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Original Article

Ear, Nose and Throat Section

Development of Minimal Pair Test in Tamil (MPT-T)

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ABSTRACT

Introduction: Speech perception testing provides an accurate measurement of the child's ability to perceive and distinguish the various phonetic segments and patterns of the sounds. From among the many types of speech stimuli used, minimal pairs can also be used to assess the phoneme recognition skills. Thus, the study focused on developing Minimal Pair Test in Tamil (MPT-T).

Aim: The aim of the present study was to develop and validate the MPT in Tamil on Normal Hearing (NH) children and paediatric cochlear implantees (CI).

Materials and Methods: It was an experimental study which included school going children in the age range of six to eight years and the duration of the study was 12 months. The test was developed in two phases. The first phase focussed on the construction of the word list, recording of the word pairs and the preparation of the test. The second phase was administration of the test on NH children and paediatric cochlear implantees. The test scores were analysed using Mann Whitney U test, Kruskal Wallis and Wilcoxon signed-rank test. The results showed a statistical significance between the NH group and the paediatric cochlear implantees.

Results: The present study included 40 NH children and 15 paediatric cochlear implantees through purposive sampling method. The specific speech feature analysis of the paediatric cochlear implantees revealed that there was difficulty identifying the word pairs differing in Vowel Length (VL) and the best performed feature was Place of Articulation (POA). The results showed statistical significance between the NH group and the paediatric cochlear implantees.

Conclusion: The developed test can be effectively used in clinic for assessing speech perception abilities of pediatric Cochlear Implantees and also in planning the rehabilitative goals.

Keywords: Paediatric cochlear implantees, Place of articulation, Vowel change, Vowel length

INTRODUCTION

Speech perception is the process by which the phonetic aspects of the language are heard, analysed and understood. In the audiological test battery, it is important to assess speech perception because it helps in the understanding of how the ear functions and also to conclude about the integrity of the auditory system, its processing abilities and also person's auditory verbal language skills [1].

The inability to comprehend speech due to hearing loss has an influence on all aspects of a child's communication development and daily functioning. The child's achievement of the speech milestones is also delayed and the sounds are also not achieved age appropriately. Therefore, a battery of tests should be employed that include measures of spoken word recognition skills and the receptive and expressive language abilities of the children. It is important to account for the level of performance of the child in each skill, because the ability of these children to discriminate between the sounds is impaired and it is only initiated in these children after they are fitted with auditory prosthesis, which can be a Hearing Aid (HA) or Cochlear Implant (CI). It is essential to track their development in their speech perception abilities, because hearing loss produces a significant impairment on speech perception. So, it is necessary to document the changes with respect to their performance before and after the auditory prosthesis is fitted and also at regular intervals which will help in effectively planning the rehabilitation process for the children [1].

Speech perception evaluation quantifies a child's ability to perceive and distinguish between the phonetic segments and patterns of the sounds in words, sentences, minimal pairs and connected discourse level, primarily to assess the overall auditory perception of that individual [2]. From among the many types of speech stimuli used in the test materials, minimal pairs can also be used to assess phoneme recognition skills. A minimal pair has only one feature difference with a particular phoneme. Minimal pair as defined by Trask RL (1996) is "two words of distinct meaning which exhibit different segments at one point but identical segments at all other points" [3]. Moreover, their use in the clinical and acquisitional population is documented for studying the intelligibility of speech [4].

Literature search has yielded information about studies utilising minimal pairs in Telugu, Malayalam, Hindi and English to document the perceptual abilities of typically developing children and comparing the performance of hearing impaired children [5-8]. However, there is no test that has been developed which uses minimal pair words in Tamil language to assess speech perception in children. Hence, the present study aimed to develop and validate MPT-T for typically developing NH children aged six to eight years and paediatric cochlear implantees.

MATERIALS AND METHODS

The present study was an experimental study, done at the Department of Audiology, MERF-Institute of Speech and Hearing (P) Ltd., Chennai. The study was done over a period of one year from June 2018 to June 2019 which included school going children and paediatric cochlear implantees. Ethical clearance was obtained from the ethical committee of Madras ENT Research Foundation (P) Ltd., (MERF-ISH/EC-FEB.19/05). Informed consent was taken from the parents and the guardians after explaining the purpose of the study. The data was collected through convenient random sampling from 40 NH children and from 15 paediatric cochlear implantees who met the inclusion criteria through purposive sampling method.

