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Research Article

Word Recognition Score in White Noise Test in Healthy listeners

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Abstract: The acoustic cues of the speech signals which are consisted of consonants and vowels are very important for speech perception in noisy competing situations. Since the perception in noise test is one of the valuable measures in the perception/production abilities, so the objective of this study is to determinate a norm for word recognition in white noise (WN) with a signal-to-noise ratio (SNR) between +5 and +10 dB in healthy adults Iranian listeners. In this cross-sectional study (from April to June 2013) any individuals with our criteria were included, which consisted of 19 female and 18 male within the audiology department of Hamadan University of medical sciences. The assessments consisted of pure-tone audiometry, speech testing in quiet, tympanometry, word recognition sore in white noise test (WRS in WN). Intera class correlation (ICC) and Cronbach's Alpha (CA) used to study the stability of the WRS in WN. Independent two sample T-test was to compare findings among the groups. All subjects had normal hearing thresholds and WRS in quite. We found the mean of the WRS in WN with a SNR between +5dB (78.02±11.13, Min= 48 and Max=100) and +10 dB (86.2±9.77, Min= 60 and Max=100). There was statistically significant difference between the mean scores of +5 and +10 dB (P= 0.005, t= -2.93). We defined a norm for WRS in WN test with a SNR between +5 and +10 dB (78 and 86 percent, respectively) in healthy listeners.
Keywords: Speech, Perception, Noise, Word, Recognition.

INTRODUCTION

Speech perception in noise depends on correct understanding by the listener, whether in terms of discrimination, identification, recognition or comprehension [1, 2]. The ability to speech perception in noisy interfering needs the listener to devote significant processing resources to encode highly detailed information in the speech signal [1]. In highly changeable listening situations, identity of vowels is generally conserved and confirmed the special functional role of consonants during lexical recognition. While vowels played central role in the word- detection step that precedes the word identification step in noisy competing situations, consonant seems essentially used to identify the lexical item [3]. Individual listeners vary a great deal in their skill to perceive speech in difficult listening settings [4]. A consistent challenge in the field of spoken word recognition in noise is identifying the underlying sources of individual differences in speech perception skills [1]. Listeners who are able to allocate more resources to speech perception in noisy conditions may show better abilities to use the available acoustic-phonetic and lexical information in the signal, along with context cues in adverse listening conditions [5].

Listening to speech in noise, recruits areas outside auditory cortex, in the left frontal pole, left dorsolateral prefrontal cortex, and right posterior parietal lobe. These are areas that might be expected to be active in any task recruiting attentional mechanisms (such as target detection), consistent with the perceptual problems in listening to speech in noise [2]. Speech in noise problems are frequently attributed to reduced temporal or frequency resolution or to an incapability to separate signals binaurally are depended on the individual and the particular listening demands [6].

Regarding to importance of the speech evaluation in noisy competing situations and acquisition the criteria for word recognition tasks in presence of WN, we investigated healthy iranian listeners. However, until time there is not a valuable norm to evaluate speech recognition in noise test in our country. So, the objective was to study speech perception in white noise using word recognition tasks in healthy Iranian listeners.

MATERIAL AND METHODS

The type of study was cross-sectional. Our study group comprised 19 female and 18 male evaluated within the audiology department of Hamadan

University of Medical Sciences. Subjects were aged 7–10 years, with a mean age of 8.37±9.72 years. All subjects gave informed consent for the study. This study was approved by the ethical committee (ethical code number = پ/16/2350) of the Hamadan University of Medical Sciences. All had normal otoscopy findings. They were monolingual and right-handed. For the present study, social status was not taken into consideration. Testing was performed bilaterally. A total of 74 ears were evaluated.

During the selection process (from April to June 2013) any individuals with the following were excluded: hearing impairment, otological disorder, noise exposure and ototoxic medication. Included individuals were required to have: hearing thresholds better than 25 dB hearing level (HL) at octave intervals from 0.25 to 8.0 kHz; WRS in quiet better than 96 percent; no cochlear sensitivity; middle-ear pressure between the limits of ±50 mm H_2O.

