Research Article

Development of the Persian Listening in Spatialized Noise Sentence Test: A Preliminary Study

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Short running title: Development of the Persian Listening in…

Highlights:
- LiSN-S is auditory processing test for diagnosing spatial processing disorders
- PLiSN-S test was developed in IRAN based on its original Australian version
- PLiSN-S test evaluates the ability to perceive speech in simulated 3D environment

ABSTRACT

Background and Aim: Listening in Spatialized Noise Sentence (LiSN-S) is one of the auditory processing disorder test battery that specifically diagnose spatial processing disorders. This research aimed to develop The Persian version of the LiSN-S, for assessing auditory processing disorders in the Persian speakers' population.

Methods: The PLiSN-S test was developed based on its original Australian version. The speech stimuli were convolved with head-related transfer functions (HRTFs) to generate speech in the presence of spatialized noise. In total, 120 target sentences (consisting of five 1-3-syllable words) and competing stories were presented in four conditions. These included the Same Voice co-located condition (SV0°), Different Voice co-located condition (DV0°), Same Voice separated condition (SV±90°), and Different Voice separated condition (DV±90°). Then, data from 30 adults aged 18–23 with normal hearing were obtained.

Results: The results from the normal-hearing subjects showed that the Speech Reception Threshold (SRT) scores, expressed as Signal to Noise Ratios (SNR), varied across the four conditions (SV0°, DV0° SV±90°, DV±90°) the highest and lowest SRTs belonged to the first and last conditions, respectively. The amount of advantage in all conditions was lower than in the previously published English versions.
Conclusion: Considering the impact of spatial separation on the SRTs, PLiSN-S appears to be an effective tool for measuring spatial processing skills.
Keywords: Persian; auditory stream segregation; spatial hearing; speech in noise

Introduction

Humans are regularly exposed to different sounds, which combine while approaching our ears. In these complex auditory environments, the acoustic characteristics of many of these sounds overlap. Although each human ear has access only to a single sound stream consisting of several mixed sound waves [1], the human auditory system should be able to segregate them from each other correctly [2]. Auditory stream segregation is done based on spatial and non-spatial cues in the auditory system. These cues are mainly the results of the spatial location of the sound source and the speaker's pitch, which are essential in locating the sound source [2]. The ability to focus on the target sounds, such as speech, and suppress the competing sounds that originate from different locations at the same time is called spatial release from masking or Spatial Processing (SP) [3]. SP is one of the important components of Auditory Processing (AP) and is related to the ability to utilize the spatial cues embedded in an incoming signal to our ears to segregate the target signal from the unwanted one, therefore it is one of the important auditory functions for understanding and following target speech in everyday situations [4]. Conversely, Spatial Processing Disorder (SPD) is the inability to use spatial cues to segregate wanted from unwanted signals [5, 6]. SPD could be the only cause of difficulties in understanding speech in the presence of background noise in a classroom setting in a group of children with Auditory Processing Disorder (APD) specifically with a history of otitis media [6].

The first version of the LiSN-S was developed in Australia to assess auditory stream segregation capabilities in children with suspected Auditory Processing Disorder (APD). The LiSN-S test evaluates the ability to perceive speech in the presence of competing speech in a simulated 3D listening environment under headphones. Evaluation under headphones has several advantages over the conventional free-field evaluation method. First, it minimizes the changes in the Sound Pressure Level (SPL) at the eardrum caused by the movements of the listener's head. Second, it reduces reverberation in the test environment [7]. However, the obvious disadvantage of testing under headphones is not useful for listeners with hearing-assisting devices.

The LiSN-S test includes spatialized speech sentences created in a three-dimensional auditory environment under headphones by convolution of speech stimuli with non-individualized Head-Related Transfer Functions (HRTFs). The listeners' Speech Reception Threshold (SRT) is measured by repeating the target sentences in the presence of competing speech (children's stories) using an adaptive thresholding method. Strike in the HRTFs, the target sentences are presented at a simulated 0-degree azimuth (from the listener's front), while competing stories are perceived either from 0 or ±90 degrees relative to the target sentences. The narrator's voice can be similar to or different from that of the target speech. As shown in Figure 1, In general, target sentences and competing stories are included in four listening conditions comprising the Same Voices at 0° (SV 0° or low-cue SRT), the Same Voices at ±90° (SV±90°, SV±90°), different Voices at 0°(DV0°), and Different Voices at ±90° (DV±90° or high-cue SRT).