Inclusion criteria: School going children in the age range of six to eight years with normal hearing were categorised into group 1 (6 to 7 years) and group 2 (7.1 to 8 years). A total of 15 implant age matched paediatric cochlear implantees were included as group 3.

Exclusion criteria: The children who had illness/neurological/otological problems/speech and language disorders were excluded from the study.

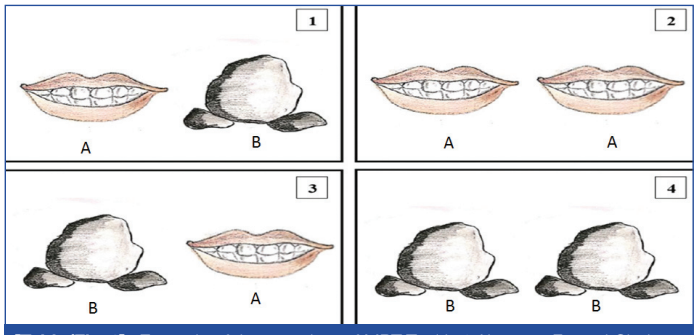
Phases of the Study

The test was developed in two phases. The first phase focussed on the construction of the word list, recording of the word pairs and the preparation of the test plate. The second phase was administration of the test on NH children and paediatric cochlear implantees.

Phase I-Development of the MPT-T

Selection of the stimuli was done in following method. The word pairs chosen for the construction of the test material were collected from Tamil text books of children aged six to eight years. The pairs were categorised into pairs varying in one feature, two features and more than two features. The word pairs selected for the test differed only in the initial position contrast. The list was then content validated by Speech Language Pathologists (SLPs) currently practising in the field for more than three years, school teachers with more than three years of teaching experience and finally parents of children of the same age group. Content validity was carried out in terms of familiarity and frequency of usage of words. The final list after content validation consisted of 45 word pairs differing in Vowel Change (VC), VL and POA. The recording of the test stimulus was carried out in a sound treated room. A female native Tamil speaker aged 28 years who did not have any complaints of speech and voice disorder was trained to record the words, maintaining constant loudness and without dialectal variations. The microphone of Lenovo P410 On Ear headset was placed at a distance of six inches away from the speaker's mouth throughout the recording. The input was stereo recorded at a sample rate of 44,100 Hertz (Hz) using the Audacity version 2.3.1 software with 64 bit resolution. The recorded tracks were normalised and were played back to five experienced SLPs to rate for the naturalness on a 4-point rating scale ranging from 0 to 3 (score 0-for unnatural/robotic speech and 3-natural speech) [8]. The audibility and intelligibility of each word pair along with deviations in the sound quality were noted and necessary changes were made. The SLPs were also asked to identify the nativity of the speaker based on their accent.

The test plate for 30 picturable word pairs were hand drawn and coloured by an experienced artist. Hand drawn pictures were informally field tested to check familiarity and ability to be recognised by five native Tamil speaking children randomly selected in the age range of six to eight years who were not a part of the other phases of the study. Modifications were made in the pictures to represent them correctly after the field testing. The test plate was designed on a A4 sheet which represented four combinations of the selected word pair. For example for the target pair-(kəl-pəl), the four combinations [4 Alternate Forced Choice (AFC)] were-(pəl-kəl) (AB),-(pəl-pəl) (AA),-(kəl-pəl) (BA),– (kəl-kəl) (BB) as shown [Table/Fig-1]. In order to avoid the chance performance the order of occurrence of the four combinations on the test plate were randomised for the 30 test plates. These four combinations were numbered 1 to 4, for the ease of scoring. All the test plates were laminated separately.



[Table/Fig-1]: Example of the test plate of MPT-T with 4 Alternate Forced Choice, the four choices were AB, AA, BA, BB (A= Lips, B=Stone).

