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Application of Arabic hearing in noise test on subjects with sensorineural hearing loss

Wessam Mostafa Essawy*

Department of Otorhinolaryngology, Faculty of Medicine, Tanta University, Egypt

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***Correspondence:**
Dr. Wessam Mostafa Essawy,
E-mail: wessamessawy@yahoo.com

ABSTRACT

Background: HINT sentence test is one of adaptive speech in noise tests. It has been used in many clinical applications such as recording of speech perception threshold using sentences material in quiet and in noise and verifying the benefit from hearing-aid amplification and cochlear implants, especially in noise. This study was designed to apply HINT to subjects with SNHL to get a normative data for this group.
Methods: This study included 50 subjects with bilateral mild to moderate sensorineural hearing loss.
Results: In SNHL subjects, the mean of sSRT in quiet was 49.46 dB (A)±0.68 dB. The mean of S/N ratio at threshold was 7.69 S/N ratio ±0.68, -8.18±0.33 and -8.18±0.35 in the noise conditions 0°, 90° and 270° respectively.
Conclusions: The statistical reliability and efficiency of the test suit it to practical applications especially in SNHL subjects.

Keywords: Hearing in noise test, Sentences speech recognition thresholds, Signal to noise ratio, Sensorineural hearing loss

INTRODUCTION

Speech recognition is essential for social integration, as it enables efficient interpersonal communication. The ability to understand speech in the presence of background noise is a major challenge for any listener, especially for those with hearing impairment.[1]

The hearing in noise test (HINT) was developed by Nilsson et al, 1994 for the measurement of reception threshold for sentences (sSRT) in quiet and in the presence of noise. The HINT includes 25 phonemically balanced Lists of 10 sentences which were adapted from the Bamford-Kowal-Bench (BKB) sentences. The goal of the HINT is to provide a reliable and efficient tool to estimate hearing handicap, directional hearing, hearing aid benefits and to perform comparison between hearing aids.[2]

Arabic HINT (A-HINT) was developed by Essawy et al, 2019. This test is composed of 28 equivalent Lists of ten sentences. Arabic HINT can be used with reliable results in quiet, noise 0°, noise 90° and noise 270° conditions.[3]

This study was designed to apply HINT to subjects with sensorineural hearing loss (SNHL) to get a normative data for this group to be used easily in other applications of HINT in HA and CI evaluation.

METHODS

This work was done in audiology unit, Tanta University in the period from September 2018 to March 2019. Ethical approval code no. was 1821/04/13.

This is a prospective study. The idea of the research was explained in details to the participants. An informed consent was obtained from all participants in this

research. The participation was voluntary, and that the subjects may discontinue participation at any time without penalty or loss of benefits.

Subjects

This work included 50 subjects with bilateral symmetrical mild to moderate sensorineural hearing loss. Hearing threshold average was more than 25 up to 55 dB hearing loss (HL) at audiometric test frequencies 250-8000 Hz.

As regards MCL and UCL, we don't need to do it because in HINT test procedure we present speech at 60 dB A and noise at 65 dB A which is an audible level and not reach MCL or UCL for these subjects.

All participating subjects had normal middle ear function as determined by normal type (A) tympanograms with ipsilateral and contralateral acoustic reflex thresholds at expected levels when using pure tone of the following frequencies 500, 1000, 2000 and 4000 Hz in both ears.

They were 22 males and 28 females. Their age ranged from more than 18 up to 60 years. In this group, the duration of hearing loss ranged from 1 to 6 years. Thirty three subjects only from this group used monaural HAs with a duration ranged from 1 to 3 years (mean 2.1±4.2).

All subjects were subjected to full audiological history, otological examination and basic audiological evaluation.

Measuring A-HINT

Equipment

- Sound treated room: Transacoustic model no. RE241.
- Pure tone audiometry: AC 40 clinical audiometer.
- Immittancemetry: Interacoustic AT235h.
- Loudspeakers: Two loudspeakers Mixmax separated by a 90° azimuth the ear level of the tested subject.
- CD player: Thomson Cs 96.
- CD of pre-recorded calibrated test material of HINT sentences List mixed with speech noise.

