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Original Article

Development, Validity and Reliability of the Persian Version of the Consonant-Vowel in White Noise Test

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ABSTRACT

Background: One of the most common complaints expressed by individuals with hearing-impairment is the difficulty in speech perception in background noise. Different tests have been developed for the evaluation of reduced ability of speech perception in noise, and the Consonant-Vowel in noise test is one of the simplest one regard to speech materials. The goal of the present study was development and determined validity and reliability of the Persian version of the Consonant-Vowel in noise test, among 18 to 25 year old Persian speaking because of the lack of a Persian version of this test.
Methods: This was a tool-making research that had 3 main stages: development of the Persian version of the Consonant-Vowel in noise test (4 lists and each list in 5 different signal to noise ratio), examination of its content validity, and its administration on a total of 50, 18 to 25 year normal hearing individuals (20 men /30 women) that selected by random sampling method, in order to examine the reliability of the test from the students of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. For descriptive reports, central tendencies and indices of dispersion were used and for statistics relations; Pearson correlation test, intra-class correlation coefficient (ICC), paired t-test and independent t-test were used.
Results: The content validity ratio for each item was acceptable (CVR>0.62). The lists number 2, 3, and 4; and also the lists number 1 and 4 in the Consonant-Vowel in noise test, were highly correlated (P<0.05). The test-retest correlations were statistically significant at all signal-to-noise ratios (P<0.05). There was no significant differences between the scores of left and right ears (P>0.05) and also men's and women's scores (P>0.05). Participant's performance improved as the SNR increased.
Conclusion: According to the study results, it can be concluded that the Persian version of the Consonant-Vowel in noise test has acceptable content validity and reliability, and can be used in clinical and research works.

Introduction

In our acoustic environment, we are rarely confronted with a single auditory signal; rather auditory system must process simultaneously occurring complex acoustic signals to extract relevant information. The canonical example of this is listening to speech in noise, a task that needs complex interactions between auditory system and cognitive skills (such as attention and memory) of the central nervous system to be able to differentiate between

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a target sound and competitive noise [1]. According to the theories regarding speech perception in noise, top-down and bottom-up mechanisms are involved in this ability. Bottom-up mechanisms are fundamental mechanisms in the auditory processing of acoustic stimuli in the central nervous system such as brainstem [2]. Top-down mechanisms involve different mechanism such as the effect of attention and using the syntactic and semantic characteristics of the text, cognitive and language processing. In fact, this information leads to internal redundancy in speech signals, and allows the listener to perceive a speech message, even in the hardest communication situations or in the presence of a competitive message that leads to a reduction in the external redundancy of stimulus [3].

Difficulties in speech perception in noisy environments are one of the most common signs of central auditory processing disorders (CAPD) [2]. The clinical use of separated diagnostic category for CAPD started in the 1970s. CAPD refers to difficulties in the perceptual processing of auditory information at the level of the central auditory nervous system. Today, the main diagnostic measures of central auditory processing disorder are classified into 2 main categories, including behavioral and electrophysiological measures [4]. One of the important parts of behavioral evaluation skills is the evaluation of speech perception in noise.

Given that CAPD is a category consisting of complex and heterogeneous disorders with unknown origins, different tests with different speech materials have been developed to assess the processes dependent on auditory pathways (from the most peripheral centers to higher-level processing centers in the auditory system) and processes dependent on speech and language pathways to determine the nature of a processing deficit [3].

There are several tests to assess speech understanding in noise in English language. These tests include Quick Speech In Noise test (QSIN), Word In Noise test (WIN), Hearing In Noise Test (HINT), Speech Perception In Noise test (SPIN) and Consonant-Vowel in noise test [5-9]. Persian versions of WIN and QSIN tests are available [10,11]. The WIN was developed to quantify the ability of adults to understand speech in a background of multitalker babble [6]. It uses the monosyllabic words presented at multiple signal-to-noise ratios. The QSIN is a faster version of the original Speech In Noise test. It consists a series of sentences presented in a background of four-talker babble [7].