Phase II-Administration of MPT-T on Normal Hearing (NH) children and Paediatric cochlear implantees.

The test was administered on 40 NH children in the age range of six to eight years divided into two groups (Group 1- 6 to 7 years, Group 2- 7.1 to 8 years) whose hearing sensitivity was within normal limits (≤20 dBHL) which was confirmed through Pure Tone Audiometry (PTA). Group 3 consisted of 15 pediatric cochlear implantees who satisfied the following inclusion criteria were included. Bilateral congenital severe to profound deafness (non-syndromic origin), unilateral cochlear implantees (with normal cochlear anatomy), implant age between six to eight years, the aided thresholds with the CI within 25 dB HL, the speech discrimination scores of the child should be 50% in quiet using open set identification based on the previous assessments [4].

The test was carried out in a double room audiometric setup. The stimuli were routed through loudspeakers placed at an angle of 90° azimuth on the side of the implant for cochlear implantees. While testing NH children, the stimuli were routed through Telephonics TDH-39 headphones connected to a two-channel diagnostic audiometer (Piano Inventis). The target pictures were placed in front of the child. Two clinicians were involved in the test; one presented the test plates to the child by sitting beside and the responses were marked, while the other presented the word pairs.

For NH children, following the Pure Tone Audiometry (PTA), Speech Recognition Threshold (SRT) was established using the spondees. The presentation level for the administration of MPT-T was SRT+20 dB HL and SRT+40 dB HL. For cochlear implantees, the external components (speech processor, transmission coil, microphone, cable) were checked for any physical damage in order to discard any technical problems with the device before the commencement of the test. Aided audiogram was obtained after the device verification for the frequencies from 250 Hz to 8000 Hz following that, SRT was established by using spondees. The presentation level for the administration of the test was SRT + 20 dB HL. A score of 1 was given for the correct response and a score of 0 was given if the response was incorrect.

STATISTICAL ANALYSIS

The obtained data was tabulated and the analysis included Mann Whitney U test, Kruskal Wallis and the Wilcoxon Signed rank test using Statistical Package for Social Sciences (SPSS) Software Program Version 23.0. The p-value <0.05 was considered statistically significant.

RESULTS

The mean PTA and SRT values of children in group 1 was observed to be 15.39 dB HL±2.29 and 28.25 dB HL±22.44, respectively. In group 2, the mean PTA was 15.14 dB HL±2.49 and the mean SRT was 27.75±2.55. The mean aided thresholds of children in group 3 were 35.41 dB HL±5.77 and the aided SRT was 45.33 dB HL±4.80. The analysis between the PTA and SRT of the two groups (group 1 and group 2), revealed that there was no statistical significance between the PTA (p=0.668) and SRT (p=0.524) values. These results concluded that the two groups are homologous and their performance was similar on PTA and SRT.

The test was performed at two levels for the NH children (group 1 and group 2) across two presentation levels (SRT + 20 dB HL and SRT + 40 dB HL) and the mean and the standard deviation were tabulated in [Table/Fig-2]. Statistical significance was observed in the performance of the test at 20 decibels Sensation level (dB SL) (w.r.t. SRT) (p=0.01) and there was no significant difference in the performance at 40 dB SL (w.r.t. SRT) (p=0.30) between the groups [Table/Fig-3].

The scores of the performance of the test were compared and analysed between the three groups for the presentation level

Groups	Presentation Level (PL)	Mean value	SD
Group 1	SRT + 20 dB HL	23.85	4.00
	SRT + 40 dB HL	28.75	1.77
Group 2	SRT + 20 dB HL	27.78	2.23
	SRT + 40 dB HL	29.25	1.29

[Table/Fig-2]: Mean values and standard deviation of the performance of NH children (group 1 and group 2) across the two presentation levels.
SRT: Speech recognition threshold; dB HL: Decibels hearing level; SD: Standard deviation; NH: Normal hearing.