The test material (HINT sentences)

The HINT sentences were 280 sentences used to develop the 28 equivalent Lists of the A-HINT. The following procedure was used to maximize measurement reliability with Lists matched in their phonemic content. The phoneme distribution within the sentence set was determined according to the phonological transcriptions and classification into 28 consonants and 6 vowels (3 long and 3 short vowels).

Twenty-eight lists of 10 sentences, which matched the phonemic distribution of the entire sentence set, were formed using a trial-and-error process to exchange sentences between Lists to match the distribution for each list to the overall distribution as closely as possible

Recording was made of the revised materials using a male native professional voice speaker. The speaker was a radio broadcaster, news reader, etc., with professionally trained voice. The speaker was instructed to maintain clarity, pace and effort while reading the sentences.

The sentences were recorded on digital audio tape (DAT) and were digitally transferred to computer soundtrack files. The sentences were sampled directly to disk at 488 Hz using an Ariel digital signal processing board with a HP3G processor and 24-bit A/D and D/A converters.

Recordings were made in a double-walled sound treated room with acoustic foam on the walls and ceiling. A Neumann microphone was placed perpendicular to the speaker at a distance of 1 m. Average signal levels at the microphone were maintained at about 65-70 dB SPL. Signal levels were monitored with an oscilloscope throughout the recording session to confirm that peak signals were not clipped.

Masking noise

Multi-talker babble was recorded, transferred to computer programs and mixed with the recorded A-HINT sentences Lists in the CD material in a fashion that enabled to direct separate inputs to the audiometer (one channel can transfer sentences material and the other channel can transfer masker noise).

The test environment

The test required a sound-treated room with two loudspeakers, a chair, a compact disk player and an audiometer. The two loudspeakers were positioned so that the center of the subject's head is one meter from each loudspeaker.

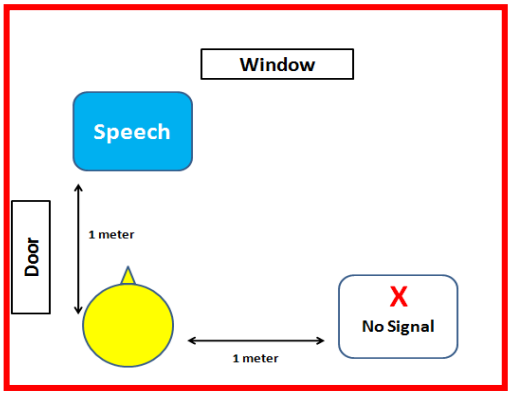

Figure 1: Loudspeakers arrangement in quiet condition.

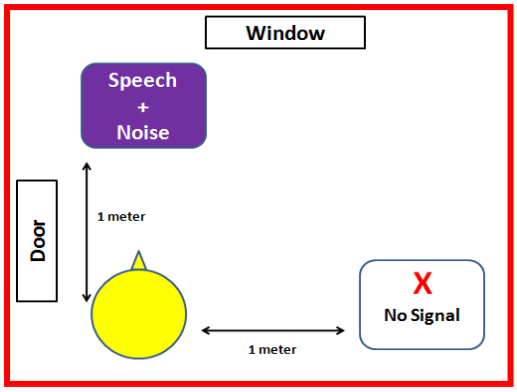

Figure 2: Loudspeakers arrangement in noise 0° condition.

