Research Article

The Use of Homotonic Monosyllabic Words in the Persian Language for the Word-in-Noise Perception Test

Seyede Faranak Emami[1,2]

[1] *Department of Audiology, School of Rehabilitation Sciences, Hamadan University of Medical Sciences, Hamadan, Iran*
[2] *Hearing Disorder Research Center, Hamadan University of Medical Sciences, Hamadan, Iran*

Use your device to scan and read the article online

Citation: Emami SF. The Use of Homotonic Monosyllabic Words in the Persian Language for the Word-in-Noise Perception Test. Aud Vestib Res. 2024;33(1):28-33.

https://doi.org/10.18502/avr.v33i1.14271

Highlights

- The WINP test evaluates the auditory brain's function in understanding the meaning
- The homotonic-monosyllabic words with the same vowel were used for the WINP test
- Since there are 6 vowels in the Persian language, the test has 6 lists of 25 words

Article info:
Received: 30 May 2023
Revised: 16 Jul 2023
Accepted: 27 Jul 2023

Corresponding Author:
Department of Audiology, School of Rehabilitation Sciences, Hamadan University of Medical Sciences, Hamadan, Iran.
faranak_imami@yahoo.com

ABSTRACT

Background and Aim: Speech perception is an important auditory need. A test that can evaluate the function of the auditory brain in discovering consonants and understanding meanings in Persian language is necessary. Therefore, this study aims to determine the norm values of the Word-in-Noise Perception (WINP) test for Iranian people aged 18–25 years.

Methods: In this study, participants were 101 people with normal hearing, stress level, night sleep, and mini-mental states. The measures were the 28-item general health questionnaire, mini-mental state examination, Petersburg sleep quality index, acoustic immittance assessment, pure tone audiometry, speech reception threshold evaluation, and the WINP test with Homotonic-Monosyllabic Words (HMWs). Data analysis was performed using the Mann-Whitney U test.

Results: The mean scores of the WINP test at three Signal-to-Noise Ratio (SNRs) of 0, +5, +10 dB were 53.14%, 68.15%, 88.70% for the right ear; 52.95%, 67.83%, 88.13% for the left ear; and 53%, 68%, 88% for both ears, respectively. The mean scores of the right ear were higher than those of the left ear, and the women's scores were higher compared to men; however, the differences were not statically significant.

Conclusion: By using the WINP test with the HMWs, it is possible to evaluate the function of the auditory brain in understanding the consonants in Persian language. The WINP test scores are similar between both ears and both sexes.

Keywords: Speech perception; noise; lexical; semantic

Introduction

There are two main mechanisms in speech processing for non-tonal languages: phonological and semantic. Phonological processing includes sound structure and phonetics [1]. The speech sound structure contains fundamental frequency (F0) and its formants (F1, F2, F3) [2, 3]. The vocal cord vibration in humans produces F0 [2]. The resonance of the vocal tract creates formants. F0 is the lowest frequency and the most energetic part of the sound spectrum [3]. The psychoacoustic equivalent of F0 is the pitch of the human voice (100–400 Hz), which is stable for each individual [4]. When the vowels of the same language are produced by the same speaker, they have the same F0, but different formants [2]. The brainstem is sensitive to F0 and its formants, thus, recognizes the vowels and the pitch of the voice [3]. The F0 does not provide the necessary information for the semantic processing. The auditory brain is not sensitive to F0, but it reacts to the difference in the frequency of vowels and is more sensitive to F1 and F2. The sensitivity of the auditory brain to F1 and F2 of foreign language vowels is similar to that of native language [5]. In this way, it detects phonemes (sound units) and consonants that are in spoken syllables [4]. The auditory brain recognizes the smallest meaningful unit of speech, which is called a morpheme [6]. Consequently, in the processing of single words, the auditory brain has two important roles: Recovery of phonological processing, and access to lexical-semantic information [7]. Semantic processing consists of two stages: choosing the correct word to express the desired content, and knowing the meaning and grammatical position of words in sentences [1].