Variables	SRT + 20 dB HL	SRT + 40 dB HL
Mann-Whitney U	79.500	165.500
Z-score	-3.287	-1.022
Asymp. sig. (2-tailed)	0.001	0.307

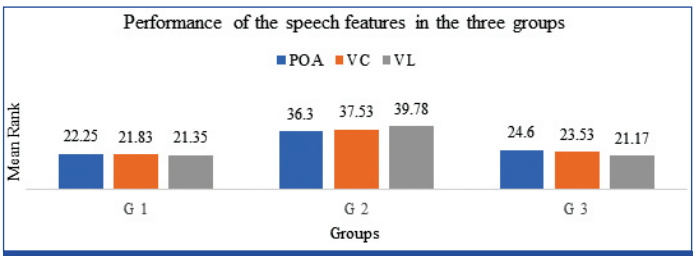
[Table/Fig-3]: Statistical details of Mann Whitney U test of the performance of MPT-T between group 1 and group 2 at the two presentation levels.
p<0.05 was considered statistically significant. SRT: Speech recognition threshold; dB HL: Decibels hearing Level; Asymp. Sig.: Asymptotic significance.

of 20 dB SL (w.r.t. SRT). The presentation level for testing the paediatric cochlear implantees (group 3) was set at 20 dB SL (w.r.t. SRT) due to the loudness discomfort reported by the children when testing at 40 dB SL (w.r.t. SRT). The analysis indicates a significance (p=0.000) between the groups. The speech feature analysis also showed a statistically significant difference between the three groups in terms of POA, VL and VC [Table/Fig-4]. The p-value for the word pairs differing in POA was p=0.010 for vowel change p=0.002 and for vowel length p=0.000 [Table/Fig-4].

Groups	POA	VC	VL	SRT + 20 dB
Group 1 (6 to 7 years)	22.25	21.83	21.35	23.03
Group 2 (7.1 to 8 years)	36.30	37.53	39.78	39.65
Group 3 (CI)	24.60	23.53	21.17	19.10
Chi-Square	9.28	12.39	17.64	17.30
df	2	2	2	2
Asymp. Sig. (2-tailed)	0.010	0.002	0.000	0.000

[Table/Fig-4]: Statistical details using Kruskal Wallis test of the performance and speech feature analysis.
POA: Place of articulation; VC: Vowel change; VL: Vowel length; SRT: Speech recognition threshold; dB: Decibels; CI: Cochlear implantees; df: Degree of freedom; Asymp. Sig.: Asymptotic significance. p<0.05 was considered statistically significant.

From [Table/Fig-5], It is concluded that group 2 performed better compared to group 1 followed by group 3 when overall performance and speech feature analysis was carried out (Groups: 2 >1 ≥3) [Table/Fig-6].



[Table/Fig-5]: Bar diagrams illustrating the performance of the specific speech feature in each group.
POA: Place of articulation; VC: Vowel change; VL: Vowel length; G: Group.

On comparing the performance between group 1 and group 3, it was found that there is no significant difference in the performance on this test. The two groups are equivalent in their performance. This similarity in the performance could be because of the chronological age of the typically developing children (group 1) which corresponds to hearing age of the cochlear implantees(group 3). Comparison between group 2 and group 3 revealed a statistical significance (p=0.000).

Groups	Group 1	Group 2	Group 3
Place of articulation	34.33	30.50	28.07
Vowel change	34.05	28.80	27.37
Vowel length	23.13	32.20	13.57
Chi-square	5.560	0.445	12.413
df	2	2	2
Asymp. Sig. (2-tailed)	0.062	0.800	0.002
Significance	NS	NS	S

[Table/Fig-6]: Mean rank and test statistics for the comparison among the speech features in MPT-T within each group.
Specific speech categories; POA: Place of articulation; df: Degree of freedom; Asymp. Sig.: Asymptotic significance; S: Significant; NS: Not significant; p<0.05 was considered statistically significant

