Aud Vest Res (2016);25(4):194-200.

RESEARCH ARTICLE

The Persian version of words-in-noise test for young population: development and validation

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Received: 7 Aug 2016, Revised: 20 Aug 2016, Accepted: 2 Sep 2016, Published: 29 Nov 2016

Abstract

Background and Aim: Different tests have been developed to evaluate reduced ability of speech perception in noise, and the words-in-noise test is one of the easiest ones in terms of speech materials. This study aimed to develop and determine the validity and reliability of the Persian version of the words-in-noise (WIN) test for 7 to 12-year-old children.

Methods: This research is a tool-making, non-empirical study including three main stages: first, development of the Persian version of the WIN test (including 2 lists each one designed at each of 7 different signal to noise ratios), second, the assessment of its content validity, and third, its administration on sixty three 7-to 12-year-old normal hearing children (36 boys and 27 girls) with a mean age of 9.32 (SD=1.66) years old, in order to assess the reliability of the test (list equivalency). Participants were selected from the students of primary schools in Tehran.

Results: The content validity ratio for each item was above 0.62. List 1 and 2 of the WIN test were highly correlated ($p<0.05$). The test-retest correlations were statistically significant for both lists ($p<0.05$). There was no significant difference between the scores of the left and right ears and gender ($p>0.05$). The Mean of speech in noise ratio (SNR) 50% for each list was also determined.

Conclusion: Based on the study results, it is concluded that the Persian version of the WIN test has acceptable content validity and reliability and can be used in clinical and research studies.

Keywords: Speech perception in noise; words-in-noise test; validity; reliability

Introduction

Speech perception in noise depends on top-down mechanisms such as cognitive and language processing as well as bottom-top mechanisms like auditory reception [1,2]. Noise functions not only as a perceptual masker but also as an important distracter, which has disruptive effects on every individual especially on children [3]. Moreover, students' attention and concentration might be affected by high level of noise in classrooms [4]. Presenting the speech stimuli in silence shows no difference in the auditory function of children and adults, but in noisy environment, children have more difficulty in speech perception than adults [5].

Most children, who encounter difficulties with speech perception in noise, are under the age of 15, because cognitive resources are not recruited automatically for speech understanding and

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Table 1. The content validity ratio (CVR) for 118 monosyllabic words based on ten Specialists judgment

CVR	Number of words
1	37 (31.3%)
0.8	14 (11.8%)
0.62	54 (45.7%)
0.4	9 (7.9%)
0.2	4 (3.3%)
Total	118 (100%)

their auditory brain structure has not completely developed yet. They also have less ability to use spectro-temporal and spatial cues than adults for separating the target from noise. Various studies have demonstrated destructive effects of noise on speech perception in younger children [3]. The estimation of World Health Organization (WHO) for allowable noise level in classrooms is less than 35 dBA [5]. However, studies reported that the level of noise in classrooms in primary schools is 60 dBA [6,7].

Considering that information in educational settings such as schools are mostly presented orally, listening in suitable situations is very important for academic achievements [3], therefore, educational audiologists need to rely on sensitive, helpful and efficient measurement tools to evaluate behavioral effects of the classroom noise on speech perception [6,7].

There are a lot of tests for evaluating the speech perception in noise in children [8] which assess the child's performance in noisy environment by reducing language redundancy. Word-in-noise (WIN) test is an adaptive perceptual test that was developed by Richard Wilson in 2003 to measure adults' speech understanding in a background of babble noise. They used Northwestern University Auditory test No. 6 (NU.6) monosyllabic words, presented at multiple signal to noise ratios (SNRs) to generate a psychometric function from which the 50% point can be calculated with Spearman-Kärber equation [9-13].

Since the primary school stage is a foundation for other levels of education, and first learning experiences are gained during this period, and as according to Iranian Supreme Council of Education age of entry to primary school is the exact six years old, this study was conducted on school children aged 7-12 years old.

Methods

This study is a tool-making, non-empirical research including three main stages: development of the test, assessment of its content validity, and administration of the test on a sample of 7-12-year-old children in order to check the reliability of the test. At the first step, 118 monosyllabic words which were most frequent and prevalent among average age group of 7-12 were chosen to prepare the test. We selected the appropriate words, for each age group from the "Basic Farsi vocabularies of the Persian speaking children" [14].

