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RESEARCH ARTICLE

List equivalency of the Persian quick speech in noise test on hearing impaired subjects

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Abstract

Background and Aim: The quick speech in noise (Q-SIN) test have been designed to evaluate individuals' ability to recognize speech in noise. This study established to evaluate the test-retest reliability and equivalency of the five test lists of the Persian Q-SIN test in subjects with sensory hearing loss (SHL) and normal hearing individuals.

Methods: This cross-sectional study was performed on equal number of subjects with normal hearing and SHL, 36 in each group. The participants aged from 18 to 55 years old. The Persian Q-SIN test materials which were recorded on a CD were presented binaurally via an audiometer using standard earphones. For evaluating reliability retest was conducted on the same subjects after three weeks.

Results: The mean signal-to-noise ratio (SNR) loss was 0.16 (SD=0.70 dB) in normal hearing subjects. There was a significant difference bet ween the mean results of lists 1, 2 and 4 and lists 2, 3 and 4 as well as lists 4 and 5. The mean SNR loss in subjects with SHL was 6.62 (SD=3.20 dB). There was a significant difference between the mean results of list 1 and that of lists 3, 4 and 5 ($p<0.001$). For reliability analysis of the two groups, there were no significant differences between test-retest results of the five test lists.

Conclusion: Lists 3 and 5 as well as lists 2 and 5 are reliable and equivalent for determining SNR loss in individuals with normal hearing and SHL individuals.

Keywords: Quick speech in noise test; reliability; list equivalency; Persian

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Introduction

Speech recognition in noise involves a complex set of cognitive and perceptual skills which allow the auditory system to separate and isolate heard sounds and identify the targeted signal [1,2]. However, considering the effects of hearing loss on this ability on the one hand and low satisfaction of hearing aids in noisy environments on the other, hearing in background noise is usually a challenge to hearing impaired individuals [3,4,5]. Reductions in sensitivity to gentle sounds and auditory resolution caused by damages to the outer and inner hair cells, respectively, can limit one's auditory ability in background noise [6,7].

The quick speech in noise (Q-SIN) is used to evaluate the word-recognition abilities of individuals when listening in a background noise of multitalker babble [8]. The Q-SIN,

which is a shortened version of the speech in noise test (SIN), is a sentence in multitalker babble protocol that involves the presentation of six sentences at six signal-to-noise ratios in 5 dB decrements from 25 to 0 dB. Each sentence has five target words concatenated in appropriate syntactic form with subtle semantic cues creating limited contextual cues in these meaningful sentences [9].

The Q-SIN test utilizes signal-to-noise ratio (SNR) loss to assess speech recognition in presence of noise [8,10]. SNR loss is defined as the increase in SNR required by a hearing impaired person to have a performance similar to that of a normal hearing individual in a noisy environment. In other words, SNR loss refers to the difference between normal and hearing impaired individuals in accurate detection of 50% of the words [10,11]. A person with normal hearing needs about +2 dB SNR to detect 50% of words in the English version of the Q-SIN test. The value of SNR loss is derived from the SNR-50 (SNR for 50% correct) score. A hearing-impaired person who requires speech to be 8 dB higher than the noise to achieve a 50% correct score would have a 6 dB SNR loss [10]. The SNR required for 50% correct is easily computed by subtracting the total number of correct words of a list from 27.5 dB SNR. For calculation of listener's SNR loss, mean SNR-50 for normal hearing persons at that language subtracted from above formula [9,10].

The Persian version of the Q-SIN test that developed by shayanmehr et al. [12] is composed of five test lists. Each list contains of six sentences and each sentence has five keywords (total number of 30 keywords on each list). The sentences articulated by a female speaker are presented in four-talker babble which is continuous throughout the list of six sentences. These test lists can be used separately or in combination. Averaging the results of several Q-SIN lists improves the accuracy and reliability, compared to a single list [10].

Killion et al. [8], developed 18 Q-SIN lists and evaluated equivalency of lists on young listeners with normal hearing. They simulated high-frequency hearing loss using low pass filtering of the lists and conducted these Q-SIN lists on normal hearing subjects. The filtered data from the listeners with normal hearing indicated that Q-SIN lists of 1-12 were equivalent.

McArdle and Wilson [9] examined the equivalency of 18 Q-SIN lists test on listeners with normal and sensory neural hearing loss (SNHL). The results indicated that only 9 test lists were equivalent. They concluded that what is equivalent or homogeneous for listeners with normal hearing is not necessarily equivalent or homogeneous for listeners with hearing loss.

Shayanmehr et al. [12] evaluated Persian version of Q-SIN test for equivalency and reliability of test lists on normal hearing individuals only. However, the equivalency and reliability of the test lists in normal hearing people do not ensure the same features in hearing impaired subjects. Since these new lists have not been evaluated on individuals with hearing loss, the present study assessed the equivalency and reliability of five lists of the Persian Q-SIN test in both individuals with sensory hearing loss (SHL) and normal hearing people.