Speech Recognition Score (SDS) or Word Recognition Score (WRS) tests, are performed in quiet or in noise by non-Homotonic-Monosyllabic Words (non-HMWs) [8]. The non-HMW lists have different vowels [4]. Words with pitch changes can facilitate the phonological processing by the brainstem [1, 3]. If these non-HMW lists are spoken in sequence, they create a sense of tonality change in the listener. They contain many phonological information that provides listeners with many phonetic codes [8]. Then, the brainstem is involved in the detection of speech vowels and the recognition of non-HMWs [5]. However, if the HMW lists are spoken in the same sequence, they no longer create a sense of tonality change in the listeners and convey a sense of uniformity, thus it will not be possible to distinguish them based on their similar tonality [8]. As a result, the participation of the brainstem in the recognition of vowels is restricted and the auditory brain discovers speech consonants. Therefore, lexical-semantic processing is performed [1, 3, 8]. Considering the important role of the auditory brain in speech perception in noise [5], it is necessary to have a valuable criterion for lexical-semantic processing. Therefore, this study aimed to determine the norm of the Word-in-Noise Perception (WINP) test for Iranian people aged 18–25 years.

Methods

This cross-sectional study was conducted in the winter of 2023 in Hamadan, Iran. Participants were 101 people aged 18–25 years (mean age: 21.81±1.00 years), including 41 women (40.59%; mean age: 21.93±1.43) and 60 men (59.41 %; mean age: 21.63±1.51) who were selected from among 167 volunteers with normal hearing thresholds, normal levels of stress, night sleep quality, and mini-mental states.

The inclusion criteria were: being monolingual (Persian), right-handiness, having a normal score in stress testing (based on 28-Item general health questionnaire), night sleep (based on Petersburg sleep quality index), mental health (based on mini-mental state examination). The exclusion criteria were: unwillingness to participate in the study, having hearing, speech, and general health problems, drug use, smoking, and being left-handed. The measures were the 28-Item general health questionnaire, mini-mental state examination, Petersburg sleep quality index, acoustic immittance measure (clarinet middle-ear analyzer), pure tone audiometry, speech perception threshold test (AC33 audiometer, Interacoustics, Denmark), and the WINP test using three Signal-to-Noise Ratios (SNRs) of 0, +5, +10 dB. All general audiological tests were performed in the audiology department of Hamadan University of Medical Sciences. For the WINP test, phonetically balanced monosyllabic word lists of the Persian language (i.e. HMWs) were used [8]. Since there are 6 vowels in the Persian language, 6 lists of 25 HMWs were selected, with one vowel in each list (See Appendix A). All HMWs were checked and approved by 20 experts in linguistics and Persian literature. Phonetic and frequency spectrum similarity of HMWs were assessed by an expert in psychoacoustics using the Fourier analysis. In this regard, the HMWs that were not simple and fluent in terms of meaning were removed and those with phonetic inconsistencies were excluded. The HMWs were recorded in the recording studio by a woman speaker, and then white noise was added to the speaker's voice.

The WINP test was done at the comfortable listening level of the participants and the recorded voice was presented through a high-quality headphone connected to a computer. Each ear was examined separately. Participants were asked to respond quickly. The interval between the two words was 2000 ms. If there was no response, the next trial was automatically initiated 2000 ms after the last word was played [8]. The inter-trial interval of each 25 HMW list was 1000 ms. In other words, after presenting the last word in each list, there was a pause for 1000 ms and the first word of the second list was then presented after 3000 ms. To calculate the norm of the WINP test, we multiplied the number of HMWs repeated correctly by 4 and expressed the norm in percentage: 25×4=100 %. The statistical analyses were done in SPSS v.17 software. Kolmogorov-Smirnov test or Shapiro-Wilk test were to check the normal distribution of variables. Norm values were defined by mean, standard deviation, and percentage. Mann-Whitney U test was used to examine the differences between variables. $p<0.05$ was considered statistically significant.

