Research Article

The Reliability and Equivalency of the Persian Version of Quick Speech-in-Noise Test in 7-12-Year-Old

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Highlights

- The Q-SIN test cannot use for 7–8-year because of indistinguishing APD from normal
- The least mean SNR loss belongs to participants who were 11-12- year old
- It is recommended that Q-SIN can be used for children more than 9

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ABSTRACT

Background and Aim: In a noisy environment, children struggle more than adults to understand speech. Various tests at different levels of cognition are available to evaluate children's speech perception abilities in a noisy environment. The present study aimed at determining the reliability and equivalency of the Persian version of the quick speech-in-noise (P-Q-SIN) test in 7-12 years old school-aged children.

Methods: A total of 120 (60 girls) students with normal hearing were chosen from primary schools in district 2 of Kerman City, Iran. They were in five age groups ranging from 7 to 12 years (24 children per age group). Pure tone audiometry test was performed on the samples, then nine lists of P-Q-SIN of previous studies (Khalili et al. and Shayanmehr et al.) were administered on these participants. To obtain the test-retest reliability, three weeks later, the re-test was performed.

Results: In the test-retest reliability, lists 1 and 4 of Khalili et al. and list 2 of Shayanmehr et al. were highly correlated ($p<0.05$). There were no significant differences between the scores of girls and boys ($p>0.05$). The participant's performance improves as the age increases.

Conclusion: None of the lists of Shayanmehr et al. was reliable and equivalent. List 1 and 4 of Khalili et al. were reliable and equivalent; therefore, they can be used in clinical application for children in the age range of 7 to 12 years by considering the norm of signal-to-noise ratio loss.

Keywords: Children; equivalency; normal hearing; quick speech-in-noise test; reliability; signal to noise ratio loss

Introduction

Both higher level (language and perceptual process) and lower level (perception of auditory characteristics) functions are involved in speech perception in noise [1]. Although peripheral auditory mechanisms emerge early in childhood, central auditory processing and higher-level processing have a longer growth trajectory [2]. The classic example is listening to speech in noisy environments, a task that necessitates complex coordination between the auditory system and cognitive skills (such as attention and memory) to distinguish between distinct sounds. Children's auditory abilities are like adults. However, the auditory structure in the brain is immature before 10–12 years, and there is little automatic utilization of cognitive resources in childhood. Therefore, speech perception in children for loud sound and reverberant environment is more complex than in adults [3]. In general, audiometric exams use 1-syllable words to assess people's speech perception in silence. Speech recognition results in a quiet environment, and the 1-syllable words are not adequate to estimate a person's hearing abilities in a real-life situation. Some people with normal hearing thresholds and a high word recognition test score in quiet have difficulty understanding speech in noisy environments. As a result, traditional pure tone assessments and word recognition cannot predict an individual's performance in noisy situations [4].

There are many tests to evaluate speech perception in noise, including speech-in-noise (SIN), the word-in-noise (WIN), the hearing-in-noise test (HINT), Bamford-Kowal-Bench (BKB) speech-in-noise (SIN), and the quick (Q)-SIN test. Q-SIN is the most appropriate and accurate of these measures, and since 2001, audiologists have used it to detect speech perception difficulties in noise [5]. The signal-to-noise ratio (SNR) loss is used as a diagnostic index in this test. Compared to normal subjects, SNR loss is characterized as the amount of SNR increase required to achieve correct word recognition 50% of the time. Q-SIN is an open-set sentence recognition test in which a competing condition of multi-talker babble noise and target speech is presented. Each list contains six sentences, each sentence consists of 5 keywords, and each keyword that the listener has correctly repeated is scored. The test is binaurally presented at 70 dB HL [4]. The English Q-SIN included 18 lists of each 6 sentences, 12 lists of 30 dB with emphasis on high frequency, and 12 lists of low-pass filtered [6].

In Iran and among adult subjects, Khalili et al. prepared a Persian version of Q-SIN and investigated its reliability and equivalency in normal hearing subjects and the elderly [7]. Five new lists for the Q-SIN test were generated by Shayanmehr et al. [8]. Haniloo et al. tested these new lists on subjects with normal hearing and sensory-hearing loss [9]. Lotfi et al. developed the Persian version of the WIN test for the young population. They administered the test on 63 7 to 12 years old normal-hearing children and proposed two equivalent lists, presented monaurally [10]. Arbab et al. investigated the psychometrics of the Persian Q-SIN test and proposed four equivalent lists from a total of six. The test presentation level was 70 dB HL, presented binaurally [11]. Mehrkian et al. obtained normative data for consonant-vowel in noise test for 8-12-year-old Persian-speaking children [12]. Moossavi et al. developed the Persian version of the BKB SIN test and determined its content validity in normal Persian-speaking children aged 6-12 years [13].

