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Original Article

Development of Trisyllabic Word Recognition in Noise Test for Marathi-Speaking Children

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Abstract

Background Language and culture-specific speech perception tests help in the assessment of children's linguistic proficiency and comprehension. Recognizing difficulties in speech perception and implementing interventions in challenging auditory conditions are pivotal for their holistic development.

Objective The aim of this study was to develop a speech perception in noise test in Marathi using trisyllabic words for children between the age ranges of 3 and 6 years.

Method The study was conducted in two phases. The first phase comprised the development of trisyllabic word recognition in noise test in Marathi and the second phase comprised administration of the test on 90 typically developing normal hearing children aged 3 to 6 years. These children were divided into three groups (group A: >3–4 years; group B: >4–5 years; and group C: >5–6 years), with 30 participants in each group.

Results As the signal-to-noise ratio (SNR) increases, children across different age range show an improvement in their speech perception scores. Also, young children require a more favorable SNR compared with older children to effectively comprehend speech in noisy conditions.

Conclusion The Trisyllabic word recognition in noise test will help in optimizing classroom acoustics for typical developing and hearing-impaired children. An SNR-based evaluation can provide guidance regarding interventions, amplification decisions, and auditory training, ensuring effective education and communication for children with hearing impairment.

Keywords
- cochlear implant
- speech perception
- trisyllabic words
- signal to noise ratio

Introduction

Speech perception is crucial for children's language development, communication, and cognitive growth.[1] It involves auditory processing, phonemic awareness, lexical access, and interpreting spoken language sounds, enabling vocabulary, grammar, and communication skills acquisition.[1] This foundational skill aids in developing phonological awareness, vocabulary, syntax, grammar, and pragmatic skills.

Young children frequently encounter noisy and reverberant environments such as kindergartens, schools, playgrounds, and other daily settings. Given the substantial time children spend in these noisy surroundings, studying the impact of noise on their speech perception is highly relevant. Both typically developing, normal-hearing children and those with hearing loss face challenges in formal schooling and incidental learning due to noisy classrooms. Background noise reduces speech clarity and intelligibility, leading to increased cognitive effort, concentration and attention demands, listening fatigue, and reduced learning efficiency, ultimately hindering their ability to follow instructions. Younger children, compared with older ones, process speech less accurately and

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less efficiently in noisy conditions. Research indicates that children struggle more than adults to recognize speech in noise due to immature central auditory processing rather than an underdeveloped peripheral auditory system.[2–4] Children also find it harder to separate target speech from background noise and focus on important speech.[3,5,6] Assessing speech perception in noisy environments is essential for understanding children's real-life listening performance, as they spend a significant part of their daily activities in such conditions.[7]

In India, evaluating speech perception in children is challenging due to the limited availability of age-appropriate measures and the diverse multilingual environments children are exposed to. Researchers[8–10] have addressed this issue by developing speech perception tests in Indian languages like Hindi, Marathi, and Tamil. However, there is a continued need for tests tailored to specific age groups and languages, considering India's linguistic diversity. This is essential for accurate assessment, identifying speech perception disorders, and providing targeted interventions that align with children's cultural and linguistic contexts.[11]

In response, the current study aims to develop a speech perception test using trisyllabic words for children aged 3 to 6 years to evaluate speech perception in background noise effectively. The objectives of the study are the following: (1) to develop and assess the reliability of a trisyllabic word recognition in noise test for Marathi-speaking children; (2) to compare speech perception scores in noise at different signal-to-noise ratios (SNRs) within the age groups of greater than 3 to 4 years, greater than 4 to 5 years, and greater than 5 to 6 years; and (3) to compare speech perception scores in noise using trisyllabic words across these different age groups of typically developing children.

Materials and Methods

The study was a cross-sectional research. The study was conducted in two phases. The first phase comprised of development of trisyllabic word-in-noise test. The second phase comprised of administration of the test on 90 typically developing normal hearing children in the age range of 3 to 6 years. The current study was approved by ethics committee of Bharati Vidyapeeth (Deemed to be University) with REF:-BVDUMC/IEC/203 and was conducted in accordance with the university's ethical guidelines.