All subjects underwent pure tone hearing threshold assessments between 250 and 8000 Hz. Air and bone conduction hearing thresholds and speech tests were conducted within sound proof rooms, using an MADSEN (OB822, Denmark). Subjects' air conduction hearing thresholds were measured, using standard earphones (TDH-39) at 250–8000 Hz. Bone conduction hearing thresholds were measured using 60273 vibrators (Oticon, Denmark) at 0.5–4 kHz. Audiometers were calibrated using 4152 artificial ears with a Larson Davis (U.S.) sound level meter.

Subjects' speech reception thresholds were assessed using a two-syllable word list. Speech recognition was tested using a monosyllable, phonetically balanced word list developed in Hamadan university of medical sciences. The uncomfortable loudness level was also determined. For the impedancemetric tests, middle-ear pressure and acoustic reflex measurements were made using Interacoustics MAICO MI34 impedancemeters and TDH-39 earphones.

The WRS in WN was applied with a SNR of +5 and +10 dB, separately. Phonetically balanced word lists were transmitted at 40 dB sensation level (SL) and white noise at 30 dB SL to subjects' ipsilateral test ear, at the same time. The word lists were presented to subjects via an adapted CD player. Four different word lists comprising 25 syllables were presented.

All analysis was done by means of the statistics software $SPSS_{17}$. Data expressed as mean ± standard deviation and as percentages. Kolmogorov-Smirnov test is used for evaluation of normal test distribution. Intera class correlation (ICC) and Cronbach's Alpha (CA) used to study the stability of the WRS in WN. Independent two sample T-test was to compare findings among the groups. P-value of < 0.05 considered to indicate statistical significance.

RESULTS

We evaluated total value of intraclass correlation coefficient (0.43) and cronbach's alpha (0.90) acquire to study the stability of the WRS in WN with a SNR between +5 and +10 dB. These values also found on the right and left ear (Table 1). The performance on the initial test and a re-test was strongly correlated, displaying excellent test/re-test reliability.

We found the mean of the WRS in WN with a SNR between +5 dB (78.02±11.13, Min= 48 and Max=100) and +10 dB (86.2±9.77, Min= 60 and Max=100) (Fig. 1). There was statistically significant difference between the mean scores of +5 and +10 dB (P= 0.005, t= -2.93).

The mean score of the right ear with a SNR between +5 dB was greater than the left ear. But, there was no statistically significant difference between left ear and right ear scores (P_{+5dB}= 0.51, t_{+5dB} = 0.65 and P_{+10dB} = 0.83, t_{+10dB} = 0.21). Also, the mean scores of the female was greater than the male (Fig. 2). But, there was no significant difference on the sex (P_{+5dB} = 0.18, t_{+5dB} = 1.37 and P_{+10dB} = 0.21, t_{+10dB} = 1.27).

We found a norm for WRS in WN test with a SNR between +5 and +10 dB (78 and 86 percent, respectively) in healthy Iranian listeners.

Table 1: Intraclass correlation coefficient (ICC) and cronbach's alpha (CA) on the right and left ear to study the stability of the word recognition in white noise test with a signal-to-noise ratio (SNR) between +5 and +10 dB

Variable	CA	ICC
SNR of +5 dB in Right ear	0.92	0.95
SNR of +5 dB in Left ear	0.97	0.98
SNR of +10 dB in Right ear	0.62	0.71
SNR of +10 dB in Left ear	0.64	0.76