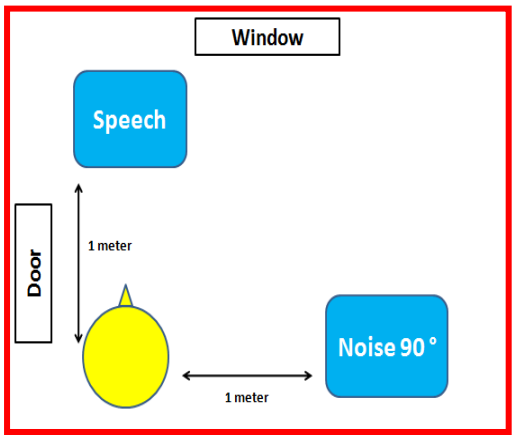

Figure 3: Loudspeakers arrangement in noise 90° condition.

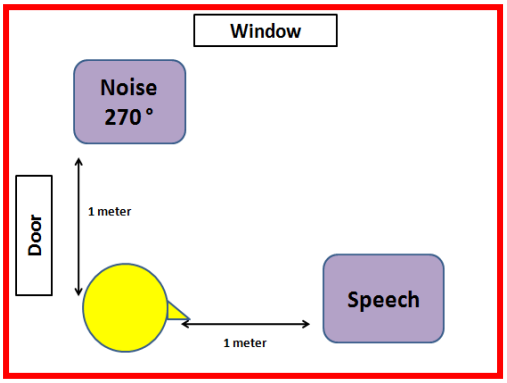

Figure 4: Loudspeakers arrangement in noise 270° condition.

The loudspeakers are separated by a 90° azimuth at the ear level of the tested subject. Sentences speech recognition threshold (sSRT) was measured in quiet and in noise. Sentences speech material location remained fixed at 0° in all tested conditions. The location of noise source differed in three tested conditions: noise front (0°), noise (90°) and noise (270°) as shown in the (Figures 1-4).

Calibration of fixed signal-to-noise ratio A-HINT audio CDs:

The loudspeaker calibration protocol involved the presentation of calibration noise and measurement of the output level. Once this calibration was performed, the speech stimuli were also calibrated.

Position of the reference microphone (here we used sound level meter) (SLM) at the location corresponding to the center of the subject's head and one meter from each of the speakers in the following steps:

- One channel from the CD player was routed to (external) input of the audiometer.
- The appropriate interrupt switch of the audiometer was turned on and the calibration noise from the selected audio HINT CD was played. The audiometer dial was turned on to ensure that the signal was routed to the sound field speaker. The interrupt switch was turn off.
- The interrupt switch of the audiometer was turned on and the calibration speech from the selected audio HINT CD was played. Then we set the volume unit meter to zero.
- The A-weighting mode for the sound level meter was selected.
- Then we turned on the appropriate interrupt switch and played the calibration noise from the selected audio HINT CD. We used A-weighting on the sound level meter for all calibration measurements. The dial on Channel 1 was adjusted until the calibration microphone (SLM) measures a noise level of 65 dB (A). Then the interrupt switch was turned off. We used this dial setting to deliver the required 65 dB (A) noise signal. It has to be noted that the dial settings on the audiometer are not necessarily related to the output level in dB (A).
- The HINT system was recalibrated each time the audiometer was recalibrated and whenever the loudspeaker positions were changed or the loudspeakers were replaced.

The test procedure

The sentence lists were administered using adaptive testing procedure according to HINT guidelines. In quiet condition, the starting level was 30 dB SL (referred to SRT by loudspeaker). In noise conditions, the noise level was fixed at 65 dB (A), whereas the intensity levels of sentences were adjusted according to the participant's response. The sentence was initially presented at -5 dB signal-to-noise (SNR) and the sentence presentation level was increased in 4 dB steps until the participants repeated 100% of the words in the sentence. The presentation level then was lowered by 4 dB after a correct repetition of the entire sentence or raised after an incorrect response. The 4 SNRs in the first four sentences were averaged and used as the starting presentation level for the 5th sentence.