DISCUSSION

The study was carried out to develop and validate MPT–T and to determine its utility on assessing the speech perception skills on pediatric cochlear implantees in Tamil language. Minimal pairs included in the current study were restricted to variation in POA, VC and VL as Tamil language has restricted combinations of the consonants which differ in manner of articulation. Also, this language is spoken by many people in many different geographical locations across Tamil Nadu and thus has many dialectal variations. The phonological structure of Tamil language has five pure vowels and can be categorised into, short and long vowels. The long vowels are two folds longer than the short vowels. The diphthongs are pronounced about 1.5 times as long as short vowels [9]. The voicing feature is not focussed because Tamil language does not have sharp distinctions between the voiced and voiceless sounds [10]. Based on [Table/Fig-5], the paediatric cochlear implantees had difficulty in identifying the minimal pairs varying in VL. This could be due to the duration differences present between the short and the long vowels in Tamil language [9]. Thus, the present study showed that consonantal feature is performed better than the vowel features as opposed to the previous findings from literature, where vowels are identified better than the consonants which could possibly be due to the structure of the Tamil phonemes [5,8]. Along with this the spectral resolution of the formants are also needed for the identification of vowel contrasts which may be poorer in children with CI [11].

The significant difference in the performance at a presentation level of SRT + 20 dB between groups (group 1 and group 2) could be due to the fact that auditory functions improve till seven to eight years of age. Also, the auditory system gains more specificity in its performance with increase in age. Discrimination by Identification of Pictures (DIP) test compared the performance of children in the age range of three to eight years across intensities from 0 to 15 dB SL. The increase in intensity led to an increase in the performance and a similar trend was seen in the present study [12]. The differences in the performance between the presentation levels in both the groups could possibly be due to the increased availability of acoustic cues which help in better identification where more cues are available with increase in intensity levels and also the subtle changes are identified [6,12].

In the age groups included in the present study, it can be inferred that the better performance was noted by the seven year old children (group 2) followed by the six year old (group 1) and then the cochlear implantees (group 3). The results of the present study are in line with the previous studies, which states that the cochlear implantees perform poorer than the NH children [5,11,13,14]. This is due to the degraded speech output from the CI device. Studies which compared NH children's performance on closed set task on the same hearing age CI found that the vocabulary scores of the implanted children varies, but they can reach the expected results of their age matched NH peers [15,16]. Thus, children with CI are able to perform at similar level to that of hearing children in vocabulary tests, but this depends on certain variables that transcend their age at the time of implantation or even at the

time of insertion of the electrode. Literature reports that among all the factors which would transcend the performance, family participation in the rehabilitative process was shown to have critical importance in the child's vocabulary development and also in the use of oral language [17]. Evidence from the literature and the findings from the current study reveals that there is a relation between the chronological age of the typically developing children and the implant age/ hearing age of cochlear implantees [15,17]. Also, the speech feature category performance did not show a significant difference thus confirming the similarity in the performance between the two groups.

Another result of the study, showed a significant difference in the performance between group 2 and group 3. This is due to the development in the auditory functions which is reported to improve with age till seven to eight years and that the auditory system gains more specificity in its performance [12]. Thus, NH children perform better with increase in age [18]. Literature findings from various phoneme discrimination tasks/ studies also reveals that the performance of the children increased with increase in age [8,12].

This narrows down to a conclusion that the CI users make use of the cues in the frequency, time and intensity domain for the identification of vowels and consonants [19]. Moreover, the performance of the cochlear implantees is affected due to many factors and they can be categorised into intrinsic and extrinsic factors. Intrinsic factors such as cognition, previous use of hearing device, age at implantation plays a major role. Extrinsic factors such as the speech processing strategy, mapping and the implant type also play a role in the determination of their performance in the task of discrimination. The neural plasticity, cognition, auditory training and critical period for speech and language development should be focussed as this helps in understanding the probable variables influencing the performance of cochlear implantees [20].

Limitation(s)

The age group taken for the study was six to eight years, thus the administration of the test to younger and older age group children can be done to document their speech perception abilities. The number of participants included were limited.

CONCLUSION(S)

To conclude, it is of great value to assess the speech perception abilities and selecting a linguistically suitable test for young children. Therefore, the developed test tool helps to assess one of the aspects of speech perception (minimal pair word identification). The MPT-T test takes approximately 30 minutes to administer and it provides vital information about the child's ability to discriminate the minimal differences between the words and also helps in planning rehabilitative goals.

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