Methods

This cross-sectional study was conducted on all individuals who attended in a private audiology clinic, Tehran, Iran, during December 2014 to April 2015. Participants were 18-55 years old including 36 normal hearing subjects and 36 individuals with SHL. They were recruited if an informed consent for testing was provided.

Pure tone averages (PTA) of the two groups were less than 20 dB and 70 dB in both ears, respectively. Subjects with SHL had symmetrical hearing loss (difference between left and right ear puretone threshold <15 dB), air bone gap of less than 10 dB and a sloping loss in both ears with a minimum 20 dB drop from 500 to 4000 Hz [8,13].

As right-handedness was an inclusion criterion, only individuals scoring +10 on the Edinburgh Handedness Inventory were included [14]. The mini-mental state examination (MMSE) was then used to examine the subjects' cognitive and mental conditions. Individuals with the score of

21 and above on the MMSE [15] and no history of head trauma, neurological diseases or any diseases in the sound transmission system of the ear were recruited. Pure tone audiometry (CA 86, Pejvak Ava Co, Iran) at octave frequencies of 250-8000 Hz as well as tympanometry and acoustic immittance testing (ZA86, Pejvak Ava Co, Iran) were conducted for both ears of all participants. Type A tympanogram, i.e. with a peak pressure between -50 and +50, a static compliance of 0.27-1.38, a normal ear canal volume (0.63-1.46 cc) and an acoustic reflex (ipsilateral acoustic reflex at 0.5, 1, 2 and 4 kHz and contralateral acoustic reflex at 0.5, 1 and 2 kHz) is required to confirm normal peripheral hearing [16]. The presence of an acoustic reflex and a positive Metz test result ensured the absence of any damage to the auditory nerve in subjects with SHL. The Metz test has a positive result if the acoustic reflex threshold is no more than 60 dB higher than the pure tone threshold at octave frequencies of 500-2000 Hz. Such a positive result indicates cochlear damage [17].

After obtaining informed consent for testing, the Persian Q-SIN test (developed by Shayanmehr et al. [12]) was conducted on all subjects in the acoustic room of the private clinic. The test lists, each requiring one minute, were played with a dual-channel CD player (NSX-VC320, Aiwa, Japan) and routed through an audiometer (CA86, Pejvak Ava Co, Iran) to binaural earphones. Test for normal hearing and hearing loss at 45 dB hearing level (HL) and less is conducted in the intensity of 70 dB HL and for hearing loss more than 45 dB HL is conducted at person's most comfortable level (MCL) [9]. The participants were asked to repeat each sentence after it was played. In order to familiarize the subjects with the test, sample lists were played and participants were allowed to practice the procedure. Prior to the practice trials, each participant was given the instructions suggested in the Q-SIN manual: "Imagine that you are at a party. There will be a woman talking and several other talkers in the background. The woman's voice is easy to hear at first, because her voice is louder than the others. Repeat each sentence the woman says. The background talkers will gradually become louder, making it difficult to understand the woman's voice but please guess and repeat as much of each sentence as possible" [10].

The confounding effects of the list order were eliminated by changing the presentations order of. All participants were retested about three weeks after the initial test. The total number of correct repeated words on each list was counted and the SNR loss was calculated according to the following equation:

SNR loss (in dB)=27.5 − the total number of correct words − Persian mean SNR 50

The Persian mean SNR 50 in normal hearing was estimated at -4 dB in the production of the Persian Q-SIN CD. In order to apply the SNR 50 for each language, this value can be either added to the equation or used to adjust the noise level in the CD [12]. Since 4 dB noise was added to the test CD during its production, the original equation (excluding SNR 50 in SNR loss calculations) was administered.

The concept of reliability suggests that measuring devices on the same terms yields to same results to some extent. In this study, evaluation of the reliability to assess the statistical significance of similarity between two or more categories of findings was done using three ways including comparison of average SNR loss in the first and second tests (test-retest) by paired t-test, the correlation coefficient for test-retest by Pearson test and interclass correlations (ICC) coefficients.

In order to determine the equivalency of the 5 test lists, one-way analysis of variance (ANOVA) was used to compare mean scores of 5 test lists. The equivalent lists were identified using the Bonferroni test which also used to compare the mean results of each list to that of the other four lists. All analyses were performed using SPSS 17 (SPSS Inc, Chicago, IL, USA) at a significant level of $p<0.05$.

