed on a larger and more diverse group of children before it can be used for widespread assessment and rehabilitative purposes.

### Directions for Future Research

Future studies should compare the performance of HTSP on a larger number of children sampled across a wider age range using unilateral or bilateral cochlear implants. It also would be helpful to compare HTSP outcomes to children's language, speech, visual perception and cognitive skills.

## References

Adobe Systems Incorporated (2007). Adobe Audition. (Version 3.0) [Computer Software] San Jose, CA.

America Speech and Hearing Association (1978). *Guidelines for manual puretone threshold audiometry*. ASHA, *29*, 297-301.

American National Standards Institute (1989). *American National Standard Specification for audiometers*. (ANSI S3.6-1989). New York: ANSI.

American National Standards Institute (1991). *Permissible ambient noise levels for audiometric test levels.* (ANSI S3.1-1991). New York: ANSI.

Bittencourt, A. G. B., Torre, A. A. G. D., Bento, R. F., Tsuji, R. K.,& Brito, R. (2012). Prelingual deafness: Benefits from *cochlear implants versus conventional hearing aids. International Archives of Otolaryngology*, *16* (3), 387-390.

Carhart, R. (1965). Speech audiometry. In F. N. Martin & J. G. Clark (Eds.) *Introduction to Audiology, 9th Edition,* (pp. 113-147). Delhi: Dorling Kindersley.

Census of India. (2001). *Abstract of speakers' strength of languages and mother tongues.* Retrieved 10 January, 2013, from http://www.censusindia.gov.in/Census_Data_2001/Census_Data_Online/Language/Statement1.htm.

Erber, N. P. (1980). Use of auditory numbers test to evaluate speech perception abilities of hearing impaired children. *Journal of Speech and Hearing Disorders*, *45*, 527-532.

Jijo, P. M. (2008). *Early speech perception test development of Malyalam speaking hearing impaired children.* Unpublished Master's thesis, University of Mysore, Mysore, India.

Kishon-Rabin, L., Taitelbaum, R., Segal, O., Henkin, Y., Tene, S., Muchnik, C., & Hildesheimer, M. (2000). Speech perception: Implanted versus aided children. In S.B. Waltzman & N.L. Cohen (Eds.), *Cochlear Implants* (pp. 212). New York: Thieme.

Kreul, E. J., Bell, D. W., & Nixon, J. C. (1969). Factors affecting speech discrimination test difficulty. *Journal of Speech and Hearing Research*, *12*, 281-287.

Ling, D. (1976). *Speech and the Hearing-impaired Child: Theory and practice.* Washington DC: Alexander Graham Bell Association for the Deaf.

Madell, J. (2011, February 7). Pediatric amplification: Using speech perception to acheive best outcomes. http://www.audiologyonline.com/. AudiologyOnline, Article 841. Retrieved 12 November, 2013, from http://www.audiologyonline.com/.

Mildner, V., Sindija, B., & Zrinski, K.V. (2006). Speech perception of children with cochlear implants and children with traditional hearing aids. *Clinical Linguistics & Phonetics*, *20,* 219-229.

Moog, J.S. & Geers, A.E. (1990). *Early speech perception test for profoundly hearing-impaired children*. St. Louis: Central Institute for the Deaf.

Nilsson, M., Soli, S.D., & Sullivan, J.A. (1994). Development of the Hearing in Noise Test for the measurement of speech reception thresholds in quiet and in noise. *Journal of the Acoustical Society of America*. *95*, 1085.

Norton, N.B. & Berliner, K.I. (1977). Environmental sounds: Test and training program for the hearing impaired. Presentation at the American Speech and Hearing Association, Chicago.

Oyer, J.J. & Doudna, M. (1970). Structural analysis of word response made by hard of hearing subjects on discrimination tests. In W. F. Rintelmann (Ed.), *Hearing Assessment*. Boston: Allyn and Bacon.

Parkinson, J.A., Newall, P., Byrne, D., & Plant, G. (1996). Relationships of aided speech recognition to hearing thresholds and aided speech-peak sensation levels in severely and profoundly hearing-impaired adults. *Journal of the American Academy of Audiology*, *7*, 305-321.

Ranjan, P. (2006), Performance of Speech Perception in children using hearing aids and cochlear implants: A comparative study, Unpublished Master's thesis, University of Mumbai, Mumbai, India.

Ross, M. & Lerman, J. (1979). A picture identification test for hearing impaired children. *Journal of Speech and Hearing Research*, *13*, 44-53.

Savarkar, M.S. (1999). Development of Speech Perception Test for Hearing Impaired Children in Marathi. Unpublished Master's Thesis, University of Mumbai, Mumbai, India.

Somers, M.N. (1991). Speech perception abilities in children with cochlear implants or hearing aids. *American Journal of Otology*, *12*, 174-178.

Sreedhar, J.S., Venkatesh, L., Nagaraja, M.N., & Srinivasan, P. (2011), Development and Evaluation of paired Words for Testing of Speech Recognition Thresholds in Telgu: A Preliminary Report. *Journal of the India Speech Language and Hearing Association*, *25*, 128-136.

Svirsky, M. A. & Meyer, T. A. (1999).Comparison of speech perception in pediatric CLARION cochlear implant and hearing aid users. *The Annals of Otology, Rhinology and Laryngology Supplements*, *177*, 104-109.

Zheng, Y., Meng, Z., Wang, K., Tao, Y., Xu, K., & Soli, S. (2009), Development of the Mandarin Early Speech Perception Test: Children with Normal Hearing and the Effects of Dialect Exposure. *Ear and Hearing*, *30*, 600–612.

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## Appendix A

Test Stimuli: Picture Boards with Familiar Words