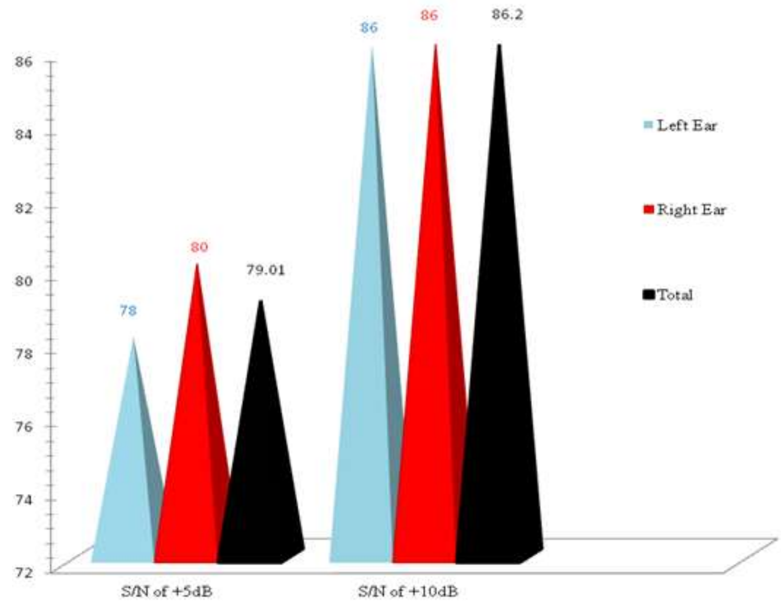

Fig. 1: The mean of word recognition scores in white noise (percent) with a signal-to-noise ratio (SNR) between +5 and +10 dB on the right and left ear (perpendicular shapes are offered)

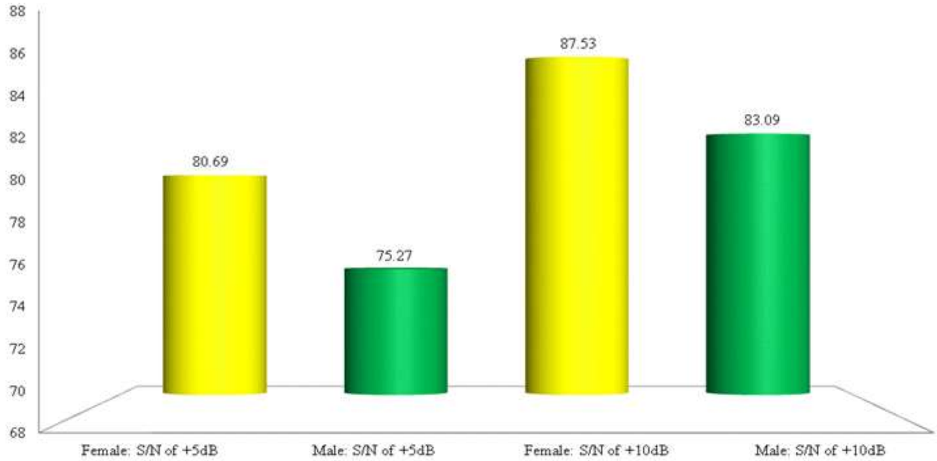

Fig. 2: The mean of word recognition scores in white noise (percent) with a signal-to-noise ratio (SNR) between +5 and +10 dB on the sex

DISCUSSION

The most common speech recognition tests are the speech reception threshold (SRT) and word recognition (WRS) in quiet. WRS in quiet test is a routine speech evaluation in all audiology center of Iran which has not true efficiency and task successfully in definition of speech perception abilities. Because, one of the most basic features of everyday real-world speech communication is that individuals interact with a variety of different people in different environments and contexts.

Since, one must continuously detect sound signals against background noise and WRS in quiet cannot estimate this necessity. So, we must found a valuable norm which should be practical in clinical assessments and daily life. Then, we assumed that better central auditory function is usually associated with better speech recognition in noise scores and the importance of WRS test is its quality of judgment about personal abilities in social and linguistic events. This influence of people's actions only can be detectable by WRS in WN test and scores cannot be predicted accurately from either pure tone thresholds or speech-in-quiet test.

It has mentioned that word recognition declined significantly with increasing level, when SNR was held constant which was attributed to nonlinear growth of masking and reduced effective SNR at high speech-shaped masker levels, as indicated by audibility estimates based on the articulation index [4]. Also, it has been reported that the words-in-noise test is a suitable clinical assessment to evaluate word-recognition performance in background noise [6] and it should be considered the stress test for auditory function [7, 8]. Regarding to these attentions, the importance of true evaluation of speech abilities in noisy competing real world is one of our notice to this study.

