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Original Research Article

Development of Hindi word identification in noise test for school aged children

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ABSTRACT

Background: Word identification in noise is crucial for effective communication in everyday environments. For children, the ability to identify words in noisy conditions directly impacts language development, learning, and social interaction. This study aimed to develop and standardize Hindi word identification in noise test for children (HWINT-C) and evaluate its performance among school aged typically developing children across varying SNR and word length.

Methods: The study included forty two participants which were further subdivided into subgroup one consisting of 22 typically developing children aged 6-7.11 years (SGI) and 20 typically developing children aged 8-10 years in subgroup two (SGII). Development of Hindi word identification in noise test for children (HWINT-C) involved multi-step processes including selection of words, familiarity rating, and content validation, internal consistency and test-retest reliability. The test included bisyllabic and monosyllabic words recorded by a native Hindi female speaker presented in eight-talker babble at +5 dB and +7 dB SNR administered diotically at 65 dB SPL.

Results: The developed HWINT-C in this study demonstrated to have high internal consistency and test-retest reliability. Typically developing children in the older group (SGII) significantly outperformed the younger group (SGI), Additionally performance improved with increasing signal-to-noise ratio (SNR) in both SGI and SGII, but no significant differences were found across word lengths.

Conclusions: The HWINT-C test is a reliable and valid tool for assessing word-in-noise perception in children. Age-related trend was observed, where performance improved with age, Similar findings were observed with increase in SNR, emphasizing need of favorable conditions in younger population.

Keywords: Babble noise, Signal to noise ratio, Word in noise

INTRODUCTION

Phonological and semantic processing are the two major mechanisms that constitute speech processing.[1] Phonological processing includes features of pitch, accent, and rhythm of speech. Semantic processing includes choosing the correct word for a specific concept, as well as recognizing the features and syntax of words in a sentence.[1,2] Young children are subjected to acoustically challenging environments that mainly comprises of background noise and reverberation, mostly in schools and playgrounds. They often struggle more than adults to understand speech when noise is present. However, this difficulty persists and speech recognition in noisy conditions continues to develop throughout childhood.[3] Determining the difference between noise and the speaker's speech requires a decade of listening experience. Since the maturation of the neural system of speech perception and its related areas continues until the age of 14, at younger ages, the ability to understand speech in noise is weaker than that of adults.[2] In addition, the cooperation of non-sensory and cognitive issues such as attention, memory, internal body sounds, and auditory programs are effective in creating differences between children and adults in the temporal processing of sounds.[4]

The developmental trajectory of children's speech-in-noise performance underscores the necessity of acoustically optimized learning environments to support their academic success. The recommended classroom signal-to-noise ratios (SNRs) of at least +15 dB including an ambient unoccupied noise level below 35 dBA to ensure intelligible speech for all learners.[5,6] Yet field measurements frequently revealed much lower SNRs in real classrooms or instance, an Indian study reported average occupied SNRs around +11.7 dB, well below recommended norms and some classrooms even recorded values below +10 dB.[7] Dubas et al investigated the performance of word recognition and discrimination in noise in preschool children. Their findings showed that the age factor and the characteristics of the words have a direct effect on the obtained scores. As the age of the child increases and the difficulty of the words decreases, the performance of speech recognition and discrimination improves.[8]

Various types of background noise can affect how well words are recognized, and researchers have examined different noise conditions to assess how resilient children's word recognition is in challenging listening environments. The characteristics of these noise types differ, white noise and babble noise, for instance, influence speech perception in distinct ways.[9,10] Babble noises, especially when made up of only a few voices, can cause what is known as informational masking.[9] The effect of informational masking on speech perception reduces as the number of competing speakers exceeds ten, as individual distracting signals reduces in ability to distinguish and therefore has less interference in the processing of target speech.[11] Research has highlighted the efficiency of babble noise as a competing noise as it disrupts immediate passage comprehension in normal-hearing children and closely replicates the acoustic conditions typical of preschool environments, such as daycare centers and playgrounds.[12]

Diverse multilingual environments in India impose challenges in the evaluation of speech perception in children due to the limited age-appropriate measures. Though researches have answered this gap by developing standardized speech perception tests in many Indian languages there is still a need to develop tests specifically for different age groups and other languages. This will help in identification and planning of intervention in various linguistic contexts for children with speech perception disorders. The present study aimed to develop Hindi word identification in noise test among children aged 6-10 years. The objectives of the study are to evaluate psychometric properties of developed Hindi word identification in noise test for children aged 6-10 years followed by evaluation of the performance of Hindi word identification in noise test among children across age and gender and subsequently varying signal to noise ratio and word length.