This book is the outcome of a four year research project at national level in which most frequently used words by children in primary schools have been collected and standardized. Afterwards, in order to determine its content validity, the word lists were given to 10 experts including audiologists, speech therapists and linguistics. They determined the appropriateness of the selected words using Lawshe questionnaire (using following options: important and relevant, no need/not important but can be used, not relevant and unimportant).

Content validity ratio (CVR) was used for each monosyllabic word. The CVR is a suitable method for omitting or selecting the test options. Schipper [15] has designed a table in which the minimum acceptable CVR from statistical point of view is shown proportional to the number whom of specialists review the validity. Based on this table, ratio of 0.62 is acceptable for 10 specialists. In this stage 107 words obtained higher ratio than the acceptable amount (Table 1).

Afterwards, all confirmed words were recorded by a female talker familiar with phonetics (on the basis of test guidelines) in an acoustic studio [16], consequently, they were converted from

MP3 to wave with Wave pad sound Editor software, and then were normalized under dynamic compression condition by Sound forge100 on the level of the average RMS of -25 dB with attack and release time of 200 ms.

In the next step, for determining the words difficulty in noise, we conducted a pilot study for three times (once on 10 adults with mean age of 25.3 years old and twice on children with the age range of 7-12 years old). The mean difficulty of the words was determined using. Mean ± 1.96×SD formula according to which the maximum and minimum acceptable scores for the words were 11.7 and 5.5, respectively. Due to these amounts, all the words were classified in three levels of easy, acceptable and difficult. When the words were between 5.5 and 11.7 scores they were considered as suitable, less than 5.5 as easy and words with scores higher than 11.7 were classified in the difficult category.

Of these words, only 49 words obtained convenient scores. Considering the limitation of children words, we had to select some words from the easy and difficult categories which their means were close to the maximum and minimum limits.

Fifteen words were omitted from the total as some of the words were easier or more difficult than what was appropriate for children. Finally, 92 words remained which based on the stated criteria, 70 monosyllabic, phonetically balanced words were selected and then were randomly distributed into two lists so that each one includes 35 words in 7 signal to noise ratios (SNR) decreased by 4 steps. In each list, easiest words were considered for higher SNR and other words were distributed randomly to other ratios.

In the next step, for developing the test, the final selected words were mixed with babble noise including six speakers (three women and three men) which were talking simultaneously about different matters so that it was not understandable [16,17]. Its intensity was set equal to -25 dB average RMS and the words were placed in each SNR using Sound forge100 software, and 2.7 seconds intervals were considered for each babble noise.

Afterwards, we performed the test monaurally with a laptop on which Sound forge 100 software was running. In order to familiarize the children with the words, we presented the word lists to one ear without any babble noise, then the lists were presented to the opposite ear in the presence of babble noise, and children were asked to repeat aloud after listening. To prevent learning effects, the order of the words in list presented in quiet is different from the order of the words in list that is presented in noise.

Furthermore, in order to familiarize children with the words and also to save the test time, with the help of project consultant, we depicted all words for younger and cochlear implanted children.

For accurate presentation of the words at each of 7 SNRs from +24 to 0 dB SNR in 4 dB decrements in the babble noise at the constant level of 60 dB HL, the output level of HP laptop (Pavilion dv3-4305se entertainment) and the connected circumaural headphone (Philips) were calibrated using sound level meter (SLM) analog 1.3 octave band (B&K, Denmark) and the maximum output of the laptop was set on 50% and software output in 89.02%.

After obtaining written consent from parents of children who met the inclusion criteria, we performed the otoscopic examination and conventional pure tone audiometry (PTA). Inclusion criteria were being in the age range of 7 to 12 years old, normal hearing in both ears (mean PTA threshold less than 25 dB with less than 10 dB difference in mean PTA), normal tympanic membrane with no infection in external and middle ear, being a monolingual Persian speaker, right-handedness (according to Edinburg), no history of psychological disorder, epilepsy, head trauma and surgery.

In case of unwellingness to continue the cooperation, they were omitted from the project.

Children were instructed to repeat any word they heard. All responses were recorded and each list was scored based on the number of correct responses at each SNRs, the SNR 50% score was calculated using the following equation: “50%= i+1/2 (d)–(d) (#correct)/(w)” in which: i= the initial presentation level (+24)

Table 2. The distribution of age and sex of children

	Age (years)					
Sex	7	8	9	10	11	12
Girls	6	6	5	5	4	1
Boys	6	4	8	4	8	6
Total	12	10	13	9	12	7

SNR, d= the size of decrement step (4), w= the number of words (5words) in each step, and the term correct shows the number of words that were repeated correctly in each list [18,19].