An individual's performance on the LISN-S is reported for the low-cue and high-cue SRT scores, as well as for the advantage measures. To obtain an advantage measure, the difference scores are obtained in conditions where vocal, spatial, or both vocal and spatial cues are available in competing stories compared to the baseline (low-cue SRT) condition [8]. Difference scores serve to minimize the influence of higher-order language, learning, and communication skills on test performance. they allow a relatively pure assessment of the child's ability to use spatial cues to improve speech understanding [8]. Considering the LiSN-S test as a language-based test in identifying Spatial Processing Disorders (SPDs), developing this test in other languages is desirable. So far, only the English version has been developed in Australian and North American accents [8, 9]. This study aimed to develop the Persian version of the LiSN-S test. Also, in this study, the question was answered whether the Persian version of the LiSN-S can assess the skill of auditory streaming segregation based on pitch and spatial cues. For this purpose, the present study was conducted in five stages of sentence generation and equivalence, development of PLiSN-S, initial normative data collection in 30 normal adults, and reliability assessment (test/retest) of the data in 15 participants.

Methods

The Persian version of LiSN-S (PLiSN-S) was developed in MATLAB R2020b based on the LiSN-S described in detail (Figure 2) by Cameron et al. [7].

Stimulus construction

Speech stimulus

Three hundred fourteen standard Persian sentences were made based on the Bamford-Kowal-Bench (BKB) sentence test [9, 10]. The wording was based on the stories for young children, 6 to 9 years of the Center for Intellectual Development of Children and Adolescents under the supervision of a linguist. Short sentences with familiar words and simple grammar were used to suit children. According to experts and linguists, only five words with 1–3 syllables were selected in each sentence. According to experts and linguists familiar with auditory processing and relevant tests on the appropriateness of the sentences' semantic and syntactic characteristics were collected using a questionnaire to calculate the content validity [9]. They were asked to evaluate the sentences based on the criteria of Persian sentence structure and Lawshe's three-choice questionnaires. The three evaluation items are 1) suitable, 2) somewhat suitable but usable, and 3) not suitable. The Content Validity Ratio (CVR) was calculated for each sentence. The lowest acceptable CVR was 0.62. By calculating the CVR, 190 sentences with a CVR higher than 0.62 were selected [9]. Two stories (competing speech), entitled "Donya cheghadr bozorg ast" and "Amoo Nowruz" that suit children, 6 to 9 years old were selected from the storybook published by the Centre for the Intellectual Development of Children and Adolescents.

Recording target and distracted sentences

The target sentences and competing speech of the PLiSN-S test were recorded by three female narrators in the studio of the Tehran Broadcasting Organization. The first narrator (narrator 1) recorded the target sentences and two competing speech materials, and the other two narrators (narrator 2 and narrator 3) recorded the two competing speech materials. All the stimuli were produced in standard Persian in the Tehrani accent. Standard Persian is the standard type of Persian language and the official language in Iran, Tajikistan, and one of the two official languages of Afghanistan. Standard Persian refers to how Persian is written and spoken in public media, such as television, radio, publications, and official speeches in public gatherings. For the target sentences and the competing speech, the narrators were asked to speak in a clear and normal voice using a standard accent, maintaining a normal speech rhythm, and avoiding stress on keywords. Sound recording was done in the studio with a Studer OnAir 1000 (made in Switzerland) and an AKG P5S microphone (made in Austria) with a sampling frequency of 48000 Hz. The target sentences and competing speech were edited with Adobe Audition 1.5 and MATLAB 2020. A 100 ms silence period was applied before and after each narration based on original studies. Extra pauses were removed during editing to ensure that the competing speech materials were narrated constantly. The duration of "Donya cheghadr bozorg ast" story was two minutes and thirty-five seconds and for "Amoo Nowruz" was two minutes and thirty-two seconds.