Development of Marathi Trisyllabic Word List

A collection of 109 trisyllabic words, specific to cultural contexts and represented through pictures, was gathered from sources such as nursery books, magazines, newspapers, and everyday conversations of 3- to 4-year-old children. To validate the content of both the words and pictures, three audiologists and speech-language pathologists with over 5 years of experience in the field were involved. These validators used a 2-point rating scale, where a rating of 0 indicated an incorrect trisyllabic word and 1 indicated a correct one. Among the trisyllabic words, 97 received unanimous "1" ratings from all the audiologists and speech-language pathologists. These were then subjected to a familiarity check to ensure that the selected words were part of the children's vocabulary.

For the familiarity check, 30 typically developing native Marathi-speaking children aged 3 to 4 years with normal vision acuity and corrected vision and normal hearing sensitivity were engaged. This task took place in a distraction-free, quiet environment. A female clinician presented the words orally for a picture identification task to assess familiarity. Words that achieved a correct identification score of 90% were considered familiar.

After the familiarity check, 57 trisyllabic words were chosen from the initial 97. These were then further categorized into a final list of 5, each list containing 20 words ensuring a balanced representation of consonants and vowels across low-, mid-, and high-frequency ranges, ensuring effective coverage.

Recording of the Stimuli

A native female Marathi speaker recorded trisyllabic words within a sound-treated room using Audacity software version 2.0. Additionally, recordings were made of classroom noise in different school situations.

Construction of Test

Using the MATLAB (MathWorks, United States) software, recorded word lists and classroom noise were merged at different SNRs and subsequently normalized. A total of five lists were created, each having varying SNRs including 0, 5, 10, 15, and 20 dB. These lists were then saved onto a compact disk (CD).

The test developed was titled as Trisyllabic word recognition in noise test in the Marathi language.

Administration of the Test

Participants

The study comprised a total of 90 typically developing children within the age range of 3 to 6 years. These children were divided into three groups (group A: >3–4 years; group B: >4–5 years; and group C: >5–6 years), with 30 children in each group. Children within the chronological age range of 3 to 6 years who were native Marathi speaker with normal hearing sensitivity, corrected vision, and no illness during testing were included in the study. Children with known history of cognitive and behavioral issues, neurological disorders, middle ear infections, and any other associated problems like sensory and motor issues were excluded from the study.

Procedure

Parents were given participation information sheet and written consent was obtained from the parents. For children whose parents provided consent for the study, a thorough case history was obtained through interviews with the parents, and otoscopy was conducted. Hearing screening for all children was done using a laptop-based hearing screening test using the Indian hearing test (IHS).[12] Children who passed the hearing screening were considered for the test.

Testing was performed in a quiet room with low ambient noise, that is, noise less than 35 dB sound pressure level (SPL). Adequate lighting conditions were provided in the test room to facilitate good visibility of the picture plate. Instructions regarding pointing pictures were given in the Marathi language before starting the test. A practice trial was given with few pictures to check any false-positive responses.

The trisyllabic word recognition in noise test was administered using a Lenovo (E49-3464) laptop connected to a JBL loudspeaker and positioned at a 0-degree azimuth angle. The output of the laptop through the speaker was measured using a sound level meter and the volume control was adjusted to ensure that the stimuli were presented at 65 dB SPL. Setup was arranged in a low ambient noise environment, with the loudspeaker situated 1 foot away from the listener. Closed set word recognition tasks were performed using four alternative forced choice method in which the child was presented with four pictures and the participants were instructed to point the picture of the target word. The target words were presented at 0-, 5-, 10-, 15-, and 20-dB SNR.

Responses were recorded on a scoring sheet for each child. A score of "1" was assigned for each correct response and "0" for incorrect responses. The scores were noted. The test–retest reliability was done for the developed test by administering the test again on 30% of the normal hearing children in each group after a week typically developing children in each group (n = 10) after one week.

Analysis

Statistical analysis was done using IBM SPSS Statistics version 25. An item analysis was performed using statistical software to check the internal consistency of the trisyllabic words. Data was evaluated for normality using a generalized Shapiro–Wilk test, revealing a non-normal distribution. Quantitative data were Descriptive statistics was represented using median and interquartile range. Statistical comparisons for speech perception scores in noise for three age groups were performed by the Kruskal–Wallis test. The Mann–Whitney *U* test was done to compare the speech perception scores between the groups. The Friedman test was used to check scores for different SNRs within the age groups. Subsequently, post hoc analysis was conducted to compare the speech perception scores among various SNR levels within each age group. A value of $p < 0.05$ was considered statistically significant.