Results

The average score of test-retest for each of 5 lists of subjects with normal and SHL is given in Table 1. The mean SNR loss for the five lists was 0.16 (SD=0.70 dB) in normal hearing

Table 1. Results for test-retest reliability of the Persian Quick Speech in Noise test in normal hearing and sensory hearing loss groups

Group	List	Mean score in test	Mean score in retest	t	p
Normal hearing	1	1	0.88	1.45	0.16
	2	-0.13	-0.27	1.04	0.30
	3	0.77	0.58	1.86	0.07
	4	-1.41	-1.61	1.12	0.26
	5	0.58	0.44	0.70	0.48
Sensory hearing loss	1	5	4.83	1.64	0.11
	2	6.16	5.91	1.86	0.07
	3	7.22	7.02	1.74	0.09
	4	7.5	7.36	1.71	0.09
	5	7.22	7.05	1.78	0.08

people. As it is shown in Table 1, there were no significant differences between the mean test-retest scores of normal hearing people in any of the lists ($p>0.05$). Study of the correlation coefficient between the test-retest showed strong significant correlations between the test-retest results of lists 1, 2, 3 and 5 (correlation coefficients=0.92, 0.71, 0.89 and 0.62, respectively; $p<0.001$). A moderate correlation was observed in case of list 4 (correlation coefficient=0.48; $p=0.003$). The ICC coefficients between test-retest results of lists 1, 2, 3 and 5 were highly significant ($p<0.001$). However, the calculated ICC coefficient for list 4 (0.47) suggested a moderate to low level of reproducibility ($p=0.001$).

In SHL people, the mean SNR loss for the 5 lists was 6.62 (SD=3.20 dB). According to Table 1, there was no significant difference between the mean test-retest score of lists 1-5. There were strong significant correlations between test-retest results of all lists ($p=0.001$). The correlation coefficients were calculated as 0.97 sand 0.98 for list 1 and other lists, respectively. The ICC coefficients between the test-retest results of all 5 lists were highly significant ($p<0.001$).

ANOVA with repeated measures was used to check that the mean scores of 5 lists have no significant difference. Comparison of mean scores in 5 test lists are presented separately in subjects with normal hearing and SHL in Fig. 1 (A and B).

The results of this analysis showed significant difference between 5 lists of Q-SIN test in subjects with normal hearing ($F_{(4,140)}= 28.45$, $p<0.001$) and in SHL subjects ($F_{(3.15,110.34)}=16.99$, $p<0.001$).

Table 2 presents the comparisons between the mean SNR loss of different lists in subjects with normal hearing and SHL, respectively. There were significant differences between the mean SNR losses of lists 1, 2 and 4, lists 2, 3, and 4 and lists 4 and 5 in normal hearing participants ($p< 0.05$). On the other hand, in subjects with SHL, the mean SNR loss of list 1 had significant differences with those of lists 3 to 5 ($p=0.001$).

Discussion

In the current research, the mean SNR loss in subjects with normal hearing and SHL was 0.16 and 6.62 dB, respectively. Therefore, in order for the hearing impaired individuals to perform

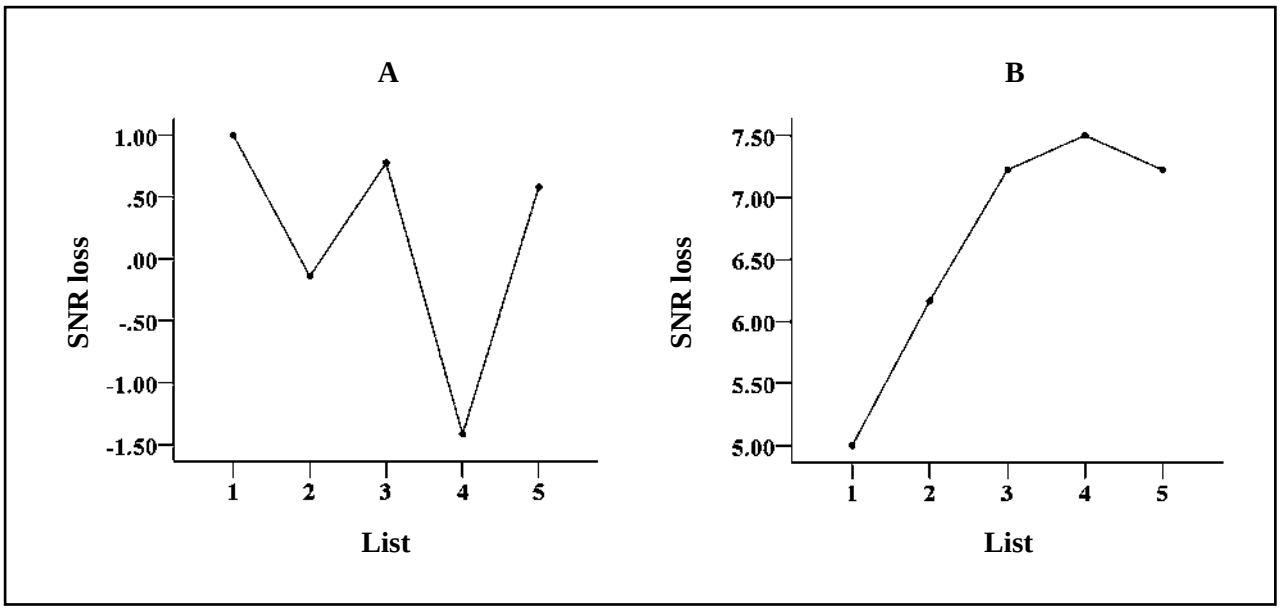

Fig. 1. Comparison of mean SNR loss in 5 test lists, separately in subjects A) with normal hearing and B) with sensory hearing loss.