The Root Means Square (RMS) values of each sentence and its competing speech were measured using MATLAB 2020b. Then the average of all RMS values was calculated. The amplitude of each sentence was divided by its own RMS and multiplied by the reference RMS (mean RMS). In the calibration stage, the final level of sentences and competing speech was coded to prevent peak clipping during the convolution of competing speech with HRTF at ±90-degree azimuth angles in MATLAB R2020b.

Convolution

In the present study, the interpolated non-individualized HRTFs (MathWorks Inc., 2020b) were used to adjust to the characteristics of the head and torso. In this method, each sentence (recorded by narrator 1) at 0° azimuth, the competing speech "How big is the world" (recorded by Narrators 1 and 2) at 0° and –90° azimuth, and "Uncle Nowruz" (recorded by narrators 1 and 3) were convolved in the HRTF at 0° and +90° azimuth.

Calibration

A 1000 Hz tone was used for calibration of speech signals according to ANSI Standard S3.6-1969. To produce speech signals with a definite SPL at the headphone output, we should produce 1000 HZ tones with an amplitude equal to the SPL of speech signals. In the next step, The RMS of the speech signals adjusted to the RMS of the 1000 Hz tones. Because the RMS of the tone is equal to the RMS of the speech signal, the intensity of the tone is also equal to the intensity of the speech signal. This procedure was done for sentences in the intensity range of 32 to 88 dB with 2-dB step intervals and combined competing speech (0°-azimuth) in the intensity of 75 dB SPL. The output of Sennheiser HD 200 headphones was calibrated using a B&K type 2250-S sound level meter and

Coupler types 4152 (Denmark) connected to a circumaural headphone adapter. The mean RMS level of the combined distracters (averaged across the recordings made by narrator 1, 2, 3) at 0° was –23.6 dB and at ±90° was –22.4 dB.
The relative sentence intelligibility and level adjustment to achieve equal intelligibility were determined which was explained in the following.

Experiment 1. Sentence equivalence study

Participants
Twenty-five volunteer students, aged 8 to 12 years, were recruited from the public schools based on inclusion criteria. The inclusion criteria were: 1) pure-Tone Audiometry (PTA) thresholds were within normal limits (<20 dB HL) for frequencies included in this PTA, thresholds difference were less than 10 dB HL between two ears; 2) ipsilateral acoustic reflex threshold at 1000 Hz and 95 dB HL in tympanometry; 3) no history of middle ear infection, other ear's parts infection, and hearing disorders as reported by parents; 4) monolingual Persian speaker (they spoke and used only Persian language in home, school and other public places); 5) no attention, learning, and speech and language disorders, 6) being right-handed (using the Edinburgh handedness questionnaire), 7) not being APD based on the reports of the mother and the teacher regarding auditory behaviors, 8) normal IQs (≥85 on Wechsler's Revised Intelligence Scale for children administered by a psychologist).

