Research Article

Normative Data for Speech-in-Noise Perception Test in Young Adults with Normal Hearing: Gender and Ear Laterality Effects

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Highlights

- The speech perception test in quiet cannot examine the speech tracking in noise
- The normative data for speech-in-noise test in normal adults was investigated
- The normative data for speech-in-noise perception can be used in audiology clinics

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ABSTRACT

Background and Aim: Adding noise to the speech audiometry tests increases the sensitivity and specificity of them. This study aimed to investigate the normative data for the Speech-in-Noise (SIN) perception test in normal-hearing adults aged 18–25, and evaluate the effect of gender and ear laterality on the test score.

Methods: In this cross-sectional study, 126 adults aged 18–25 years with mean(SD) of age: 22.28(1.61) years old participated. The SIN perception test using Persian monosyllabic words was performed in quiet and using 5 signal-to-noise ratios (SNRs; 0,± 5 and ± 10).

Results: The mean of SIN perception score was 96.48, 91 and 82.79% at the SNRs of +10, +5, and 0 for the right ear, and 97.09, 91.42, and 84.11% at the SNRs of +10, +5, and 0 for the left ear, respectively. The interaction effect of gender and ear laterality had no statistically significant effect on the test results in quiet and at any SNRs ($p>0.05$). Moreover, the main effect of gender on the test score was not significant ($p>0.05$), and there was no significant difference in the test score between the right and left ears ($p>0.05$).

Conclusion: Given the importance of including the SIN perception test in the routine audiology tests, considering normative data for this test is important. The normative data found in this study for this test can be routinely used in audiology clinics.

Keywords: Speech-in-noise recognition; word-in-noise recognition; noise; normative data; gender; laterality

Introduction

Hearing and speech perception play important roles in social life. They are necessary for language development in children. In adults, difficulty in perception of speech leads to limited social interactions and isolation. Speech audiometry is one of the main audiological tests that use speech stimuli to assess a person's auditory performance. This test is performed at two levels of threshold and suprathreshold. Speech recognition score using single-syllable words is one of the most important indicators of speech perception at the suprathreshold level. This test can be performed in quiet and in noise [1]. Since most hearing-impaired people complain of the inability to recognize speech in noisy environments, Carhart and Tillman in 1970 proposed the inclusion of Speech-in-Noise (SIN) perception test in the audiological test battery [2]. The SIN perception depends on auditory and extra-auditory factors. Spatial hearing, auditory input manifestations at different levels of the central auditory system, and the use of spectro-temporal cues are among the auditory factors affecting SIN perception [3]. Factors such as cognitive system (e.g. memory and attention) and physical environment characteristics are among the extra-auditory factors. Attention and memory are important cognitive functions that help recognize speech in the presence of background noise by using top-down and bottom-up processing systems. One of the most important physical characteristics effective in SIN perception is the Signal-to-Noise Ratio (SNR), which compares the intensity of a target signal to intensity of background noise [3]. Over the past 40 years, researchers have found that people with hearing impairment need a higher SNR (10–15 dB) than people with normal hearing. With the increase in SNR, a hearing-impaired person's ability to recognize speech increases by about 3% [1]. Therefore, it has been found that the addition of noise to the SIN perception test increases the sensitivity and specificity of the test; by adding multiple noises, the difficulty of the perception increases and the possibility of differentiating people with normal hearing from people with hearing impairment improves [1, 4].

The tests that are used to assess speech recognition in the presence of noise include the SIN test, the word-in-noise test, the hearing-in-noise test, and the quick speech in noise test [5-8]. Unfortunately, most of these tests require the recorded speech materials, CDs, a computer, etc., which may not be available in all audiology clinics [9]. Therefore, providing conditions for the ease of SIN perception assessment without the need for special equipment is necessary. On the other hand, most of clinicians compare the performance of patients to normative data. Normative data are usually collected from people who have no any known disease and are described by using mean and standard deviation and determining the cutoff scores [10]. The present study aimed to investigate the normative data for the SIN perception test in young people aged 18-25 years with normal hearing, using monosyllabic Persian words and live voice. We also examined the effects of ear laterality and gender on the SIN perception test score.