The developed test administered on sixty three 7-12 year old normal Persian speakers (36 boys and 27girls), who have been selected by convenience sampling from primary school children.

To test the reliability, two to four weeks after the first test run, retest was carried out by the same examiner on two children of each age group (total were 12) and we compared the results of test-retest. With regard to all ethical considerations approved by the Committee of Social Welfare and Rehabilitation Sciences University Graduate Studies, all the participants signed the written consent to enter the research.

Tests were performed with no charge and if any abnormality in basic auditory evaluation was noticed, the case was referred to a specialist for further evaluations. In the present study, findings were described using mean and standard deviation. The assumption of normality was checked with Kolmogorov-Smirnov test. Likewise, to assess the content validity of test materials Lawshe method was used.

The test-retest correlation was calculated by intraclass correlation coefficient (ICC) and to compare the mean score between right and left ears, and between genders, paired t-test and independent t-test were used, respectively. To check the equivalency between the two test lists, initially we obtained SNR 50% score for each list and then the scores were compared by Pearson correlation coefficient. For observing the development process in different age groups, the mean of SNR 50% of each list was analyzed and compared using one-way ANOVA between age groups. We used SPSS 21 and significance level of $p<0.05$ for all data analysis.

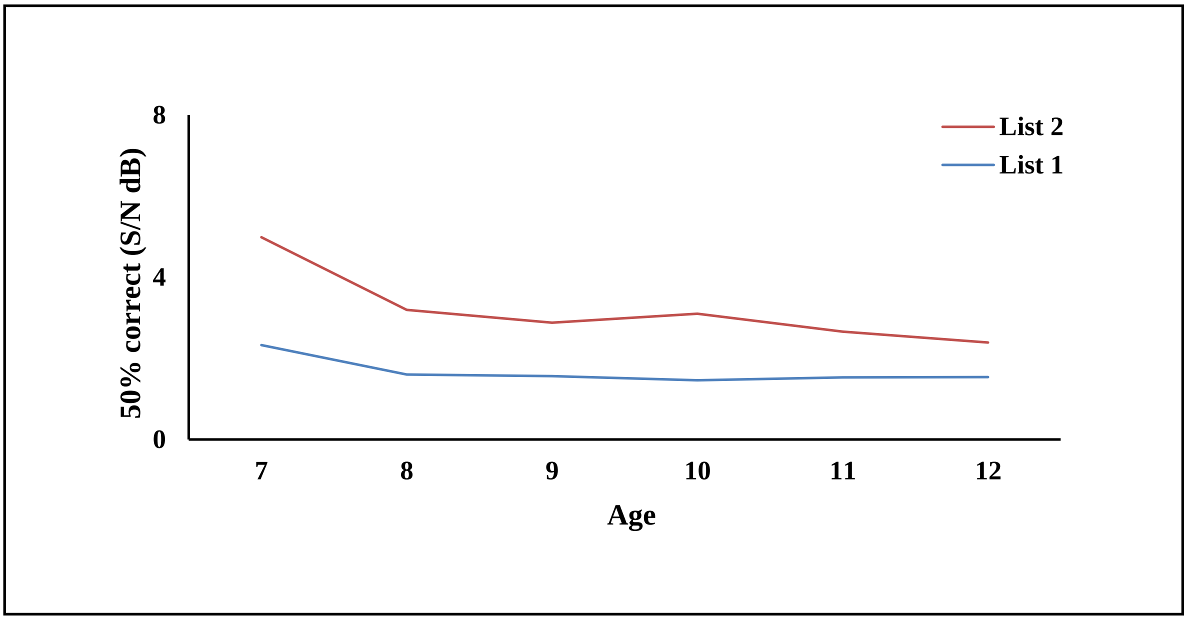

Fig. 1. Reduction of mean word-in-noise signal to noise ratios 50% scores for both lists I and II with increasing age.

Table 3. Mean (standard deviation) word-in-noise signal to noise ratios 50% scores in the right and left ears

	Mean (SD)		
	Right ear	Left ear	p*
Word-in-Noise SNR 50%	30.54 (1.73)	30.41 (2.12)	0.600

*Paired t-test

Table 4. Mean (standard deviation) word-in-noise signal to noise ratios 50% scores in girls and boys

	Mean (SD)		
List	Girls (n=27)	Boys (n=36)	P*
1	1.31 (1.50)	1.88 (1.38)	0.123
2	1.58 (1.68)	1.57 (1.62)	0.986

*Independent sample t-test

Results

This research was conducted on 63 normal children with 7-12 years of age (Table 2).