Results

An item analysis was conducted to assess the internal consistency and reliability of the developed trisyllabic word recognition in noise test. Cronbach's α coefficient for the 57 words was determined to be $\alpha = 0.785$, indicating good internal consistency. Additionally, the intraclass correlation coefficient for all 5 lists were within the range of 0.88 to 0.9, indicating good reliability.

The test was administered on 90 typically developing children aged 3 to 6 years. Results revealed that speech perception scores exhibited improvement with increasing age within the 3- to 6-year age range, as shown in ►**Table 1**. Also, a statistically significant difference was reported in speech perception scores for different SNR levels among the three age groups: greater than 3 to 4 years, greater than 4 to 5 years, and greater than 5 to 6 years ($p < 0.05$). Additionally, when comparing speech perception scores between groups A and B, groups A and C, and groups B and C across varying SNR levels (0, 5, 10, 15, and 20 dB), statistically significant differences were noted ($p < 0.05$) between groups A and B and groups A and C across all SNR levels as shown in ►**Table 2**.

Table 1 Descriptive statistics across children aged 3 to 6 years at different signal-to-noise ratios (SNRs) (n = 90)

Age group (y)	dB SNR	Median (M)	Interquartile range (IQR)
>3–4 (n = 30)	0	10	2
	5	13	2
	10	15	1
	15	17	1
	20	18	1
>4–5 (n = 30)	0	12	3
	5	14	2
	10	16	2
	15	17	2
	20	18	1
>5–6 (n = 30)	0	13	2
	5	14	2
	10	16	2
	15	18	1
	20	19	1

Table 2 Results of Mann–Whitney *U* test to check the effect of signal-to-noise ratio (SNR) in typically developing children aged 3 to 6 years

dB SNR	Age group (y)	*W*	*p*
0	>3–4 & >4–5	722	0.004
	>3–4 & >5–6	710.5	0.002
	>4–5 & >5–6	907.5	0.910
5	>3–4 & >4–5	750	0.013
	>3- 4 & >5–6	696.5	0.001
	>4–5 & >5–6	868	0.477
10	>3–4 & >4–5	728	0.005
	>3–4 & >5–6	626.5	<0.001
	>4–5 & >5–6	812	0.116
15	>3–4 & >4–5	749.5	0.012
	>3- 4 & >5–6	666.5	<0.001
	>4–5 & >5–6	861.5	0.413
20	>3–4 & >4–5	761	0.018
	>3–4 & >5–6	650.5	<0.001
	>4–5 & >5–6	802.5	0.08

When comparing speech perception scores across SNR within the three groups, it was observed that the median scores increased with rising SNR ($p < 0.05$) for all age groups as shown in ►**Table 3**. Moreover, there was a statistically significant difference ($p < 0.05$) in speech perception scores across various SNR combinations within each age group, including 0 to 5, 0 to 10, 0 to 15, 0 to 20, 5 to 10, 5 to 15, 5 to 20, 10 to 15, 10 to 20, and 15 to 20 dB.

Discussion

The present study aimed to develop a trisyllabic word recognition in noise test for evaluating speech perception and establishing standard reference values among children aged 3 to 6 years. It is important to have a language-specific and culture-sensitive test to assess speech perception skills in their primary language, identifying speech and language disorders, and customizing intervention plans. The Individuals with

Table 3 Results of speech perception scores across SNR in children aged 3 to 6 years

N	Age range (y)	dB SNR	Chi-squared (χ^2)	df	*p*-value
30	>3–4	0	117.5	4	<0.001
		5			
		10			
		15			
		20			
30	>4–5	0	117.12	4	<0.001
		5			
		10			
		15			
		20			
30	>5–6	0	117.871	4	<0.001
		5			
		10			
		15			
		20			

Abbreviation: SNR, signal-to-noise ratio; N, no. of participants.