Fısılog˘lu and Katz studied 14 children with central auditory processing disorders, 14 children with normal hearing and 12 adults (English language). They found mean speech recognition in noise scores of 41.1, 54 and 67.7 percent, respectively, at +10 dB SNR (9). In normal Turkish language and in the 10–69 year age range, Yilmaz *et al*. found mean speech recognition in noise scores of 51.96 percent for the right ear and 51.60 percent for the left ear [1]. Meyer et al descripted the mean of speech recognition scores in speech-shaped noise (normal German language) was about 76.5 percent at +10 dB SNR [3]. Beattie and Barr reported mean scores for the normal-hearing and English talker subjects 45 percent at the +5 dB SNR, 74 percent at the +10 dB SNR, and 87 percent at the +15 dB SNR [10]. Also, Wilson and Cates found the English listeners with normal hearing 92.5 percent correct on the speech recognition in noise test. The test was done with a 50 percent point on the word in noise of +2.7 dB SNR (Words binaurally at 50 dB HL in a multitalker babble at a +9 dB SNR) [8]. Our study group had normal hearing thresholds and their WRS in quiet was better than 96 percent. But, their mean scores in white noise decreased with a SNR between +5 and +10 dB (78 and 86 percent, respectively) and as the SNR was decreased, the percent of true scores reduced. Similar to recent findings, all mentioned reports used of word lists that were presented to subjects via an adapted CD player, but there is alterations between them. These alterations can be caused by *linguistic* and *sociality* differences of studied groups. Authors also described individual differences in the *ability to encode* and *maintain* highly detailed episodic information in speech [11] may underlie the variability observed in speech recognition performance in adverse listening conditions [5].

Therefore, we strongly believe recognition performance on a speech-in-quiet task does not predict performance on a speech-in-noise task, as the two tasks reflect different domains of auditory function and speech-in-noise abilities must be measured directly because speech-in-noise scores cannot be predicted accurately from either puretone thresholds or speech-in-quiet scores.

In other hand, when people listen to speech in noise, there is extensive activation in the dorsolateral temporal lobes-activation that is exceedingly similar to the activation seen when subjects listen to speech in quiet. This result may reflect the fact that an unattended speech masker is still processed for meaning, to some degree, and thus is processed along the same neural pathways as speech to which we are attending [7]. This is a valuable document for using of WRS in WN in clinical practice and evaluation of speech skills.

Additionally, previous researchs has shown that the type and level of background competition can interact with the indexical properties of the target signal. The voice characteristics of the target signal and competing talker influence the intelligibility of the test sentences, with more similar talkers resulting in poorer speech intelligibility [11-13]. The regional dialect of the talker has also been shown to reduce intelligibility to a greater extent at more challenging SNR [14]. Thus, target variability and background competition, both independently and together, influence the listening environment and create more difficult conditions for speech recognition [15].

Finally, central auditory processing problems are important possibility for low speech recognition in noise scores [14]. Understanding the efferent system may aid patients with disorders of auditory processing of background noise and help develop new treatment approaches [1]. Another new possibility for low speech recognition in noise scores can be related to abnormal function of the acoustic sensitivity of the saccule, which is evaluable by cervical vestibular evoked myogenic potentials (cVEMPs). Indeed, In high-level of noisy competing situations, healthy human saccular sensation can mediate the detection of low frequencies and possibly help in cochlear hearing for frequency and intensity discrimination [16, 17]. This means that little is known about either the utility or limitations of different assessment procedures for evaluating the individual abilities necessary to recognize spoken words.

CONCLUSION

One of the most critical aspects of daily real-world speech relation is that persons interact with a variety of different people in seperate regions and situations. Since the speech signals encode both linguistic cues (speech sounds, syllables, and words) and nonlinguistic informations about the speaker's voice (regional dialect, and native language), which can play an important role in speech perception abilities [18].

So, speech perception is an extremely robust process that can quickly adapt to changing listening conditions. In order to understand the perceptual and neural mechanisms responsible for these abilities, it is needed to develop a new generation of theoretically motivated tests that assess spoken word recognition across a range of task requirements and listening populations [19]. The results of this study demonstrate the potential value of the research for gaining a more detailed understanding of speech perception in noisy competing situations.

The link between real-world hearing and speech recognition skills based on self-reports should be further explored [20]. The implication of this study for clinical settings is importance of using WRS in WN test to examine the speech recognition performance healthy listeners.

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