The Q-SIN test aimed to assess speech comprehension in the presence of multi-talker babble noise. As all lists of Q-SIN in previous studies, including Khalili et al. and Shayanmehr et al. studies, have been made of high-frequency words, we would like to test these lists on regular school-aged children to assess its reliability and equivalency.

Methods

This research is a comparative study with a cross-sectional design. According to previous studies, 120 children (60 girls) from five different age groups (7-8, 8-9, 9-10, 10-11, and 11-12) (24 students in each age group) participated in the research [11]. Using the convenience sampling methods, we chose the samples from schools in Kerman City, Iran. This study lasted for three months (October-December) in 2020. The inclusion criteria were as follows: being 7-12 years, having normal otoscopy, normal hearing (hearing level less than 20 dB HL for octave frequencies from 250 to 8000 Hz) and symmetric hearing (interaural threshold difference less than 10 dB), having right superiority based on the Edinburg handedness scale, being monolingual (Persian native speakers), lacking any psychological illness, professional musical activity, history of brain injuries, strokes, or epilepsy, not using nervous system drugs, lacking attention deficit disorder, or developmental, behavioral or language disabilities [6]. If children or parents refused to continue participation in any stage of this research, they were excluded from the study.

The test was conducted using a circumaural headphone (Philips SHL3100MGY headphone and Asus p2440u laptop, Taiwan). The computer sound level was set at

70 dB HL (B&K 2235 sound level meter). The sound level meter showed that 50% of the laptop output level and the maximum headphones output level, equivalent to speech stimuli, were about 89 dB SPL (70 dB HL). First, we calibrated the system at a frequency of 1000 Hz by Cool Edit Pro 2.1, which was used as a measuring reference for the computer's volume control.

The Q-SIN is a sentence recognition test that runs as an open set and can be performed using headphones or a sound field. Since sound reflection from test space levels can impair speech comprehension thresholds, the Q-SIN test should be designed and standardized primarily using headphones. Before starting the test, we explained the procedure to the samples, i.e. the samples heard the speaker broadcasting some sentences with a background of a babble (humming) noise. Following that, they could repeat every sentence they heard. The samples were first given a list as a practice and were asked to respond verbally, and the examiner recorded their answers on a sheet [6]. The lists were performed randomly to eliminate the order effect [14]. Each list had 30 keywords, the examiner registered the number of correct keywords, and the following formula was used to calculate signal-to-noise ratio (SNR) loss for each list:

SNR loss=27.5–(the total number of correct words–SNR50) [6].

To measure test reliability, all 120 participants were retested by the same examiner three weeks after the first test, and the results of the two tests were compared.

In the present study, means (as a measure of central tendency) and standard deviations (as an index of dispersion) were used to describe the data. The Kolmogorov-Smirnov test was used to examine the normality of the data. Two tests of the Wilcoxon and the Spearman correlation coefficients were done. To check the equivalency of SNR loss score in normal children, we used the Friedman nonparametric test and Wilcoxon test corrected by Bonferroni (because of distribution abnormality). The obtained data were analyzed in SPSS17, and the significance level was set at 0.05.

Results

The study comprised 120 children with normal hearing (60 girls) aged 7 to 12 years. In the present study, the participants' responses were scored of correct repeating words in each list as SNR loss. Table 1 presents the mean (SD) values of SNR loss. The mean SNR loss values for the lists of Khalili et al. and Shayanmehr et al. were 4.80 and 6.67 dB, respectively.

To assess the normal distribution of the variables, we used the Kolmogorov-Smirnov test ($p<0.05$). Since the results revealed that the variables were not normally distributed, nonparametric statistical tests were used. Retest was performed for all participants within a 3-week interval to determine reliability, the Wilcoxon test, and the Spearman tests. Table 1 presents the results of the Wilcoxon test. The test-retest correlations were statistically significant in lists 2 and 3 of Khalili et al. The test-retest correlation was not significant in list 2 of Shayanmehr et al. ($p>0.05$).

Table 2 presents the Spearman correlation coefficients for the reliability analysis, and the results were 0.906, 0.908, and 0.913 for the lists of 1 to 3, which indicates a significant correlation between test and re-test. Also, this coefficient was 0.846 for list 4, indicating a strong relationship in lists of Khalili et al. The Spearman correlation coefficient was 0.822, 0.887, 0.703, and 0.892, respectively for lists 1 up to 4 indicating a strong relationship in lists of Shayanmehr et al. and also list 5 had a significant correlation (0.908). Therefore, in the present study, we had 3 reliable lists (lists 1 and 4 of Khalili et al. and list 2 of Shayanmehr et al.).