METHODS

An analytical cross-sectional research design was used for the present study. The study was done on a defined population of typically developing children aged 6-10 years who visited Sri Aurobindo Institute of Medical Sciences, Indore, Madhya Pradesh over a 2-month period of February 2027 to May 2027. The present study was conducted in two phases. First phase comprised of development of Hindi word identification in noise test for children (HWINT-C) and second phase involved administration of HWINT-C on the selected participants.

Phase I: Development of Hindi word identification in noise test for children (HWINT- C)

A total of 110 monosyllabic and bisyllabic, represented through picture words were collected from Hindi primary and kindergarten textbooks. These list of words were then subjected to content validation by five speech language pathologist with an experience of at least five years based on three parameters: ambiguity, clarity and appropriateness on a 3-point rating scale. From the preliminary word listed 32 monosyllabic and 37 bisyllabic (total 69) words rated as "3" by the validators were subjected for familiarity rating. The listed 69 words were given for familiarity ratings to ten parents of typically developing children aged 6-10 yrs. Parents were asked to rate the familiarity of the words on a 3 -point rating scale (1- not familiar, 2-familiar, 3- very familiar). The words that were rated as 'very familiar' by at least 80% of the raters were selected for inclusion in the word lists. Following familiarity rating, twenty seven monosyllabic words and 25 bisyllabic words selected and distributed into two lists: list A included 20 bisyllabic words; list B included 20 monosyllabic words. The remaining words were listed as trial words for use during the administration of the test.

Recording and construction of test

Speech samples of five native adult Hindi speakers (5 females) with no complaints of speech and voice disorder were recorded in a sound-treated room. The speaker was instructed to maintain a distance of 20 cm13 during sample recording. The recorded speech samples of all the speakers were validated by five speech language pathologists based on voice projection, speech intelligibility and clarity on a 3-point rating scale. The female speaker who received the highest ratings was chosen for the recording of the test material. Consequently, the speaker recorded the listed monosyllabic and bisyllabic words, maintaining a constant loudness and without dialectal variations using Audacity software version 3.5.1. Additionally, a 8-talker babble noise was also generated by recording paragraph reading sample from Hindi newspaper by eight adult native Hindi speakers simultaneously over a round table seating with microphone placed at a distance of 30 cm.[14]

The recorded monosyllabic and bisyllabic words, were then digitized at a 44.100 kilohertz (kHz) sampling frequency and 16-bit resolution. The recorded word lists were filtered to ensure removal of any noise present in the recordings. Each word was equalized to the average root mean square (RMS) amplitude using Audacity software version 3.5.1 to maintain the signal-to-noise ratio (SNR) of +5 dB and +7 dB. Thus, bisyllabic word list of +5 dB and +7 dB was denoted as A1 and A2 respectively and monosyllabic word list of +5 dB and +7 dB was denoted as B1 and B2 respectively. Generation of the final version of Hindi word in noise test maintained an interstimulus interval of five seconds and was named as Hindi word identification in noise test for children (HWINT- C).[15]

Phase II: Administration of Hindi word identification in noise test for children (HWINT- C)

Participants

The study comprised of a total number of 42 typically developing children in the age range of 6 to10 years. The participants were further divided into two subgroups: subgroup I (SGI) included 22 typically developing children aged 6 to 7.11 years with mean age 6.62 years (SD=0.51); subgroup II (SGII) comprising of 20 typically developing children aged 8 to 10 years with mean age of 9.44 years (SD=0.62). All children included in the study were native Hindi speakers aged 6 to 10 years. Children with known history of delayed motor milestones, neurological impairment, intellectual disability, seizure disorder and other primary diagnosis of attention deficit hyperactive disorder, autism spectrum disorder and hearing impairment were excluded from the study.

Procedure

Written consent was taken from the primary caregivers for participation in the study after explaining the procedure. Demographic details and a detailed case history were collected from children who gave consent for the test. All the participants underwent speech and language screening followed by an otoscopic examination. Hearing screening was conducted using a screening audiometer at 20 dB HL for frequencies 1000 Hz to 4000 Hz for both ears (ASHA 1997).[16] Further Screening checklist for Auditory processing (SCAP) was administered by interviewing parents/caregivers.[17] Children who passed the hearing screening and showed an age-appropriate speech and language skills were considered for the study.

Testing for the study was carried out in a well- lighted audiometric room with permissible noise limits according to ANSI specification [ANSI/ASA S3.1-1999 (R2018)].[18] All the children were comfortably seated on a chair, with calibrated loudspeakers placed at 1-meter distance and 0-degree azimuth. Instructions on mode of response were provided to the participants in Hindi language followed with a practice trial prior to the conduction of the test.