Thereafter, the adaptive procedure was preceded to the 10th sentence that would have been presented using 2 dB steps. The averaged SNR from the 5th to 10th sentences in a sentence list was regarded as the reception threshold for sentences (RTS) for that list. This procedure was similar to Nilsson et al and Hallgren et al who found that the mean and SD of threshold becomes stable after 4th or 5th sentences. Also, all participants were given one practice List each in quiet and noise at 0° azimuth conditions to familiarize them with the task (this was proven by Nilsson et al and Hallgren et al who found that one list is sufficient for subject to be acquainted with the test procedure).[4,5]

Participants were instructed to listen carefully and repeat aloud whatever they heard as much of the sentence as possible. The sentences were presented one at a time. The listener is encouraged to guess if they were not sure what was spoken.

Application of Arabic HINT on SNHL subjects was done according to Essawy et al findings and normative data acquired from the normal hearing subjects. Accordingly, the most sensitive lists in normal hearing subjects in each condition [the lists which showed the least standard error (SE)] were used. These Lists were Lists 3, 4 and 16 in quiet condition, lists 20 and 21 in noise 0° condition, Lists 9 and 10 in noise 90° condition and lists 27 and 28 in noise 270° condition. Also, according to results of normal hearing subjects as regards the recommended number of lists used for accurate sSRT threshold, sSRT was calculated by only using one List in quiet and in noise 0° condition, and using two lists average in calculating sSRT in noise 90° condition and in noise 270° condition.

RESULTS

This study included 50 subjects (22 males and 28 females) with bilateral symmetrical flat mild to moderate sensorineural hearing loss. Their hearing threshold ranged from 29-49 dB HL with a mean 36.96±6.00. Their age ranged from 18-50 years with a mean 31.92±8.30 years. In this group, the duration of hearing loss ranged from 1 to 6 years. Thirty three subjects only from this group used HAs with a duration ranged from 1 to 3 years with a mean 2.1±4.2 years.

Mean and SD of sSRT in quiet condition was calculated using lists 3, 4 and 16. It was 49.46 dB (A)±0.68 dB, 49.56 dB (A)±0.51 and 49.56 dB (A)±0.50 respectively. The S/N ratio at threshold in the noise 0 condition across all subjects ranged from -6 to -10 with the mean -7.69 a standard deviation of ±0.68 by List 20 and mean -7.91 and a standard deviation of ±0.51 by List 21. The S/N ratio at threshold in the noise 90 condition across all subjects ranged from -7 to -9 with the mean -8.18 and a standard deviation of ±0.33 by List 9 and mean -7.89 and a standard deviation of ±0.61 by List 10. The S/N ratio at threshold in the noise 270 condition across all subjects ranged from -7 to -9 with the mean -8.18 and a standard deviation of ±0.35 by List 27 and mean -8.18 and standard deviation ± 0.44 by List 28 (Tables 1, 2, 3, 4).

List equivalence for each condition in SNHL subjects

Quiet condition

The same procedure used in normal hearing subjects was used with SNHL subjects. We used lists 3, 4 and 16 in quiet condition. List equivalence was computed and expressed as a deviation score from the mean across all lists and all subjects. For each List we calculated range, mean, standard deviation, standard error, 95% confidence interval of mean and standard deviation. After calculating the standard error scores, we found that Lists 3 and 16 were equal in SE value and so both are equal in validity for calculating sSRT. In another words, these lists showed the least deviation from the overall mean. This was followed by list 4 which showed larger deviation than the other two lists.

Table 1: Range, mean and SD for of sSRT in quiet condition in SNHL subjects.

Quiet condition	List 3	List 4	List 16
Range	49-51 dB (A)	49-51 dB (A)	49-51 dB (A)
Mean±SD	49.46 dB (A)±0.68	49.56 dB (A)±0.51	49.56 dB (A)±0.50

Table 2: Range, mean and SD for of sSRT in noise 0° condition in SNHL subjects.

Noise 0° condition	List 20	List 21
Range	-6 to -10 S/N ratio	-6 to -10 S/N ratio
Mean±SD	-7.69±0.68	-7.91±0.51

Table 3: Range, mean and SD for of sSRT in Noise 90° condition in SNHL subjects.