Disabilities Education Improvement Act (2004) mandates that all children be tested in their native language.[13] The American Speech-Language-Hearing Association (ASHA) also recommends upholding linguistic diversity within audiological practice. In Marathi language, as there was no test to assess trisyllabic word identification in the presence of noise in the pediatric population, there was a need to develop norms for age-specific trisyllabic word identification in noise. Unavailability of trisyllabic word recognition in noise test in pediatric population led to the development of this test, thus providing age specific norms. A test was designed with trisyllabic words as they are more complex than monosyllabic words; hence, it can assess a higher level of speech perception skills such as phonological processing, syllable segmentation, etc., and also provide greater contextual information. The test was designed at varying SNRs to determine the SNR at which typically developing children perform opimally. This would allow for a comparison of the hearing-impaired children's scores with normative values and discern regarding their performance.

The literature also supports development of a language- and culture-specific test to assess speech perception. Dawson et al[10] adapted the English version of early speech perception in Tamil language for children within the age group of 3 to 6 years. Similarly, Bhimte[8] developed a speech perception test in Hindi for young children aged 3 to 7 years, while Priya et al[14] developed a modified speech perception test in Kannada (MESP-K) for children in the age group of 2 to 5 years. Rout[15] also developed a speech perception test using monosyllabic words for children in the age group of 6 to 8 years.

In present study, Trisyllabic word recognition in noise scores improved significantly for various SNRs with increasing age. Our results agree with previous studies in the field.[10,16,17] Improvements in digits-in-noise test and standard digits-in-noise test scores have been reported with increasing age in children aged 4 to 12 years.[16] Additionally, the literature indicates that young children under the age of 5 years experience a decline in performance when exposed to noisy environments. They exhibited significantly poorer speech perception in noise compared with older children.[17] Similarly, consistent findings indicating a developmental progression of speech perception ability with age have been reported.[18] Younger children face challenges in noisy environments, which could be attributed to their ongoing development of auditory processing capabilities. The improvement in speech-in-noise scores with increasing age in children can be attributed to the dynamic interplay of auditory, cognitive, and linguistic development. As the auditory system matures, children become more adept at discerning speech sounds from background noise. Developing cognitive skills, including attention and working memory, contribute to better noise filtering and concentration on relevant auditory cues. Additionally, advancing language proficiency enables children to navigate and comprehend complex speech patterns, while exposure to diverse auditory environments refines their adaptive listening abilities over time.

In the present study, a significant impact of varying SNRs within the age groups of 3 to 4, 4 to 5, and 5 to 6 years has been reported, which indicated that scores improved as the SNR increased for all age groups. Consistent findings are present in the literature concerning children aged 5 to 12 years, demonstrating improved speech recognition as the SNR increases.[19] Similarly, a study involving 8- to 10-year-old children with English as a secondary language (ELS) reported reduced speech perception score in noisy environments.[20] Additionally, research has highlighted the impact of the SNR on speech perception, even in children with normal hearing.[21]

The improvement in scores with an increasing SNR in children of various ages indicates that better clarity in auditory signals leads to more efficient processing of speech.[19] Higher SNRs enhance speech perception in children across ages, aiding comprehension by mitigating the influence of background noise on their developing auditory and cognitive processes. These findings imply that a higher SNR promotes more effective communication by minimizing the disruptive effects of background noise on auditory processing.[21] This highlights the significance of optimizing acoustic conditions, especially in educational settings, to improve speech intelligibility and support better learning outcomes for children.

Summary and Conclusion

The trisyllabic word recognition in noise test was developed to evaluate speech perception in Marathi-speaking children aged 3 to 6 years, offering normative data for younger Marathi speakers. Trisyllabic word recognition in noise scores demonstrated improvement across SNR levels and with advancing age. Future research could investigate the speech perception abilities of children with hearing loss, aged 3 to 6 years, who use hearing devices such as hearing aids and/or cochlear implants. This SNR-based assessment could guide interventions, assist in amplification decisions, and facilitate auditory training, thereby enhancing education and communication for children with hearing impairment. The study did not consider potential environmental influences on speech perception, including factors such as socioeconomic status, educational history, or regular exposure to noisy environments in the participants' daily life.

Conflict of Interest
None declared.

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