Procedure
The PLiSN-S test was conducted in the acoustic chamber of the School of Rehabilitation of Hamadan University of Medical Sciences, usually between 10:00 AM and 3:00 PM. The initial intensity of the target sentences was 75 dB SPL. The competing speeches were presented with their RMS level at a constant intensity of 65 dB SPL. Competing speeches were presented in the "same voice-zero degree" condition. The target sentences were presented by a female narrator and convolved with HRTFs corresponding to the 0-degree azimuth. The listener had to repeat the words they heard in each target sentence. To inform the listener about the presentation of the target sentence, the word "say" was presented before each sentence with a time interval of 500 ms from the beginning of each sentence at an intensity of 65 dB SPL. The word "say" was pronounced with a female voice different from the three narrators.
To determine the participant's SRT, the intensity level of the target sentence was changed adaptively. If the participant repeated more than 50% of the words of the target sentence correctly, the intensity was decreased by 2 dB; if s/he repeated less than 50% of the words, the intensity was increased by 2 dB. All of the words (e.g. prepositions, nouns, and verbs) in each sentence were scored separately. Measurement of the SRT commenced at the first upward reversal. The criterion for stopping the test was: completing the practice sentences plus at least 17 other scored sentences; the real-time calculated standard error for all scored sentences <1 dB. $aSE=2*SD/\sqrt{N}$ is the formula used for calculating standard error. N is number of trials in the measurement phase (i.e. after the first reversal after at least 4 trials) and the standard deviation of the SNRs in the measurement phase.
From the 190 selected sentences, 30 were used to estimate each participant's early SRT (eSRT). The remaining 160 sentences were presented at constant SNR levels for each subject. The levels of the SNRs were chosen to achieve a score of 50–90% correct, at which the psychometric functions could be adjusted. SNR levels were equal to eSRT-3, eSRT-2, eSRT-1, eSRT, eSRT+1, eSRT+2, and eSRT+3 dB. The mean percentage of correct words at each SNR for each sentence was calculated across participants. The Logit curve for each sentence used least squares regression based on the following equations: $\exp(a–b*SNR)/(1+\exp[a–b*SNR])$. The calculation was done in MATLAB R2020b.
The median b value across sentences equals –0.617 which is equivalent to a slope of 15% per dB (calculated as -b/4). The a/b ratio, referred to as r, for each sentence represents the SRT or SNR required to diagnose 50% of the words in that sentence correctly. The median value for r (r median) was 0.2 dB. Sentences were adjusted in dB to achieve equal intelligibility. The required adjustment for each sentence was obtained based on the $r–r_{median}$ result. The criteria for removing sentences were as follows: 1) the required adjustment was too great that is, $r–r_{med}<–2.0$ dB or >+2.0 dB, 2) the slope was too shallow (<6% per dB), and 3) too steep (50% per dB).
Based on these criteria, 40 sentences were excluded. Logit curves for the remaining 120 unadjusted sentences, are shown in Figure 3. The remaining sentences were adjusted in amplitude for equal intelligibility and used in the normative data study. The mean slope of the remaining sentences was 16.7% in dB. Logit curves for sentences after adjustment are shown in Figure 4.

Experiment 2. Data collection methodology for determining initial normality

Participants

The participants were 30 adults between 18 and 23 years with normal peripheral hearing (pure-tone audiometry thresholds within normal limits (>20 dB HL) for air and bone-conduction pathways at 250–8000 Hz, normal otoscopy, no history of middle ear infections in childhood, and no complaints of lack of attention, concentration, and difficulty in understanding speech-in-noise, no history of taking drugs affecting the central nervous system, neurological problems, psychological problems, head trauma, ear surgery according to self-reports and also they were native Persian speakers. The participants were selected from the Hamadan University of Medical Sciences students using convenience sampling. It took two months (April and May 2023) to collect the initial normative data and examine the test-retest.

Procedure

The test was performed using Sennheiser HD 200 headphones connected to a Lenovo IdeaPad L340 laptop in an acoustic room with a noise level of less than 30 dB A. The target sentences were first presented at an intensity level of 75 dB SPL and competing speech at a constant intensity level of 65 dB SPL. The examinee had to repeat as many words in each sentence as possible. In each of the four conditions, 30 sentences were presented. The target sentences and competing speech in the four conditions were presented in the following order: 1) DV±90°; 2) SV±90°; 3) DV0°; and 4) SV0° [8]. To determine the participant's SRT, the intensity level of the target sentence was changed adaptively. If the participant repeated more than 50% of the words of the target sentence, the intensity was decreased by 2 dB; if he/she repeated less than 50% of the words, the intensity was increased by 2 dB. All of the words (e.g. prepositions, nouns, and verbs) in each sentence were scored separately. Measurement of the SRT commenced at the first upward reversal. The criterion for stopping the test was: completing the practice sentences plus at least 17 other scored sentences; the real-time calculated standard error for all scored sentences <1 dB. To check the test-retest reliability, 15 volunteer participants were re-evaluated two months after the initial test.

Results

Thirty adults, 14 male and 16 female (20.80 ±1.46 years old) , participated in this study. The results showed that the SRT in the Same Voice co-located condition (SV0°) and in the Different Voice-separated condition (DV±90°) were the highest and lowest, respectively.