Table 3 presents the mean SNR loss of the samples in terms of gender using the Mann-Whitney test. There is no significant difference between boys and girls in the mean scores indicated in these tables ($p>0.05$).

Figure 1 shows the mean SNR loss at different ages. Based on our data, as the age increases, SNR loss scores decrease. The functions of the first and second age groups were nearly identical to those of the third and fourth age groups and the mean SNR loss of samples aged 11-12 years old was lower than the others.

Discussion

The present study investigated the validity, reliability, and equivalency of the Persian version of the Q-SIN test in school-aged children. The test was administered to 120 normal hearing students, aged 7 to 12 years, divided into 5 groups (24 children per age group). As for the differential validity, the effect of gender and age on the results was analyzed. The equivalency of the 4 list and 5 list were determined separately. The test-retest reliabilities were assessed in all samples.

Table 1. Mean percent signal to noise ratio loss and variance of test and retest of Persian quick speech in noise test studies (Khalili et al. and Shayanmehr et al.) and test-retest reliability of signal to noise ratio loss means with Wilcoxon test (n=120)

Study	List	Test					Retest					p
		Mean	Median	Variance	Min	Max	Mean	Median	Variance	Min	Max	
Khalili et al.	1	4.29	4.50	3.16	0.50	7.50	4.22	4.50	2.98	0.50	7.50	0.283
	2	5.97	6.50	3.91	0.50	9.50	5.80	5.50	3.64	0.50	9.50	0.028
	3	5.00	5.50	3.09	1.50	8.50	4.84	4.50	2.88	0.50	8.50	0.022
	4	3.97	4.50	3.01	0.50	7.50	3.89	4.50	3.30	0.50	7.50	0.329
Shayanmehr et al	1	4.29	4.50	2.97	0.50	7.50	4.12	4.50	2.93	0.50	6.50	0.027
	2	5.17	5.50	4.20	0.50	9.50	5.71	6.00	3.70	0.50	9.50	0.804
	3	6.14	6.50	3.54	0.50	9.50	5.84	5.50	3.42	0.50	9.50	0.000
	4	5.56	5.50	3.23	0.50	9.50	5.26	5.50	3.65	1.50	8.50	0.000
	5	6.67	6.50	4.46	0.50	12.50	6.45	6.50	4.35	1.50	10.50	0.016

In previous studies, the Persian Q-SIN test was administered for adults (7, 8), but in the present study, it was performed in children. Table 4 presents the mean SNR loss of both research studies.

Our findings demonstrated that SNR loss in children is between 4.29 and 6.66 dB, and the mean SNR loss of all lists in children is greater than those in adults (Table 4). The mean SNR loss in normal-hearing adults was 1.9 dB, according to data from the Etymotic research center, which created the Q-SIN test for the first time [15]. The authors of the original Q-SIN test suggested that the SNR loss should be between -2.5 and 2.5 dB, but as the authors of the present study expected, the mean SNR loss of all list in children are greater than adults.

The other study objective was evaluating the differential validity. We assessed the effect of gender and age on the results. Regarding gender, it had no impact on the Q-SIN test score in any list of this research. In the Shayanmehr et al. study, no such gender difference was identified. Khalili et al. used the original version of the Persian Q-SIN test on young groups and found that gender did not affect the outcomes of lists 1, 2, and 4 [7]. There has not been any research on sex effects on the English Q-SIN, but Calais et al. looked into gender effects on the

Table 2. Correlation coefficient between score of test and test-retest reliability coefficient values in samples with Spearman (n=120)

Study	List	Correlation coefficient index	p
Khalili et al	1	0.906	<0.001
	2	0.908	0.010
	3	0.913	0.003
	4	0.846	0.006
Shayanmehr et al.	1	0.822	<0.001
	2	0.887	0.010
	3	0.703	0.003
	4	0.892	<0.001
	5	0.908	0.002

Table 3. Mean and standard deviation signal to noise ratio loss of lists in total population and comparison of the scores in girls and boys with Mann Whitney test