The Hindi word identification in noise test for children was routed from a laptop to the audiometer through 3.5 mm RC cord and presented diotically through calibrated loudspeakers placed at 1-meter distance and 0-degree azimuth at presentation level of 65 dB SPL. The pattern of presentation was ordered as list A1 (bisyllabic words at +5 dB SNR), list B1 (monosyllabic words at +5 dB SNR) followed by list A2 (bisyllabic words at +7 dB SNR) and List B2 (monosyllabic words at +7 dB SNR). The word list was randomized to avoid learning effect. Correct score was considered only for whole-word repetition. Word identification in noise task was done with responses through four alternative forced choice method in which the child was instructed to point to the target word.

Each correctly identified word was scored as 1 and incorrect word as 0. All the scores were documented in the score sheet provided in the developed test. List-wise total scores were calculated for all the word lists. The test-retest reliability was done by administering the developed test again after 15 days on 10 typically developing children of each subgroup.

Statistical analysis

Statistical analysis was done using IBM SPSS Statistics version 23 and the normal distribution of variables was confirmed by the Shapiro-wilk test. Internal consistency of the developed lists was assessed using Cronbach’s alpha and intraclass correlation coefficient was performed to check test-retest reliability. Multiple comparisons of the variables were checked by the Mann Whitney test and the significance level was less than 0.05. Wilcoxon signed rank test was administered to compare performances across varying SNR and word length within SGI and SGII. Linear regression analysis was done to predict effect of age on list-wise mean total scores.

RESULTS

Cronbach’s alpha coefficient of all the four lists was determined to be within a range of 0.772 to 0.892 indicating high internal consistency. Additionally, the intraclass correlation coefficient for all the four lists ranged within 0.793 to 0.891 indicating a high test-retest reliability.

Performance of HWINT-C across age and gender

Results revealed that word identification in noise scores showed significant improvement with increasing age in all the developed four lists of HWINT-C i.e. higher scores was noted in SGII when compared to SGI (Table 1). Further no significant difference was found in word identification in noise scores across gender.

Table 1: Descriptive statistics and results of Mann Whitney U test across age.

Age group	List	Mean	Median	SD	P value
SGI	A1	12.63	12.00	0.71	0.000
SGII		17.00	17.00	1.84	
SGI	A2	17.04	17.00	0.70	0.000
SGII		19.25	19.00	1.21	
SGI	B1	12.70	12.00	0.50	0.000
SGII		16.50	16.00	1.59	
SGI	B2	16.30	16.00	0.71	0.000
SGII		19.30	19.00	1.18	
SGI	List A (A1+A2)	14.84	15.00	2.34	0.000
SGII		18.12	19.00	1.95	
SGI	List B (B1+B2)	14.72	14.50	2.16	0.000
SGII		17.92	18.00	1.99	

P is significant at level of 0.01.

Table 2: Results of Wilcoxon signed rank test examining performance across signal to noise ratio across age.

SNR	Age group	Z value	P value
List A1 and List A2	SGI	-4.24	0.000
	SGII	-3.95	0.000
List B1 and B2	SGI	-4.15	0.000
	SGII	-3.99	0.000

P is significant at level of 0.001.

Table 3: Results of Wilcoxon signed rank test examining performance across word length across age.

Word length	Age group	Z value	P value
List A1 and B1	SGI	-0.471	0.637
	SGII	-0.045	0.045
List A2 and B2	SGI	-2.95	0.003
	SGII	-0.564	0.564

P is significant at level of 0.001.

Performance across SNR and word length

Results revealed there was a significant difference across SNR (bisyllabic and monosyllabic words at +5 dB SNR and +7 dB SNR denote as A1, A2, B1 and B2 respectively) in both groups SGI and SGII i.e. word identification in noise scores were better at higher SNR (+7 dB SNR) for both the groups, SGI and SGII (Table 2), while no significant differences were observed across word length i.e. bisyllabic and monosyllabic words identification in noise scores were similar for both groups (Table 3).

Additionally, the findings of linear regression analysis suggested a strong significant positive effect of age on developed HWINT-C list-wise scores indicated by high R2 ranging from 0.660 to 0.776 (Figure 1). At +5 dB SNR (A1 and B1), word identification in noise scores increased by 1.44 and 1.34 units per year of age, respectively. At +7 dB SNR (A2 and B2), the increases were 0.82 and 0.91 units per year, respectively (Figure 1).