The advantage scores were the results of the subtraction of the high cue (DV±90°), SV±90° and DV0° SNRs from Low cue (SV0°) SNR. The advantages obtained were as follows: total advantage=(low cue SNR-high cue SNR), spatial advantage=(low cue SNR, SV±90° SNR), talker advantage=(low cue SNR, DV0° SNR). The results showed that the total advantage score was higher than the other advantage score. The average scores of SRT in all conditions and the advantage scores of the PLiSN-S, Australian [8] and North American [9] version are given in Table 1.

Information related to the mean and standard deviation of the SRT in the four conditions and the test-retest assessment is given in Table 2. The results related to the difference between test-retest scores and p-values are presented using Wilcoxon's test.

All scores except the total and talker advantage scores showed a very slight improvement in performance in the retest. The highest change was 0.7 dB, for the Same Voice ±90°. The minimum changes were related to the spatial advantage score was about 0.2 dB. There was no statistically significant difference between test-retest results in all PLISN-S evaluations (p>0.05).

Discussion

The PLiSN-S sentence equivalence study showed that for a one-decibel increase per SNR, the intelligibility of the sentences increased on average by 16.7% after the equalization was completed. This increase in sentence intelligibility is comparable to 18.7% per dB of the North American version of LiSN-S [7] and 17% per dB of the Australian version [8].

Preliminary normative data showed that the most difficult condition was SV0° in which the SRT/SNR was highest (i.e. poorest). This result is quite expected because acoustic cues including spatial and pitch information were not available for the auditory stream segregation. Instead, scores improved in the other three situations. The lowest (i.e. best) SRT corresponds to the DV+90° condition, where both pitch and spatial cues are available to help segregate the target sentences from the competition. As it is clear from the results, SRT SV±90° was better than DV0°. In the current study, the highest advantage score was observed in the conditions where there are spatial cues available to separate the target sentences from the competing stories (i.e. SV±90° which is equal to 8.3 dB, and DV±90° which is equal to 10.0 dB). It seems that spatial cues were the dominant information for auditory stream segregation in this task. Considering that the primary normative data of the study was collected from young people (19–23 years old), these results cannot precisely be compared with the results of the primary studies of the Australian and North American versions of the LiSN-S conducted on children. But in general it can be said that, the pattern of SRT/SNR changes in the four conditions and advantage score changes between conditions in the PLiSN-S were similar to those of the Australian [8] and the North American version (NA LiSN-S) that were conducted on children aged 6 to 11 years [7], and the Australian version was conducted on participants aged 12 to 60 years [5].

In Brown et al.'s study, NA LiSN-S was investigated on 120 participants with normal hearing, including 67 adolescents (age range:12 to 17 years) and 53 adults (age range:19 to 30 years) [9] and also Cameron et al. examined the Australian version of the LiSN-S in 130 participants aged 12 to 60. Sixty young people in the age range of 18 to 29 years (which is almost consistent with the age range of the present study), were examined [5]. The results of both studies' scores were different from the present study. The amount of talker, spatial, and total advantage scores in the North American and Australian investigation was higher than in our study, and their SNR, low cue SRT, and high cue SRT scores were lower than the results of the present study.

Regarding the data difference between the present study and the North American and Australian version data, several factors, such as language differences, and the number of studied samples may have affected the results also it seems that the use of pitch cues in the Persian language is less than in the English language according to lower talker advantage score in Persian version. In addition, one of the important differences between the Persian and English languages is the use of the vowel /e/ to connect two words in the Persian language. This vowel, which is more often used in the Persian language, can increase the energy level of masking and hence may affect dip listening. Cross-ear dip listening fluctuates in the background energy of sounds that facilitate speech intelligibility by affording speech 'glimpses,' which results in a spatial release of masking [11]. The number of uses of this vowel in the sentences could have been controlled, and perhaps in future studies, it is recommended to pay attention to the number of uses of this vowel in different conditions and use it equally in different conditions. The syllabic structure is different between Persian and English. In English, the maximum consonant cluster at the beginning and end of the syllable is three and four, respectively (consonant-consonant-consonant-vowel-consonant-consonant-consonant-consonant (CCCVCCCC)). However, in Persian, consonant clusters are limited to two consonants [12]. The presence of more consonant clusters in English can justify the greater benefit of the cross-ear dip listening phenomenon.