Results

The mean scores of the WINP test were 53.14%, 68.15%, and 88.70% in the right ear; 52.95%, 67.83%, and 88.13% in the left ear; and 53%, 68%, 88% for both ears, respectively (Table 1). The mean scores of the WINP test for the right ear were greater than for the left ear, but the differences were not statistically significance at the SNRs of 0, +5, and +10 dB (p=0.841, 0.736, and 0.873). The mean scores for the right ear were greater than for the left ear, but, the differences were not statistically significance at the SNRs of 0, +5, and +10 dB (p=0.750, p=0.615, p=0.549 respectively).

No significant differences were observed in WINP scores between women (Table 2) and men (Table 3) at SNRs of 0, +5 and +10 dB (p=0.729, p=0.652, p=0.901 respectively).

Table 1. Mean scores (%) of the word-in-noise perception test at the signal-to-noise ratio of 0, +5, and +10 dB for the right (n=101) and left (n=101) ears

Ear	SNR	Mean±SD	Max	Min
Right	0	53.14±14.80	90	20
Left	0	52.95±15.99	100	22
Right	5+	68.15±13.21	100	36
Left	5+	67.83±12.95	96	32
Right	10+	88.70±10.57	100	70
Left	10+	88.13±12.64	100	68

SNR; signal-to-noise ratio

Table 2. Mean scores (%) of the word-in-noise perception test at the signal-to-noise ratio of 0, +5, and +10 dB for the right (n=41) and left (n=41) ears of women

Ear	SNR	Mean±SD	Max	Min
Right	0	54.67±12.59	100	32
Left	0	53.17±18.45	100	28
Right	5+	70.23±11.70	100	40
Left	5+	68.54±10.83	96	36
Right	10+	90.12±9.42	100	72
Left	10+	88.78±11.35	100	72

SNR; signal-to-noise ratio

Table 3. Mean scores (%) of the word-in-noise perception test at the signal-to-noise ratio of 0, +5, and +10 dB for the right (n=60) and left (n=60) ears of men

Ear	SNR	Mean±SD (%)	Max	Min
Right	0	52.97±17.352	90	20
Left	0	51.89±19.428	90	22
Right	5+	68.64±14.139	96	36
Left	5+	67.90±15.276	96	32
Right	10+	87.45±11.376	100	70
Left	10+	86.99±10.795	100	68

SNR; signal-to-noise ratio

Discussion

In this study, the norms of the WINP test were obtained by calculating the mean scores for Iranian people aged 18–25 years. The results showed that the norms at the SNRs of 0, +5, and +10 dB for the right and left ears were 53.14±14.80%, 68.15±13.20%, 88.70±10.56%, and 52.95±15.92%, 67.83±12.94%, 88.13±12.60%, respectively. In a recent study, the norm values of the WINP test in Persian language for the age group of 14–35 years for the right and left ears at the SNR of 0, +5, +10 dB were reported as 54.20±13.78%, 67.47±17.06%, 88.13±9.13%, and 52.47±17.62%, 66.67±15.55%, 87.73±13.68%, respectively [8]. As can be seen, all standard deviations are high. In our study, the minimum WINP scores in the right and left ears at three SNRs were 20%, 36%, 70%, and 22%, 32%, 68%, respectively. Investigating the causes of our high standard deviations requires extensive and detailed studies. We cannot conclude that the lower WINP scores are due to central auditory processing disorder. Perhaps, individual differences (such as the amount of reading per day, lifestyle, genetic factors, stress, diet) have caused the difference.