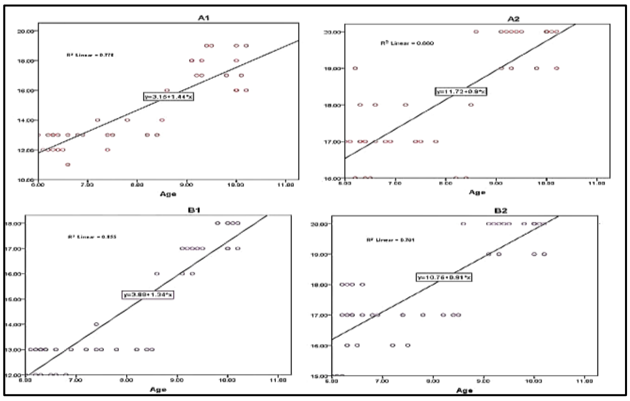

Figure 1: Regression analysis curve for lists of HWINT-C.

DISCUSSION

The present study included development of Hindi word identification in noise test for children, the developed test consisted of 2 lists list A and list B consisting of 20 bisyllabic and 20 monosyllabic words in each list presented at +5 and +7 dB SNR naming A1, A2, B1, B2. The test was administered on typically developing children aged 6-10 years and further reliability measures revealed strong internal consistency and good test-retest reliability for all the 4 lists. Therefore, the findings of the present study suggested the developed Hindi Word Identification in Noise Test in children is a valid and reliable test, these findings aligned with previous studies aimed at developing word in noise test.[19,20]

Performance on the Hindi word identification in noise test was evaluated across typically developing children aged 6 to 10 years, divided into two subgroups: SGI (6-7.11 years) and SGII (8-10 years), findings of the present study suggested improvement in performance with increase in age. In a similar course of study Disha and Sharda investigated monosyllabic word perception in noise among Marathi-speaking children across a range of of SNRs including 0 dB SNR, +5 dB SNR, +10 dB SNR, +15 dB SNR and +20 dB SNR in children aged 3 to 6 years and reported a consistent improvement in word recognition scores with increasing SNR across all age groups including 3-4 years, 4-5 years, 5-6 years.[21]Age-related improvement in word in noise abilities have been reported in similar studies.[19,22,23]

While differences in overall performance were observed between SGI and SGII with latter performing better, no gender-based differences were found within either group suggesting word in noise performance is not influenced by gender rather other factors which aligned with findings of similar previous studies.[15,23]

Performance improved with increase in SNR indicating need of favorable conditions especially observed in younger children. A steep improvement in word recognition was observed in the SGI group at +7 dB SNR, whereas the SGII group demonstrated more gradual and stable performance across both SNR levels (see Figure 1). Pathak and Nanavati, examined trisyllabic word recognition in noise among children aged 3 to 6 years across 0 dB SNR, +5 dB SNR, +10 dB SNR, +15 dB SNR, findings showed notable larger increase in performance +10 dB SNR, compared to +5 dB SNR, particularly among the younger children.[22] These findings support the notion that word perception in noise improves with age, likely due to greater auditory and cognitive maturity. Similar trends have been observed in other studies.[21]

No differences were observed across word length that includes bisyllabic and monosyllabic word identification in noise, this finding was contraindicated by similar study done.[24,25] However a possible reason could be due to SNR chosen in present study as the differences are more prominent at negative SNRs, additionally words familiarity and increased attention towards the task could also be hold responsible for these findings.[24]

The word in noise test developed in the present study lacks a set of words in quiet, availability of both words in quiet and noise would have availed a better comparison and comparison of the performances to adults could not be stated due to unavailability of adult performance scores on the test developed in the present study.

CONCLUSION

The present study demonstrated a clear developmental trend of improved word identification in noise among typically developing Hindi-speaking children. This improvement is consistent with existing literature and is primarily attributed to auditory maturation and cognitive development, particularly tolerance-fading memory. Additionally, the study emphasizes the importance of favorable listening conditions most notably higher signal-to-noise ratios (SNRs) in enhancing word identification performance. While SNR showed a positive influence, no conclusive trend was observed with word length in the current study, suggesting an area for further investigation. This developed word in noise test for Hindi speaking children aged 6-10 years will serve as a measure of their performance of word identification in noise which will help in better understanding of speech perception in daily life situations and will also help to estimate their academic performance in noisy classroom situations by assessing their word perception abilities in noisy situations. Additionally, this developed test will be helpful in catering disordered population and planning appropriate rehabilitation goals.