Some of these speech perception in noise tests are more dependent on the abilities related to top-down auditory pathways, such as the tests that include word or sentence repetition that involve syntactic and semantic characteristics, dependent on attention and memory abilities, in which a person is able to guess the key words that have not been heard completely such as QSIN, SPIN and WIN [5,12]. Some other tests evaluate bottom-up auditory processing pathways; these tests, in fact are less dependent on the contextual, syntactic and semantic characteristics and are more focused on the acoustic processing pathways. In these tests nonsense and short speech stimuli were used. This kind of stimulus structure was chosen to avoid the confounding effects of linguistic cues, increases the contribution of acoustic factors and more accurate examination of the bottom-up and subcortical pathways involved in the processing of speech stimuli. One of the most appropriate tests with these properties, is the Consonant-Vowel in noise test [5,13].

The Consonant-Vowel in noise test is a test for quantifying hearing ability in noise. Nonsense syllables are use in this test. A nonsense syllable is a one-syllable sequence of letters without any semantic or syntactic quality [13]. In every language, these syllables are phonologically correct and pronounceable [14]. There are 3 syllable structures in Persian: 1. Consonant-Vowel (CV) 2.Consonant-Vowel-Consonant (CVC) and 3.Consonant-Vowel-Consonant-Consonant (CVCC) [15]. Among these structures in Persian, the Consonant-Vowel structure was used because less cognitive abilities like attention and memory need in CV structure than CVC or CVCC and minimize the impact of adjacent vowels, so this structure is more suitable for auditory bottom-up pathway evaluation [13]. In this regard, many studies use nonsense syllables in the form of consonant-vowel combinations (like /ga/ and /da/) [5]. Some studies with these properties have been done and published by Alawn et al, Hant et al, Shobha et al and Zaar et al [5,13,16,17]. Also many studies use plosive consonants in consonant-vowel (CV) combinations. The reasons for using plosive consonants were as follows: these consonants are produced by throwing the air out of the mouth, they are very dependent on their neighboring vowels for perception and because they are at the medium frequency range (2500-3000 Hz), they may be more covered with noise, and have a more salient role in correct speech perception in noise than other consonants [18]. Another reported reason for choosing plosive consonants was that recognition of plosive consonants in the initial part of a word is dependent on acoustic characteristics (such as fundamental frequency) [15].

Due to the importance of speech perception in noise skill in auditory processing and language-cognitive disorders in one side and lack of the Persian version of the speech perception in noise test in evaluating lower-level processing pathways in the auditory system in other side, present study were performed in order to develop the Persian version of the Consonant-Vowel in noise test.

Methods

In conducting this research, all the ethical considerations suggested by the Graduate Studies Committees of the University of Social Welfare and Rehabilitation Sciences were taken into account (IR.USWR.REC.1394.248). Participants were allowed to leave the study at any time and for any reason.

The present study was a tool-making research that had 3 main stages: development of the test, examination of its content validity, and its administration on a group of 50 participants in order to examine reliability.

Twenty men and 30 women in the age group of 18 to 25 years old with normal hearing participated in the last stage of experiments.

In the selection of nonsense syllables, among the Persian consonants, we used plosive consonants. Plosive consonants are divided into 2 categories: voiced consonants, including /q/, /g/, /d/, and /b/; and voiceless consonants, including /?/, /k/, /t/, and /p/ [15]. With regard to the place of articulation, the consonants /b/ and /p/ are bilabial, /d/ and /t/ are dental, /g/ and /k/ are palatal, /q/ and /?/ are pharyngeal. In addition, we chose these vowels among the possible ones: /â/, /i/, and /u/ in accordance with other published studies in this field [5,16,17]. Non sense syllables with a Consonant-Vowel pattern were developed. These nonsense syllables were not similar to any certain word, and did not convey any particular meaning or concept.