To fully explain the importance of lexical-semantic processing and the need to use the WINP test, we take a brief look at the speech processing stages (for non-tonal languages), ranged from basic to advanced stages: detection (hearing), recognition (discrimination), interpretation, and perception. In the detection stage, a person can hear the sounds or discover two-syllabic words and repeat them, which are easier to detect due to their pitch variations [3]. In the recognition stage, a person can perceive that each word belongs to a real object in terms of phonetics, and that each object in a language has a unique sound [5]. Hence, s/he has the ability to distinguish the phonetic differences between words and produce the corresponding sound of each word [9]. At this stage, the meaning and concept of the words are not perceived, and the person only learns and memorize the phonetic form of the words [10]. The person has the ability to discriminate monosyllabic words and repeat them [4]. In the interpretation level, the linguistic knowledge of phonetics is obtained and the person knows that each sound has a specific meaning and concept. Therefore, its understanding and production requires attention and mental effort to discover the meanings of the heard words [10]. This stage is specific to understanding new words that have not been included in a person's vocabulary yet and s/he requires to use her/his all senses to learn and understand them. Creating an auditory object in the mother language is created by all the senses (auditory, visual, tactile, taste, olfactory, proprioceptive, and vestibular), which has a spatial or three-dimensional shape [5]. In the perception step, the auditory object is created for the words, and each word has a three-dimensional shape in the person's mind [4]. This stage does not require mental effort and attention to perceive and produce the words. By hearing each word, their meanings and spatial forms are recalled in the person's mind and can produce the perceived concepts [9, 10]. Therefore, since the most important aspect of human hearing is the word perception in competitive situations for communication, speech-in-noise perception is the main goal of speech performance, which includes access to lexical-semantic information [1, 11]. Evaluation of speech-in-noise perception is one of the most important indicators for examining patients with peripheral or central hearing loss, which should be done when providing diagnostic, therapeutic, rehabilitation services and prescribing hearing aids [4].

The list of HMWs, which was designed for the WINP test, includes 6 vowels and 29 phonemes in Persian language which are phonetically balanced monosyllabic words. If the words are presented randomly from different lists (non-HMWs), it can be appropriate for the SDS or WRS (in quiet or in noise) and the vowel recognition performance by the brainstem can be assessed. If words are presented sequentially from the list, they are suitable for the WINP test [8]. Then, due to the phonetic similarity of the words in each list, the performance of the auditory brain is evaluated in terms of the discovery of consonants and lexical-semantic processing [1].

The phonemotopic mapping is specific to the HMW processing, which are spoken in sequence. It is the central representation of speech phonemes, which done by the participation of the secondary auditory cortex and all brain regions in noisy environments [3, 4]. The tonotopic mapping is specific to detecting the changes in the tonality of the non-HMWs, which are spoken in sequence. Tonotopic mapping is extended from the cochlea to the primary auditory cortex [9]. As a result, word recognition tests (in noise or in quiet) are more sensitive in evaluating the tonopic map [4]. The WINP test using the HMWs evaluates speech-in-noise perception. The tonality changes of the vowels in spoken sentences are more than those of the vowels pronounced in separate words. The activity and firing rates of nerve fibers in spoken sentences are more than in single words [2]. The comprehension of the words in spoken sentences is much easier than in a list of separate words. The spoken sentences contain more phonological information than single words, because the strength and fluency of the words in spoken sentences are more than in single words [9].

In this study, no significant differences were observed in the WINP test scores between men and women, while sexual dimorphism exists in the human auditory system due to the effect of estrogen hormone which has a protective role in the auditory functions of women [12]. In fact, in women the number of outer hair cells are more and shorter than men. In addition, it seems that hearing performance from the cochlea to the cerebral cortex is better in women than in men, due to the stimulating effects of estrogen [13]. In a study, girls and women had better hearing at high frequencies than boys and men. The harmful effects of sound cause more hearing loss in men compared to women [9]. In a study on the pre-primary and primary school children, it was observed that the hearing thresholds of girls were better compared to boys [14]. The amplitudes of otoacoustic emissions and brainstem auditory responses were smaller in women than in men, and spontaneous otoacoustic emissions were more recordable in women, although the differences were not statistically significant [12-14].

Furthermore, in our study, the right ear of WINP participants did not show a dominant performance compared to their left ear. Despite the fact that the role of the brain hemispheres in auditory processing is not the same [9]. The prepared HMW lists for the WINP test in this study can be a template for other non-tonal languages. Iran is a country where different languages are spoken including Persian, Turkish, Kurdish and Arabic. Audiologists living in the cities where these languages are spoken can use the prepared HMW lists to prepare the WINP test materials.