Table 1 shows the content validity ratio (CVR) of all options in term of the number of specialists (higher than 0.62) and content validity index (CVI) of each list that was higher than 0.8.

The mean of SNR 50% of list 1 was equal to 1.64 dB (SD=1.44) and for list 2 was 1.58 dB (SD=1.63). The relationship between 2 lists SNR 50% was statistically significant (r=0.53, p=0.001).

Comparison of the mean score of SNR 50% between age groups indicated that by increasing the age, SNR 50% of each list decreases (Fig.1).

There was no statistically significant difference (p>0.05) between the mean scores of right and left ears in participants (Table 3) and between boys and girls (p>0.05) (Table 4).

There was a significant correlation between test-retest scores of the 2 lists (p<0.05). Mean score of SNR 50% of list 1 in retest (on 12 persons) was 0.8 (SD=1.2), in list 2 was 1.2 (1.5). This amount in the first test with the same number of participants in list 1 was 1.46 (SD=1.9), and in list 2 was 1.86 (SD=1.86), that showed significant correlation (p<0.001 in both list).

Discussion

All of the above mentioned test materials had acceptable validity. In this research, word recognition scores decreased with the reduction of speech in noise (SNR). This result was consistent with Wilson et al. conducted on normal hearing children aged 6 to12 [9], and with Emami which was carried out on normal hearing Persian speakers in the age range of 7 to 10 years old using white noise in ratios of +5 and +10 [20]. Likewise, as in Wilson et al. our results showed improvement in SNR 50% with increasing age. Additionally, both studies demonstrated a relative stable performance in word recognition of children aged 9 to 12 years old [9]. In their study the mean of list 1 was 7.2 dB SNR (SD=2.5) and of list 2 was 6.9 dB SNR (SD=2.3) [9]. It is probable that the differrence between the mean score of our lists and Wilson's is due to the linguistic differences in the test materials, differences in mother tongue and the easiness of materials in our study. They also used the adults list for children, whereas, in the present study the list of words was standardized for children aged 7-12. According to Wilson et al. studies, the 50% point of word-in-noise test in adults was 2.7 to 6 dB SNR [10,16]. However, in Iran, no study has been conducted on adults.

In this study, there was no relationship between word-in-noise test scores and gender. This finding is consistent with Emami study in which both sexes showed comparable perceptional performance [20].

Moreover, in the present study there were no significant differences between mean scores of right and left ear as Emami, this test has not been investigated in other studies.

Equivalency assessment across word lists showed that the two lists were equivalent (r=0.53). Wilson and et al used Pearson correlation coefficient for three monosyllabic word lists. The Pearson correlation coefficient between list 1 and 2 was equal to 0.62 (p<0.001) and between list 1 and 3 was 0.74 (p<0.001), words in list 3 and list 1 were identical but the order was different [9].

The test-retest assessment showed that the reliability of word-in-noise was acceptable ($p<0.001$). In McArdle and Wilson, test-retest reliability of word-in-noise test across inter and intra test session was also tested in two experiments. The first test protocol included 70 words-in-noise which was conducted on 315 individuals with mild to severe hearing loss in two separate sessions with an interval of 12 months (ICC=0.88) [19].

In the second experiment, intra and inter session retest reliability for two word-in-noise test protocols, each containing 35 words, was assessed on 96 individuals, 48 of whom with mild to severe hearing loss and 48 with moderate to severe hearing loss. ICC for the first group was 0.89 and for the second one was equal to 0.91. Finally, it was demonstrated that both 70 and 35 versions of word-in-noise test are consistent and stable and reliable for evaluation word perception in various degrees of hearing loss [13].

It is recommended that future research should be conducted to determine norms of this test in different age groups and its sensitivity and specificity in diagnosis of disorders such as auditory processing disorder (APD), learning disability and so on.

Conclusion

According to these findings, it seems that word-in-noise test has acceptable reliability and validity if conducted on 7-12 year old children, and could be used as a noninvasive instrument in clinical and research settings for evaluation of speech in noise perception and central auditory processing.

Acknowledgements

This paper is extracted from S. Salim's MSc thesis in Audiology submitted in University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. We would like to thanks to Najmeh Ghanbary and Mohammadreza Nikkhoo for cooperation in recording of the materials in Imam Jafar Sadegh studio.

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