similar to normal hearing people in noisy environments, a 6.46 dB increase in SNR is required.

Evaluating the test-retest reliability of the Persian Q-SIN test in the two groups suggested the absence of significant differences between the mean SNR losses of the five lists. In other words, lists 1 to 5 demonstrated high reproducibility in both hearing impaired and normal hearing subjects. Moreover, in normal hearing participants, strong significant test-retest correlation coefficients were observed for lists 1, 2, 3 and 5. However, the correlation was moderate in case of list 4 (correlation coefficient=0.48). In subjects with SHL, Pearson's correlation coefficients were 0.97 for list 1 and 0.98 for the other four lists. In this group, the test-retest results of all lists had a very strong correlation at a significant level.

Interclass correlations coefficients are used to assess the statistical significance of similarity between two or more categories of findings. These values always range between zero (no correlation) and one (perfect correlation). According to our findings, in the normal hearing group, the ICC was moderate for lists 2, 4 and 5 and high for lists 1 and 3. In subjects with SHL, on the other hand, the ICC was high for all lists.

Shayanmehr et al. evaluated the five lists of the Persian Q-SIN test for test-retest reliability and equivalency, and reported the mean SNR loss in young normal hearing people as 0.35 dB [12]. Results of their study regarding reliability revealed that the difference between the tests and retest scores for lists 2, 3 and 5 was statistically significant but it was not significant for lists 1 and 4. In Pearson test, correlation coefficient between the average scores of test and retest was statistically significant. Based on ICC results, the reliability coefficient for first and second test was statistically significant. Overall, 5 test lists were reliable in normal hearing persons. In our study, these 5 test lists were reliable in subjects with normal hearing and SHL which is similar to their study.

For assessment of equivalency, shayanmehr et al. Compared mean scores of 5 test lists together and found that there was no significant difference between them and 5 test lists were equivalent in normal hearing subjects.

In the present study, examining the equivalency of the lists revealed significant differences in the

Table 2. Results for equivalency of the 5 Persian Quick Speech in Noise test lists in normal hearing and sensory hearing loss groups

Group	Lists		p
Normal hearing	List1	List2	0.000
		List3	1
		List4	0.000
		List5	1
	List2	List3	0.01
		List4	0.000
		List5	0.13
	List3	List4	0.000
		List5	1
	List4	List5	0.000
Sensory hearing loss	List1	List2	0.09
		List3	0.000
		List4	0.000
		List5	0.000
	List2	List3	0.09
		List4	0.05
		List5	0.08
	List3	List4	1
		List5	1
	List4	List5	1

mean SNR loss of the lists in both groups. In order to determine the exact differences, the mean SNR loss of each list was separately compared to that of other lists. These comparisons were performed on both groups and the results are summarized in Tables 2. In the normal hearing group, lists 1, 3 and 5 and also lists 2 and 5 were equivalent. In subjects with SHL, lists 2, 3, 4 and 5 as well as lists 1 and 2 were equivalent. The difference between their findings and ours could probably be due to the method of presenting the test materials to the participants (shayanmehr et al. used sound fields) and the reflection of sound from surfaces of closed space.

McArdle and Wilson examined the equivalency of 18 lists in the English Q-SIN test. They reported that only 9 lists are equivalent including list 1, 2, 6, 8, 10, 11, 12, 15 and 17 in subjects with normal hearing and SNHL [9].

Conclusion

The evaluation of the reliability and equivalency of the lists in the Persian Q-SIN test in this study showed that lists 1 to 5 were reliable in both groups. Moreover, lists 3 and 5 as well as lists 2 and 5 were co-equivalent in subjects with normal hearing and SHL. Hence, these lists are reliable and equivalent for clinical use. In clinical application for greater accuracy, two or more test lists were averaged and these lists should be equivalent. These equivalent and reliable test lists can be beneficial in choosing an appropriate hearing aid (e.g. an FM system) and consulting the patients in order to have a realistic expectation from their hearing aids. Finally, the efficiency of a hearing aid's directional microphone can also be evaluated by the Persian Q-SIN test in both active and passive modes in background noise with different and equivalent test lists.

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