In the second stage, according to the opinion of this study's linguistician, proper syllables among the constructed ones were selected. Then the developed syllables in order to determine content validity was checked by several audiologists and Speech-language pathologists. In doing so, a questionnaire consisting of a list of the test materials was sent to 10 audiologists and Speech-language pathologists to give their opinions on the nonsense syllables. Therefore, the content validity ratio (CVR) was calculated for each nonsense syllable item. Finally 12 nonsense syllables out of 18 were selected by experts. After making some necessary modifications, the final version containing 4 lists was developed. Each list comprised of 25 syllables, and the syllables were randomly put into the lists, so that each syllable repeated at least 2 times in every list. In addition, the syllables were presented at 5 different SNRs (-6, -12, 0, +6, +12) and silence. Finally, a score of 4 was assigned to each syllable, so that if any person had the correct answer to all items in each SNR at each list, the sum score was equal to 100. Then, the test was prepared to be recorded.

In the second stage of the study, the test was developed. In the test, 2 kinds of stimuli were used: nonsense syllables and white noise. The speech stimuli were recorded in the Islamic Republic of Iran Broadcasting center by a male speaker who was familiar with phonological issues. Then the MATLAB software (MathWorks, Natick, USA) was used to add noise to the speech stimuli at different SNRs. Finally the WavePad Sound Editor software (WavePad Masters Edition v 6.31, NCH Software, Australia) was used to arrange and make intervals between items. The final version of the test was presented by a Laptop. Each list was presented for about 12 minutes, and the interval between the speech stimuli was 3 seconds. The speech and noise stimuli were all equal in terms of intensity, so that they all had equal powers (Root Mean Square). Speech stimuli 30 dB above the speech perception threshold (the most comfortable level), were presented to participants, in noise and at the following SNRs: -12, -6, 0, +6, and +12; the stimuli were presented to each ear in Ipsilateral mode. In this stage, the order of presenting the lists and different SNRs was random to prevent memorizing the items by the participants, breaks were arranged between stages and also increase the time interval between stages that had the same lists were considered. Finally, the percentage of correct syllables for each participant was calculated in each list and at different SNRs.

In the third stage, the developed test was administered to 50 healthy individuals (30 women and 20 men) who were randomly selected, according to the inclusion criteria, from the Persian language students of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

The inclusion criteria included normal and symmetrical hearing thresholds in both ears (average pure-tone thresholds below 25 dB from 250 to 8000 Hz, and less than 10 dB difference between the average pure-tone thresholds in both ears), normal results in otoscopy for both ears, right handedness (assessed by the Edinburgh Handedness Inventory), monolingual, Persian speaking; and having no history of psychological, speech or language and neurological disorders like epilepsy, head injury and brain surgery based on physician reports. Subjects were excluded if they were not paying attention to test's lists, losing any of the inclusion criteria and/or were unwilling to continue the study.

According to the method mentioned in the test development section, and using Philips over-ear headphones connected to a Sony laptop (VAIO CW Series, Sony, Minato-ku, Japan) that had been calibrated using a Bruel & Kjaer sound level meter (analog model, 1/3 octave band, Denmark), and using the Sound Forge software, the test stimuli were presented to both ears at the comfortable hearing level. The sound level meter showed that 60% of the laptop output level and the maximum headphones output level, equivalent to speech stimuli, were about 84 dB SPL (50 dB HL). In order to examine reliability, within 2 weeks after the initial test, a total of 10 participants were retested by the same examiner, and the scores on 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, and the Kolmogorov–Smirnov test was used to examine the normality of the data. The Lawshe's method was used to determine the content validity of the test material, and Pearson test was used to determine the correlation between four lists together. The intra-class correlation coefficient (ICC) was used to determine test-retest reliability. A paired t-test was used to compare the mean scores for the right and left ears. An independent t-test was also used to compare women and men in terms of the mean score and the mean age. All statistical analyses were conducted using SPSS 17 (SPSS Inc., Chicago, IL, USA). The statistical significance level was set at $P<0.05$.

Results

A total of 50 normal hearing individuals (30 women and 20 men) aged 18-25 years old (mean: 21.30±2) were included in the study. According to the results of the Kolmogorov–Smirnov test, the age was normally distributed.