Conclusion

The Word-in-Noise Perception (WINP) test is a novel test for lexical-semantic assessment. The norm values of the WINP test using the Homotonic-Monosyllabic Words (HMWs) can be used for estimating the meaning comprehension. By using the HMWs, it is possible to evaluate the performance of the auditory brain in understanding the consonants. The WINP test scores of women are not different from the scores of men. Also, the right ear does not have a dominant function compared to the left ear in this test.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the ethics committee of Hamadan University of Medical Sciences (Code: IR.UMSHA.REC.1401.419).

Funding

This study was financially supported by Hamadan University of Medical Sciences (Grant Number: 140105183699).

Authors' contributions

This article has only one author.

Conflict of interest

There are no competing financial interests.

Acknowledgments

The author would like to thank the participants for their cooperation in this study.

References

[1] Hickok G, Poeppel D. The cortical organization of speech processing. Nat Rev Neurosci. 2007;8(5):393-402. [DOI:10.1038/nrn2113]

[2] Emami SF. Is all human hearing cochlear? Scientific World Journal. 2013;2013:147160. [DOI:10.1155/2013/147160]

[3] Abrams D A, Kraus N. Auditory Pathway Representations of Speech Sounds in Humans. In: Katz J, Chasin M, English K, Hood LJ, Tillery KL, editors. Hand book of Clinical Audiology. 7th ed. Philadelphia: Wolters Kluwer Health. 2015. p. 527-44.

[4] Emami SF, Shariatpanahi E. Central Representation of Speech-in-Noise Perception: A Narrative Review. Aud Vestib Res. 2023;32(3):166-73. [DOI:10.18502/avr.v32i3.12932]

[5] Emami, SF. Central Representation of Cervical Vestibular Evoked Myogenic Potentials. Indian J Otolaryngol Head Neck Surg. 2023;6:1-7. [DOI:10.1007/s12070-023-03829-8]

[6] Hickok G, Poeppel D. Towards a functional neuroanatomy of speech perception. Trends Cogn Sci. 2000;4(4):131-8. [DOI:10.1016/s1364-6613(00)01463-7]

[7] Humphries C, Willard K, Buchsbaum B, Hickok G. Role of anterior temporal cortex in auditory sentence comprehension: an fMRI study. Neuroreport. 2001;12(8):1749-52. [DOI:10.1097/00001756-200106130-00046]

[8] Emami SF, Shariatpanahi E, Gohari N, Mehrabifard M. Aging and Speech-in-Noise Perception. Indian J Otolaryngol Head Neck Surg. 2023;75(3):1579-85. [DOI:10.1007/s12070-023-03689-2]

[9] Scott SK, Sinex DG. Speech. In: Rees A, Palmer A, editors. The Oxford handbook of auditory science: the auditory brain. 1st ed. New York: Oxford University Press; 2010. p. 193-214.

[10] Hickok G, Okada K, Barr W, Pa J, Rogalsky C, Donnelly K, et al. Bilateral capacity for speech sound processing in auditory comprehension: evidence from Wada procedures. Brain Lang. 2008;107(3):179-84. [DOI:10.1016/j.bandl.2008.09.006]

[11] Indefrey P, Levelt WJ. The spatial and temporal signatures of word production components. Cognition. 2004;92(1-2):101-44. [DOI:10.1016/j.cognition.2002.06.001]

[12] Emami SF, Gohari N, Ramezani H, Borzouei M. Hearing Performance in the Follicular-Luteal Phase of the Menstrual Cycle. Int J Otolaryngol. 2018;2018:7276359. [DOI:10.1155/2018/7276359]

[13] Emami SF. Studying the Inter-Peak Latencies of Auditory Brainstem Response in Menopause Women. J Iran Med Counc. 2022;5(4):677-84. [DOI:10.18502/JIMC.V5I4.11341]

[14] Emami SF, Farahani F, Mortazavi SS. Studying of Distortion Product of Otoacoustic Emissions in Menopausal Women. Indian J Otolaryngol Head Neck Surg. 2023;75(Suppl 1):88-92.