Methods

This descriptive-analytical study with cross-sectional design was conducted on 126 young adults aged 18–25 years referred to the audiology clinic of Ahvaz Jundishapur University of Medical Sciences. The samples were selected from among undergraduate students of this university with normal hearing using a non-probability sampling method. To confirm the health of peripheral auditory system, participants underwent routine hearing tests, including history recording, otoscopic examination using an otoscope (25020a, Welch Allyn Inc., Auburn, New York, USA), tympanometry test using a tympanometer (AZ26, Interacoustics, Denmark), and pure tone audiometry test using an audiometer (AC40, Interacoustics, Denmark) at frequencies of 500, 1000, 2000, 4000, and 8000 Hz. Inclusion criteria were no history of problems in the outer and middle ears, having normal hearing (mean pure tone thresholds <25 dB HL at all frequencies), no history of cognitive and listening difficulties, and being right-handed (because left-handed people process language better than right-handed people due to the fact that the right hemisphere in the left-handed people is more active, which might affect the results [11]). Exclusion criteria were having hearing, cognitive and listening problems and the unwillingness to continue participation. The left-handed participated also were excluded.

For the speech audiometry test, the Speech Recognition Threshold (SRT) was first obtained from each ear. Then, the most comfortable listening level (25–40 dB higher than the SRT) was measured and the subjects were asked to report the intensity level at which they were able to hear easily. Then, the words were presented to their ears and they were asked to repeat what they hear first in quiet and then in the presence of noise (adding five white noises to SNR equal to 0, ±5 and ±10) to measure their speech perception score. In this study, the word lists presented in Mosleh et al.'s study were used including 12 phonetically balanced word lists of 25 words presented randomly to control the training effect [12]. In each subject, the selection of SNR and the assessed ear was made randomly. To calculate the speech perception score, we multiplied the number of words that the subject repeated correctly by 4 and test was performed in one trial. To avoid fatigue, the students were given a 15-minute resting period after evaluation of one ear. All speech materials used in this study presented via live voice.

Statistical analysis

Mean and standard deviation were used to describe the collected data. After measuring the normality of data distribution using Kolmogorov-Smirnov test, we used t-test, one-way and two-way analysis of variance (ANOVA) and Tukey's post hoc test to compare the results. The data analysis was conducted in SPSS 17 software (IBM Corporation, New York, USA), and the significance level for all tests was set at 0.05.

Results

Participants were 126 college students aged 18–25 years with Mean(SD) of age: 22.28(1.61) years old, 60 males and 66 females. Table 1 shows the descriptive results of SIN perception test score in quiet and in different noises (SNRs) presented to the both ears. Comparison of the scores under different pairs of six conditions using one-way ANOVA showed that there was a significant difference between the mean scores of SIN perception at each pair in the right ear ($F_{(5,741)}$=269.903, p<0.0001) and left ear ($F_{(5,734)}$=254.110, p<0.0001). By performing the post hoc test, it was found that in both ears, there was a statistically significant difference between the means of SIN perception scores at each pair of conditions (p<0.001), except for the SNR +10 and in quiet mode (p>0.05).

Table 2 shows the descriptive results of SIN perception scores under different study conditions separately for each gender and ear. The results of two-way ANOVA showed that, in quiet and at all SNRs, the interaction effect of gender and ear laterality had no statistically significant effect on the results (p>0.05). The main effect of gender on the SIN perception test score was not significant, either (p>0.05). Moreover, there was no significant difference in SIN perception scores between the right and left ears (p>0.05).

Discussion

As our environment contains many background noises, it is important to evaluate the speech perception in such environments. The speech perception tests in quiet environments cannot examine the ability of SIN perception. Hence, the importance of speech perception in the presence of noise has been raised since 1970 [2]. This study evaluated the SIN perception scores of young adults with normal hearing aged 18–25 years. The findings showed that the speech in quiet perception of par-

Table 1. Descriptive statistics of speech recognition scores in six conditions in both ears (n=126)

Ear	Condition	Mean(SD) (%)	Min (%)	Max (%)
Right ear	Silence	99.68(1.09)	96	100
	SNR 0	82.79(9.17)	60	100
	SNR +5	91.00(6.63)	64	100
	SNR +10	96.48(4.97)	76	100
	SNR –5	71.19(14.36)	44	100
	SNR –10	57.67(19.08)	24	96
Left ear	Silence	99.68(1.09)	96	100
	SNR 0	84.11(9.01)	64	100
	SNR +5	91.42(6.69)	72	100
	SNR +10	97.09(3.81)	88	100
	SNR –5	72.96(14.14)	44	100
	SNR –10	58.72(19.46)	24	100

SNR; signal to noise ratio

Table 2. Descriptive statistics of speech recognition scores in six conditions in both genders' right and left ears (n=126)

Gender	Ear	Mean(SD)					
		Silence	SNR 0	SNR +5	SNR +10	SNR –5	SNR –10
Male	Right	99.60(1.10)	81.50(8.70)	90.40(6.80)	96.40(5.40)	69.20(13.60)	55.10(16.70)
	Left	99.70(1.00)	83.80(8.20)	92.00(6.50)	97.80(3.40)	71.20(12.30)	56.50(17.30)
Female	Right	99.60(1.00)	83.90(9.40)	91.50(6.40)	96.50(4.40)	72.90(14.80)	59.80(20.70)
	Left	99.60(1.10)	84.30(9.70)	90.80(6.80)	96.40(4.00)	74.40(15.40)	60.50(21.00)