In this study, the CVR was calculated for every item of the test, and the Content Validity Index (CVI) was calculated for the total score. The CVR estimated for all test items were higher than 0.62. 12 nonsense syllables from total of 18, had a CVR above the minimum. Therefore, the syllables ka, ga, gi, gu, da, di, du, ti, pi, pu, qa and qi were accepted. CVI was 0.81 for the total score.

In the present study, the responses of the participants were scored based on the percentage of correct syllables in each list (Figure 1 shows the mean of the scores for syllable recognition in noise, at different SNRs). As you can see, participants' performance improved as the SNR increased.

To determine the correlation between four lists or equivalency of the lists in the test, Pearson correlation coefficient was used. The Pearson correlation coefficient was calculated for each SNR; it was found that the lists number 2, 3, and 4; and the lists number 1 and 4 were significantly correlated at all SNRs. Also the lists number 3 and 4 were significantly correlated at SNRs: -12, -6, 0 and +6 (Table 1).

The mean scores of right and left ears is shown as the percentage of right and left ears' responses at different SNRs (Figure 2 shows the mean of syllable recognition scores in noise in Right and Left ears at each SNR). We used a parametric paired t-test to compare the mean scores of right and left ears; the results indicated no significant difference (P values were reported in Figure 2).

In addition, the mean scores of men and women, at each SNR, as a percentage was achieved in both group. An independent samples T-test was used to compare the mean scores of men and women; the results showed no significant difference in performance between men and women ($P>0.05$).

To determine reliability, a retest was administered to 10 participants within a 2 week interval and the ICC was calculated for the scores on the Persian version of the Consonant-Vowel in noise test. The results of these examinations are shown in Table 2. The test-retest correlations were statistically significant at all signal-to-noise ratios ($P<0.05$).

Discussion

In this study, all of the test items had acceptable validity. As the SNR increased, the syllable recognition scores also increased (Figure 1). In a study by Alwan et al. it was found that participants' performance improved as the SNR increased [16]. Zaar et al. examined the recognition of nonsense consonant-vowel syllables in white and frozen noise and at different SNRs (-12, -6, 0, +6, and +12); this study also showed that syllable recognition scores increases with an increase in SNR [5]. Nureddini et al.