To obtain cut-off values, the Persian version must be applied to large populations of children, adults, and the elderly.

The test-retest examination found that some conditions' results improved slightly two months after the first evaluation. However, the amount was not statistically significant (changes between 0.2 and 0.7 dB). The most change was 0.7 dB, related to the SV ±90° and the least change was about 0.2 dB related to the spatial advantage. These results, which are consistent with Cameron et al. [5] and Brown et al.'s results [9], showed that the least changes occurred for the advantage scores.

According to the results, it seems that PLiSN-S can evaluate auditory stream segregation, and due to the insignificant difference between test-retest results, it is a potentially valuable tool for monitoring performance over time and the effects of maturation, remediation, or compensation such as an assistive listening device.

Conclusion

In this study, sentence development, sentence equivalence, norming, and examining the test-retest reliability of the Persian version of Listening in Spatialized Noise Sentence (PLiSN-S) were presented. Although the pattern of SRT/SNR changes in the four conditions and advantage changes between conditions in PLiSN-S were similar to the English language versions of this test, the amount of advantage in all conditions in the current study was lower than in the English versions for adult participants, and perhaps the difference in the type and structure of Persian and English languages can be considered as the main reason. The comparison of test-retest results was not significant, so it can be suggested to investigate the spatial processing performance of the auditory system over time and monitor the effect of spatial processing treatment. It is essential to carry out the main normalization study in Persian populations.

Ethical Considerations

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Compliance with ethical guidelines

The approval of the Ethics Committee of Hamadan University of Medical Sciences with the code of ethics IR.UMSHA.REC.1401.173 was obtained.

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Authors' contributions

ZHD: Study design, acquisition of data, interpretation of the results, drafting the manuscript, statistical analysis; NG: Acquisition of data, interpretation of the results, drafting the manuscript; AY: Statistical analysis, application software development and design, Matlab analyzing; NR: Interpretation of the results, drafting the manuscript; HD: Study design, interpretation of the results, drafting the manuscript.

Conflict of interest

The authors declared no conflict of interest.

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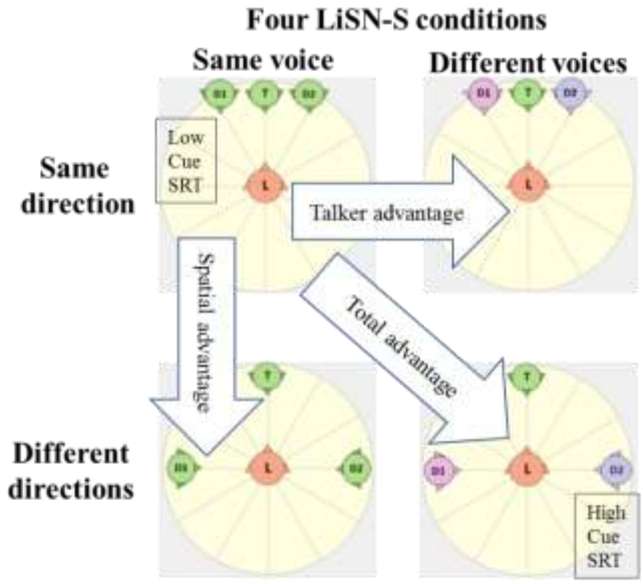

Figure 1. Four listening in spatialized noise sentence conditions. D1 and D2 refer to the two distractors (competing speech). T refers to the target sentences. Same color (green) indicate the same person talking competing speech (D1 and D2) and target sentences (T). Different color (green, purple and blue) indicate that three speakers talking competing speech and target sentences. Purple refer to DI (competing speech 1), blue refer to D2 (competing speech 2) and green refer to target sentences. LiSN-S; Listening in spatialized noise sentence, SRT; speech reception threshold