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REFERENCES

1. Emami SF. The use of homotonic monosyllabic words in the Persian language for the word-in-noise perception test. Aud Vestib Res. 2024;33(1):28-33.
2. Emami SF, Momtaz HE, Mehrabifard M. Central auditory processing impairment in renal failure. Indian J Otolaryngol Head Neck Surg. 2023;76(1):1010-3.
3. Koopmans WJA, Goverts ST, Smits C. Speech recognition abilities in normal-hearing children 4 to 12 years of age in stationary and interrupted noise. Ear Hear. 2018;39(6):1091-103.
4. Emami SF, Shariatpanahi E, Gohari N, Mehrabifard M. Word-in-noise perception test in children. Egypt J Otolaryngol. 2024;40(1):64.
5. American Speech-Language-Hearing Association (ASHA) Working Group on Classroom Acoustics. Guidelines for addressing acoustics in educational settings. Lang Speech Hear Serv Sch. 2005;36(3):221-9.
6. British Association of Teachers of the Deaf. Classroom acoustics: Recommended standards.

London, UK: British Association of Teachers of the Deaf; 2001.
7. Saravanan GS, Selvarajan HG, McPherson B. Profiling Indian classroom listening conditions in schools for children with hearing impairment. Noise Health. 2019;21(99):83-95.
8. Dubas C, Porter H, McCreery RW, Buss E, Leibold LJ. Speech-in-speech recognition in preschoolers. Int J Audiol. 2023;62(3):261-8.
9. Phatak SA, Allen JB. Consonant and vowel confusions in speech-weighted noise. J Acoust Soc Am. 2007;121(4):2312-26.
10. Phatak SA, Lovitt A, Allen JB. Consonant confusions in white noise. J Acoust Soc Am. 2008;124(2):1220-33.
11. Freyman RL, Balakrishnan U, Helfer KS. Effect of number of masking talkers and auditory priming on informational masking in speech recognition. J Acoust Soc Am. 2004;115(5):2246-56.
12. Brännström KJ, von Lochow H, Åhlander VL, Sahlén B. Immediate passage comprehension and encoding of information into long-term memory in children with normal hearing: the effect of voice quality and multitalker babble noise. Am J Audiol. 2018;27(2):231-7.
13. Wong LL, Zhu S, Chen Y, Li X, Chan WM. Discrimination of consonants in quiet and in noise in Mandarin-speaking children with normal hearing. PLoS One. 2023;18(3):e0283198.
14. Ghosh V, Devananda D, Harisanker SB, Kumar H. Speech perception in noise in Malayalam speaking young adults with normal hearing. J Hear Sci. 2024;14(2):33-8.
15. Yathiraj A, Vanaja CS. Age-related changes in auditory processes in children aged 6 to 10 years. Int J Pediatr Otorhinolaryngol. 2015;79(8):1224-34.
16. American Speech-Language-Hearing Association. Guidelines for audiologic screening. ASHA. 1997;39(Suppl 17):19-26.
17. Vaidyanath R, Yathiraj A. Screening checklist for auditory processing in adults (SCAP-A): development and preliminary findings. J Hear Sci. 2014;4(1):27-37.
18. Acoustical Society of America. Acoustical performance criteria, design requirements, and guidelines for schools (ANSI/ASA S12.60-2010/Part 1). American National Standards Institute; 2010. Available at: https://acousticalsociety.org/classroom-acoustics/. Accessed September 5, 2025.
19. Rahman TTA. Development and standardization of Arabic words in noise test in Egyptian children. Int J Pediatr Otorhinolaryngol. 2018;108:1-7.
20. Lotfi Y, Salim S, Mehrkian S, Ahmadi T, Biglarian A. The Persian version of words-in-noise test for young population: Development and validation. Aud Vestib Res. 2016;25(4):194-200.
21. Disha BR, Sharda AS. Development of speech perception test in noise for young Marathi-speaking children. J Indian Speech Lang Hear Assoc. 2024;38(2):122-7.
22. Pathak A, Nanavati N. Development of trisyllabic word recognition in noise test for Marathi-speaking children. J Health Allied Sci NU. 2025;15(Suppl 1):S11-6.
23. Mamatha NM, Yathiraj A. Variation in speech perception in noise as a function of age in typically developing children. J Indian Speech Lang Hear Assoc. 2019;33(1):32-7.
24. Liu HH, Liu S, Li Y, Zheng ZP, Jin X, Li J, et al. Effects of noise competition on monosyllabic and disyllabic word perception in children. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2017;52(5):349-54.
25. Talarico M, Abdilla G, Aliferis M, Balazic I, Giaprakis I, Stefanakis T, et al. Effect of age and cognition on childhood speech in noise perception abilities. Audiol Neurootol. 2006;12(1):13-9.

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