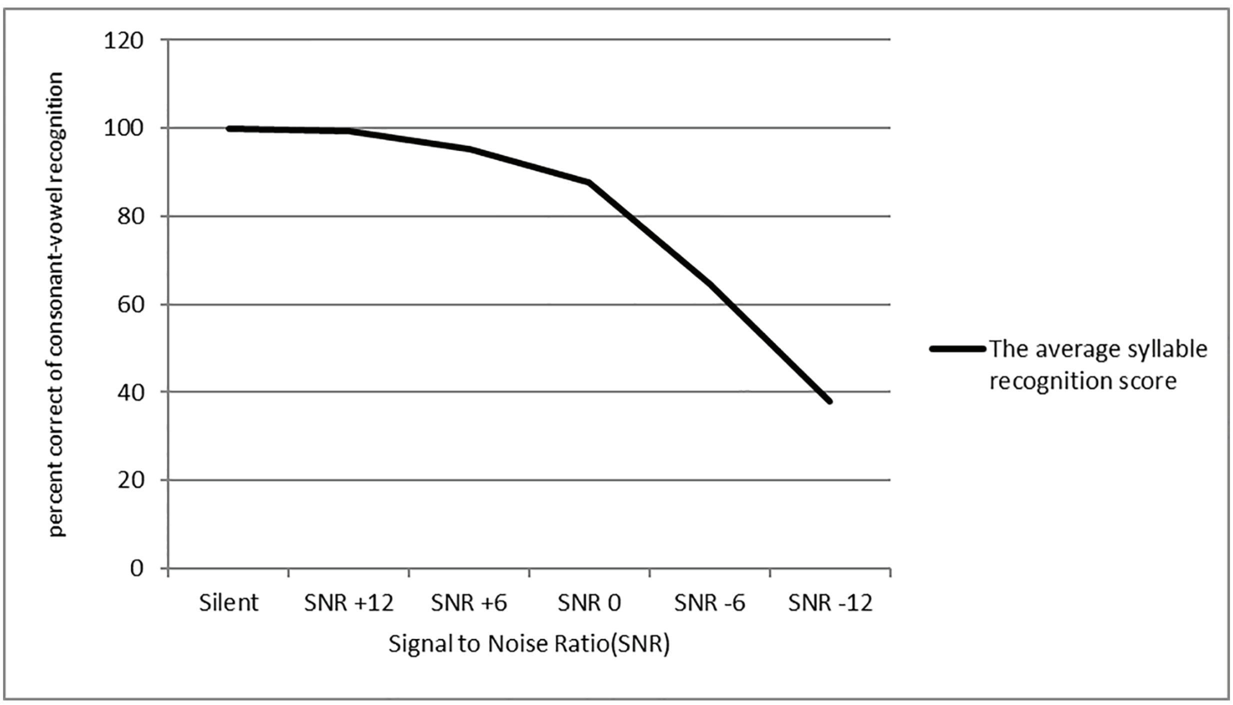

Figure 1: The average score for Consonant-Vowel recognition in noise as a function of signal-to-noise ratio

Table 1: Equivalence between lists of the Consonant-Vowel in noise test

		P value				
		SNR +12	**SNR +6**	**SNR 0**	**SNR -6**	**SNR -12**
List 1	List 2	0.62	0.86	0.29	0.05	0.46
	List 3	0.43	0.29	0.1	0.05	0.09
	List 4	0.01	0.01	0.001	0.002	0.02
List 2	List 3	0.04	0.03	0.001	0.001	0.001
	List 4	0.001	0.007	0.008	0.001	0.08
List 3	List 4	0.09	0.04	0.002	0.003	0.002