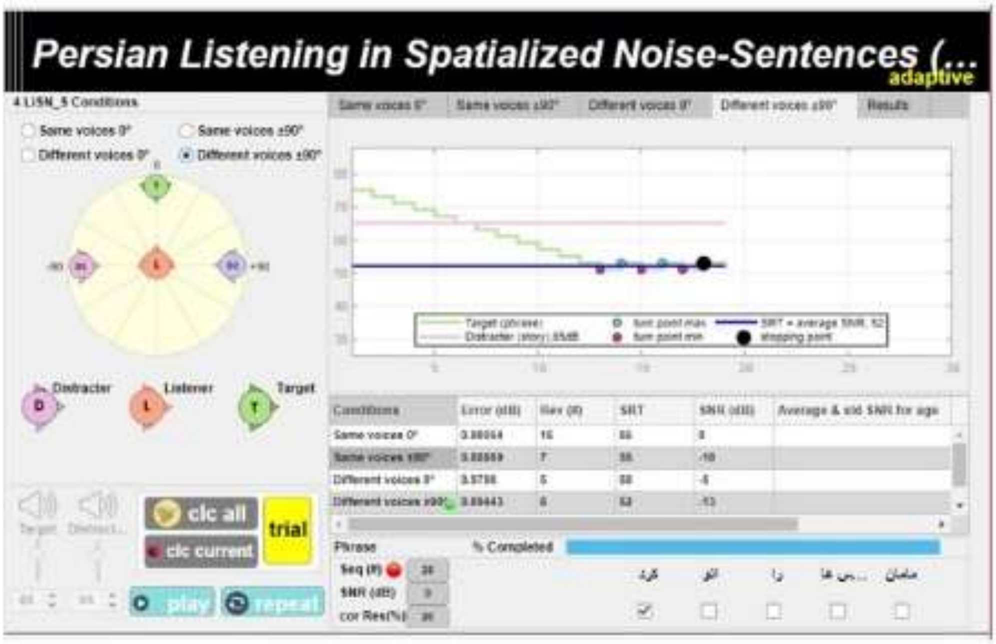

Figure 2. Persian version of listening in spatialized noise sentence test screen. The four conditions of the test are specified. The intensity of the target sentences is changed in 2-dB intervals to reach the speech reception threshold. The top horizontal line shows the level of the distracters, and the lower horizontal line shows the average level of the targets during the stable region.

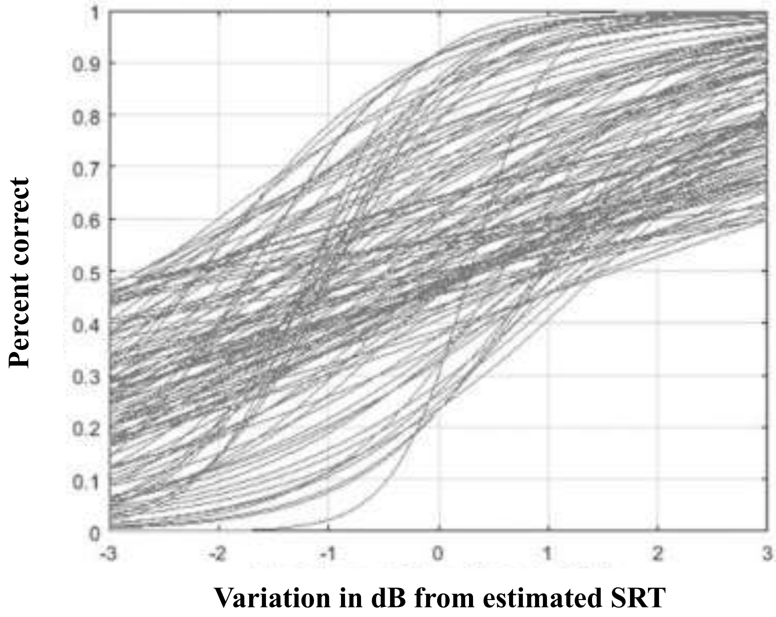

Figure 3. Logit curves for the 120 sentences before adjustment for equal intelligibility.