Study	List	Mean (SD)			p	Statistical power
		Total (n=120)	Female	Male		
Khalili et al.	1	4.31 (1.78)	4.28 (1.84)	4.30 (1.72)	0.958	0.56
	2	5.99 (1.99)	6.00 (2.04)	5.93 (1.93)	0.869	0.54
	3	5.02 (1.78)	4.98 (1.85)	5.02 (1.67)	0.953	0.57
	4	3.99 (1.75)	3.95 (1.79)	4.00 (1.69)	0.962	0.63
Shayanmehr et al.	1	4.45 (1.73)	4.37 (1.73)	4.28 (1.73)	0.821	0.45
	2	5.72 (2.11)	5.72 (2.14)	5.72 (1.97)	0.951	0.51
	3	6.15 (1.92)	6.18 (1.94)	6.10 (1.83)	0.928	0.34
	4	5.58 (1.84)	5.50 (1.94)	5.62 (1.66)	0.856	0.44
	5	6.66 (2.14)	6.70 (2.28)	6.63 (1.94)	0.913	0.59

speech perception in noise test and found no differences. Calais et al.'s findings are consistent with the results of this investigation [16].

Regarding age, our data showed that as age increases, SNR loss scores decrease. Wilson et al. established normative data for children on the WIN test, and there were three main findings: a) the biggest change in recognition performance occurred between the ages of 6 and 7 years; b) from 9 to 12 years, recognition performance was stable, and c) performance by young adults (18-27 years) was slightly better (1-2 dB) than the performance by the older children [2]. As children age, the mean score of SNR loss decreases, therefore their performance improves. A total of 120 students in this study were 7-12 years old. They were divided into five age groups with the 1-year age bracket. According to Figure 1, the mean SNR loss of children who had 7-8 and 8-9 years old was similar; mean SNR loss of students who had 9-10 and 10-11 years old were approximately the same. The least score belonged to 11-12 years-old children. The outcomes in this research were in line with previous studies that showed children's speech perception in noisy conditions is age-related.

The age range of 9 to 12 is close to each other and close to the adults' range. The 7 and 8 age group results differ from the other age groups and adults' levels. Also, the norm data of young children (7 and 8 years old) is within the abnormal range of adults. So we cannot distinguish normal children from children with auditory processing disorder by normative data of this age group. However, we can use this Q-SIN test just for children aged 9 years old and older. For children under 9 years old, we must use another SIN test, or we must design a Q-SIN test for children with speech material suitable for young children.

The reliability of the Persian Q-SIN test was performed for all participants with two tests, the Spearman correlation and Wilcoxon test.

In assessing the reliability of the test by using different analyses, two results can be obtained. First, the retest scores are better than the test scores (Table 1). It is

Table 4. Mean signal to noise ratio loss of Persian quick speech in noise test studies (Khalili et al. and Shayanmehr et al. lists) in previous study in adults and present study in children

List	Khalili et al. lists					Shayanmehr et al. lists					
	1	2	3	4	Mean	1	2	3	4	5	Mean
Adults	−0.69	−1.63	−1.52	−2.19	−1.5	0.32	0.35	0.47	0.41	0.24	0.35
Children	4.29	5.96	5.00	3.97	4.80	4.32	5.71	6.14	5.55	6.66	5.68

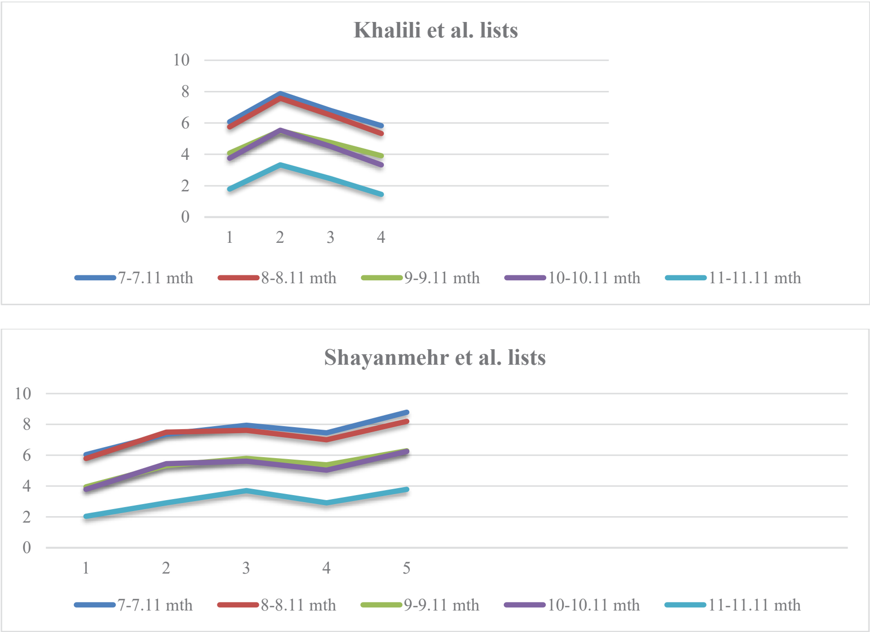

Figure 1. Mean signal to noise ratio loss for each age group in lists of Khalili et al. and Shayanmehr et al.