SNR: Signal to Noise Ratio

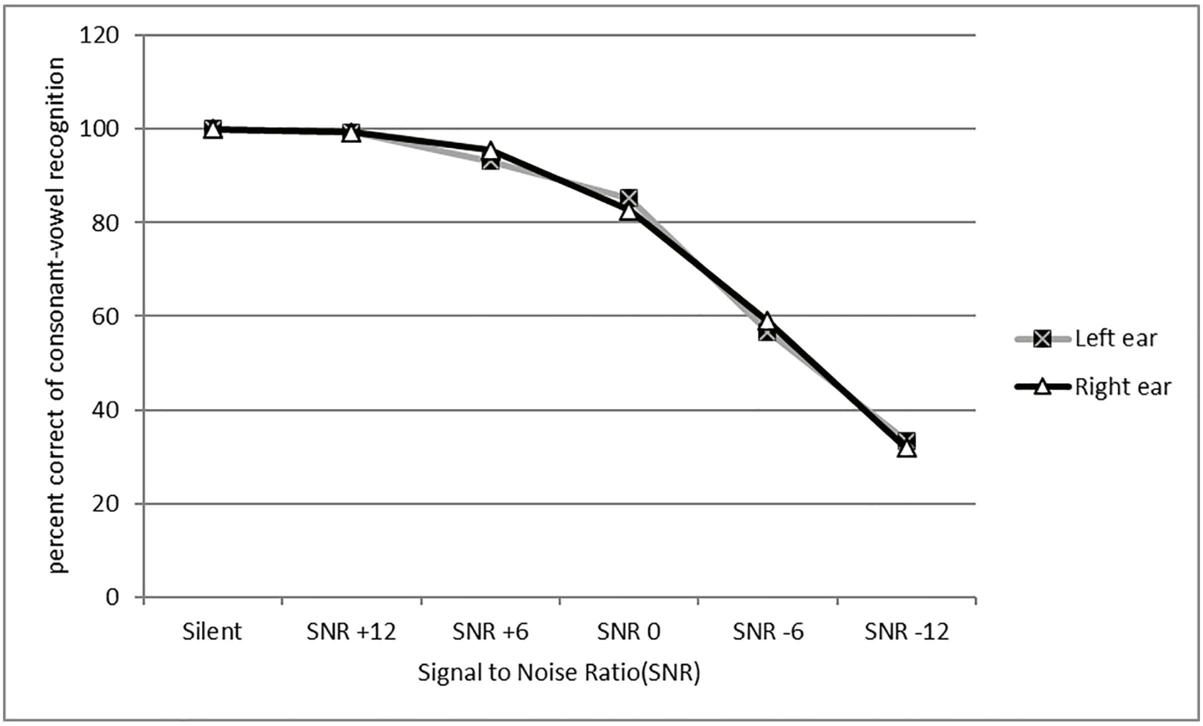

Figure 2: The mean scores of right and left ears at each SNR

Table 2: Correlations between test-retest scores on the Consonant-Vowel test in noise, at different SNRs

SNR	Correlation	P value
SNR +12	1	0.000
SNR +6	0.85	0.003
SNR 0	0.93	0.001
SNR -6	0.86	0.002
SNR -12	0.87	0.001

SNR: Signal to Noise Ratio

examined the effect of noise on the recognition of Persian consonants in a Consonant-Vowel-Consonant syllable pattern in noise, at different SNRs; they were also reported that an increase in noise leads to a decrease in consonant recognition scores, a finding which is in consistent with the results of the present study [19].

In the present study, no significant difference was found between right and left ears in the mean scores on the Consonant-Vowel in noise test (Figure 2). No published study was found about the examination of the differences in the left and right ear of the Consonant-Vowel in noise test, but results on other tests of speech perception in noise was as follows: Sbompato et al. examined the difference between the scores of right and left ears on the Hearing in Noise Test (HINT), in 79 adults of both genders, at the age of 19-44 years; no significant difference was found between the scores of right and left ears [20]. Shojaei et al. explored the effect of SNR on speech perception, in 25 elderly people of both genders, at the age of 65-74 years; in this study, participants tried to recognize words in noise and at the SNRs of 0, +5 and +10 dB, and silence; no significant difference was found between the left and right ears [21].

As mentioned in the results, the present study showed that there was no significant gender difference between men's and women's Consonant-Vowel perceptions in noise score. Calaise et al. examined the effect of gender on the results of a speech-in-noise test, in 49 elderly people. They used filtered white noise at high and low frequency ranges, in order to simulate speech noise. A SNR at +5 dB was used in this study; the results showed no significant difference between men and women which is in consistent with the findings of the present study [22]. But, in an examination of speech recognition using the NU-6 test, Wiley et al. found that men performed worse than women in recognition [23]. This finding is not consistent with our study results, and this difference can be attributed to different test materials used in the two studies.

From the examination of the equivalency of the lists in the Consonant-Vowel in noise test, in young people, we can conclude that the lists number 2, 3, and 4; and the lists number 1 and 4 are equivalent (Table 1). In addition, we can consider the list 1 as the familiarity list. Therefore, given to the fact that administering the test takes so much time, and sometimes, becomes intolerable for a participant, it is possible to use fewer numbers of equivalent lists. Another advantage of access to the equivalent lists of the test is that examiners and clinicians can use these lists in the process of rehabilitation and assessments before and after the rehabilitation.

Examination of test-retest reliability revealed that the Consonant-Vowel in noise test has acceptable reliability at different SNRs (Table 2). No published study was found about the examination of the validity and reliability of the Consonant-Vowel in noise test.

It should be noted that this study was performed with a limited time so determination of standard values in other age groups and test sensitivity and specificity in identifying the affected groups were not available. It is suggested that future studies examine the psychometric properties of the Consonant-Vowel in noise test in different age groups, and determine its sensitivity in detecting vulnerable groups, such as those with CAPD, learning disabilities and etc.

Conclusion

According to the study findings, it can be concluded that the Persian version of the Consonant-Vowel in noise test has acceptable validity and reliability, and can be used as a non-aggressive, clinical and research instrument in the examination of speech perception in noise and central auditory processing.

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