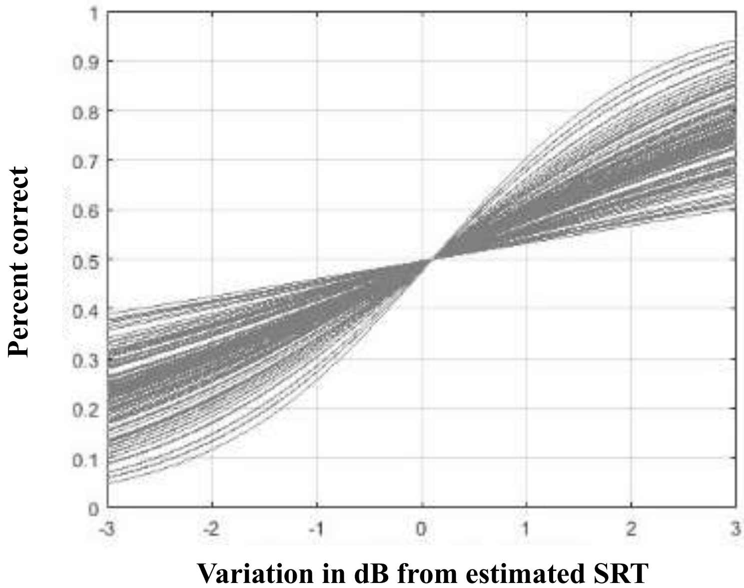

Figure 4. Logit curves for the 120 sentences after adjustment for equal intelligibility

Table 1. Mean and standard deviations (in dB) of speech reception thresholds (expressed as signal to noise ratios) for each condition and advantage measures in Iran (n=30), Australia (n=70)* and North American (n=120)**

Measures	Iran	Australian		North American		
	Hamadan University of Medical Sciences	Male	Female	University of Cincinnati	Calgary Health	University of Texas at Dallas
Low-cue SRT(Mean±SD)	0.1(1.6)	–1.9(1.8)	–1.9(1.7)	–1.8(0.9)	–1.3(1.0)	–1.4(0.9)
High-cue SRT(Mean±SD)	–9.9(2.0)	–15.9(2.2)	–16(2.4)	–15.3(1.9)	–14.3(1.8)	–15(2.3)
SV±90° (Mean±SD)	–8.2(2.2)	-	-	-	-	-
DV 0°(Mean±SD)	–3.7(1.7)	-	-	-	-	-
Talker advantage (Mean±SD)	3.5(1.7)	5.4(2.6)	5.4(2.6)	8.3(2.8)	8.8(2.1)	8.5(2.0)
Spatial advantage(Mean±SD)	8.3(1.3)	12.6(2.1)	12.8(2.1)	11.4(1.5)	11.5(1.7)	11.9(2.1)
Total advantage(Mean±SD)	10.0(1.8)	14(1.9)	14.2(2.1)	13.4(1.6)	13(1.9)	13.6(2.2)

SRT; speech reception threshold, SV; same voice, DV; different voice

* Cameron, Glyde and Dillon, 2011, ** Brown et al., 2010

Table 2. Mean scores and standard deviations (Signal to Noise Ratio in dB) for all conditions at test and retest (n=15)

Measures	Mean(SD)			p
	Test	Retest	Paired difference	
Same voice 0° (low-cue SRT)	–0.1(1.7)	–0.6 (1.8)	0.3(0.7)	0.07
Same voice ±90°	–8.6(2.0)	–9.4(2.6)	0.7(1.4)	0.70
Different voice 0°	–3.3(1.7)	3.5(1.8)	0.6(1.1)	0.60
Different voice ±90° (high-cue SRT)	–10.1(1.9)	–10.6(1.8)	0.4(0.8)	0.10
Talker advantage	2.8 (1.8)	2.7(1.7)	0.5(1.3)	1.00
Spatial advantage	8.6(1.4)	8.8(1.6)	0.2(0.7)	0.30
Total advantage	10.0(1.4)	9.9 (1.4)	0.3(0.6)	0.40

SRT; speech reception threshold