probably due to the intervention of memory and cognitive factors and learning effects [17]. Second, the reliability and repeatability of the test lists are good (Table 1) ($p<0.05$). Evaluation of the correlation coefficients of the test-retest results with the Spearman test for the four lists of the Khalili et al. study showed a high correlation in SNR loss between test-retest in all four lists as well as the other 5 lists of Shayanmehr et al.

Moreover, test-retest reliability with the Wilcoxon test (Table 1) indicated no significant difference between the mean SNR loss of list 2 of Shayanmehr et al. study and lists 1 and 4 of Khalili et al. study. In other words, there is a difference in lists 2 and 3 of Khalili et al. and all lists of Shayanmehr et al. except for list 2, which can be attributed to the effect of learning in the re-test. Therefore, in the present study, 3 lists of 9 lists, including lists 1 and 4 of Khalili et al. and list 2 of Shayanmehr et al., are reliable to use in the children.

Regarding the equivalency of the lists in the two investigations, the mean SNR loss of the lists was significantly different. To learn about the difference of the mean SNR loss of the lists, the mean SNR loss of each list was compared with the other lists separately. It was found that there was a significant difference between lists 1 and 2 and the rest of the lists from the Shayanmehr et al. study. Lists 1 and 4 of Khalili et al. were equivalent to no significant difference (Table 2). Wilson et al. studied the equivalency of 18 English lists, showing that only lists 1, 2, 6, 8, 10, 11, 12, 15, and 17 were equivalent [2]. In 2010, except for lists 1 and 4, Khalili et al. demonstrated that all lists were equivalent in adults [7]. Shayanmehr et al. showed that their 5 lists are of good equivalent in young adults [8].

Because just 3 lists were reliable in children and each of these lists has limited sentences, and the test itself has a learning effect, it is advisable to create another Q-SIN with sufficient speech material instead of using these adult tests.

The advantage of having access to the test's equivalent lists is that examiners and clinicians can utilize them in the rehabilitation and evaluation process before and after the rehabilitation for children aged 9 years and older.

In 2019, Coronavirus disease created a challenge. A limitation of our study was a lockdown and various restrictions during the wave of COVID-19 with its sharp rise and decline. We had a responsibility to ensure the safety of the participants and their parents. Students had virtual learning, and based on guidelines for research during COVID-19, we described the risks and preventive measures in detail for parents. If they accepted to participate in our study, the child and his/her parents came to school one by one without any crowding population. All the protocols were followed during tests, and the participants wore masks. Alcohol-based hand sanitizer and sanitizer for surfaces, e.g. chairs, tables, and other devices, were used. Headphones were covered by disposable covering, and after ending tests, used covers were thrown away. These limitations caused the long process for this research.

Conclusion

This study evaluated the validity, reliability, and equivalency of the lists of the Persian quick speech-in-noise (Q-SIN) test. Since the test results are unaffected by gender and the older children's performance was slightly better than the younger, the validity of all lists was high. In the present study, lists 1 and 4 of Khalili et al. were reliable and equal. So, they can be used as a non-aggressive, clinical, and research instrument to examine speech perception in noise and central auditory processing for children aged 9 years and older. By considering the norm of signal-to-noise ratio loss, none of the lists of Shayanmehr et al. was reliable and equivalent in the present research. Q-SIN is one of the few Persian exams developed to assess speech perception in noise in real-life situations. It also aids in the monitoring and evaluation of auditory rehabilitation, as well as consulting patients and initiating rehabilitation interventions.

Ethical Considerations

Compliance with ethical guidelines

In the present study, all ethical considerations recommended by Tehran University of medical Sciences (TUMS) were taken into account and the study was approved by TUMS with Ethical code of IR.TUMS.FNM.REC1399.065. Participation in the study was based on obtaining an informed consent from all parents.

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Authors' contributions

AAZ: Study design, acquisition of data, interpretation of the results, statistical analysis, and drafting the manuscript; FF: Study design, interpretation of the results, and drafting the manuscript; SF: Interpretation of the results and drafting the manuscript; SJ: Statistical analysis.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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