SNR; signal to noise ratio

ticipants was 99–100% in both ears and in both genders, which was reduced when a noise was added. Although the SIN perception score depends on the type of speech stimulus, (e.g. consonant-vowel or word), and the type of noise (e.g. speech noise, babble, etc.), with the increase of noise level, the difficulty of perception increases and the perception score decreases in all tests [8, 13–15].

Due to a significant increase in the minimum and maximum range of SIN perception score with a SNR of –5 and –10, it can be said that the negative SNRs increases the degree of perception difficulty in people; due to the high difficulty and wide response range, negative SNRs do not seem to be suitable for collecting normative data and evaluation. It can be concluded that, the SNR of 0, +5, and +10 in the right and left ears can be used clinically as a norm and criterion for assessing SIN perception. In a study for finding the normative data of AzBio sentence recognition test, after evaluating the SNRs of +10, +5, 0, –5, and –10, the use of 0, +5, and +10 SNRs were suggested for clinical evaluation in adults [15]. According to the findings of the present study, the mean of SIN perception score was 96.48, 91, and 82.79% at the SNRs of +10, +5, and 0 in the right ear, and 97.09, 91.42, and 84.11% at the SNRs of +10, +5, and 0 in the left ear, respectively.

Despite studies on the superiority of the right ear and left hemisphere [16-18] and the result of Wilson's study on the superiority of word recognition score in the presence of noise in the right ear [19], the scores of two ears at different SNRs in our study were not significantly different, as reported in some studies [20, 21]. Anatomically, the male brain is larger according to human and animal studies [22, 23]. Thus, gender differences in human performance have been found [23]. Gender differences in the gray matter and white matter volumes in the brain have also been observed [24]. On the other hand, peripheral hearing sensitivity, auditory processing ability, and cognitive skills affect SIN perception score [25]. Some studies have shown differences in the reduction of peripheral hearing sensitivity between males and females [26, 27], while Cruickshanks et al. showed no difference in the rate of reduction [28]. Despite the contradictory results regarding the effect of gender on peripheral hearing sensitivity, it has been found that the cognitive skills of males and females are different [29]. For example, females perform better memory, language, and perceptual skills [29, 30]; however, according to the study by Miller and Halpern, many conclusions about gender differences in cognitive abilities need to be reexamined [31]. In our study, similar to other studies [28, 31, 32], it was found that gender factor in subjects aged 18–25 years and at different SNRs had no effect on the SIN perception score. The reason for this finding may be the fact that word in noise recognition tests rely more on listening skills rather than cognitive skills [33].

Evaluating and finding normative data for monosyllabic word in noise recognition tests in people at the ages of 18 to 25 years has several advantages. By assessing speech recognition at the suprathreshold level, instead of setting the threshold at the 50% of response rate, the perception ability of the individual can be assessed more accurately. Using words instead of sentences leads to the assessment of auditory skills, rather than cognitive and linguistic skills, and can be better distinguishable to patients with central auditory processing disorders compared to normal-hearing people [4, 33]. By choosing a limited age range, more reliable results can be obtained because studies have indicated the importance of paying attention to the effect of age on the test results in children (<12 years) and the elderly (≥65 years). Therefore, it is necessary to determine a separate list of monosyllabic words for children and consider the reduced perception score in the elderly with normal hearing [34]. Due to the presence of babble noise in everyday conversation, it is important to evaluate the auditory perception in normal-hearing adults in the presence of babble noise [35]. One of the limitations of this study was the lack of normative data determination for other age groups; in children and the elderly, the SIN perception test score is lower [34]. therefore, it is recommended that this study be performed in other age groups.

Conclusion

Given the importance of including the SIN perception test in the routine audiology tests, having normative data and standard data for this test is important. The normative data found in this study can be routinely used in audiology clinics for young adults aged 18–25 years.

Ethical Considerations

Compliance with ethical guidelines

All participants signed an informed consent form. The study was approved by the research ethics committee of Ahvaz Jundishapur University of Medical Sciences (Code: IR.AJUMS.REC.1400.268).

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Authors' contributions

MA: Study design, interpretation of the results, drafting the manuscript, and revision the manuscript; MM: Acquisition of data; SZR: Acquisition of data; HA: Acquisition of data; ZIPM: Acquisition of data, drafting the manuscript, and revision the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest to be reported.

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