Noise 90° condition	List 9	List 10
Range	-7 to -10 S/N ratio	-7 to -10 S/N ratio
Mean±SD	-8.18±0.33	-7.89±0.61

Table 4: Range, mean and SD for of sSRT in noise 270° condition in SNHL subjects.

Noise 270° condition	List 27	List 28
Range	-7 to -10 S/N ratio	-7 to -10 S/N ratio
Mean±SD	-8.18±0.35	-8.18±0.44

Noise 0 condition

In noise 0 condition, we used lists 20 and 21. List equivalence was computed and expressed as a deviation score from the mean across all lists and all subjects. For each List we calculated range, mean, standard deviation, standard error, 95% confidence interval of mean and standard deviation. After calculating the standard error scores from the mean of each List, we found that List 21 was better than list 20 and the list that showed the minimum deviation from the overall mean.

Noise 90 condition

In noise 90 condition, we used Lists 9, 10. List equivalence was computed and expressed as a deviation score from the mean across all Lists and all subjects. For each list we calculated range, mean, standard deviation, standard error, 95% confidence interval of mean and standard deviation. After calculating the standard error scores from the mean of each List, we found that List 9 was better than list 10 as regards the deviation from the overall mean. In another words, list 9 had a smaller SE than Lists 10.

Noise 270 condition

In noise 270 condition, we used the best lists which were Lists 27 and 28. List equivalence was computed and expressed as a deviation score from the mean across all Lists and all subjects. For each List we calculated range, mean, standard deviation, standard error, 95% confidence interval of mean and standard deviation. After calculating the deviation scores from the mean of each List, we found that both lists 27 and 28 were equal as regards SE scores

DISCUSSION

In subjects with sensorineural hearing loss, the sSRT in quiet ranged from 49 to 51 with the mean sSRT 49.48 dB (A), with a standard deviation of ±0.68 dB. The S/N ratio at threshold in the noise 0 condition across all subjects ranged from -6 to -10 with the mean -7.86 and standard deviation of ±1.16. The S/N ratio at threshold in the noise 90 condition across all subjects ranged from -7 to -9 with the mean -7.90 a standard deviation of ±0.87. The S/N ratio at threshold in the noise 270 condition across all subjects ranged from -7 to -9 with the mean -8.21 a standard deviation of ±0.73.

In this study, the difference between the normal and SNHL patients was 30.48 dB (A) in quiet and was 2.5 S/N ratio in noise 0 and 2.55 S/N ratio in noise 90 condition and 3.48 S/N ratio in noise 270 condition.

The only two studies that used HINT on SNHL subjects were Danish HINT Nielsen et al and Parrish.[6,7]

In Danish HINT, the overall sSRT in noise across test Lists was 0.09 dB with a standard deviation of 1.79 dB (compared to sSRT for normal hearing subjects in the same study which was - 2.52 S/N ratio with a standard deviation of 0.87 dB). The overall sSRT for SNHL subjects (0.09 dB) was found to be 2.6 dB higher than for the normal hearing listeners (-2.52 dB). This suggests that the test is sensitive to the listeners' ability to follow a conversation in noise.[6]

Parrish found that the mean sSRT in quiet for the normal hearing participants was 19.64 dB, which was within the HINTs norms. The mean sSRT in noise for normal hearing participants was -1.07 S/N ratio. Also, the mean sSRT in quiet for the SNHL participants was 34.20 dB (A) and the mean sSRT in noise for SNHL participants was 1.78 S/N ratio. The difference between the two groups for sSRT quiet was 14.56 dB. The difference between normal and SNHL participants for sSRT Noise was 2.85 dB S/N ratio.[7]

Our results differed from the results of the previous two studies in quiet condition. However, the difference in S/N ratio between normal and SNHL subjects were equal in our study and the two previous studies (equal to 2 to 3 dB S/N ratio difference).

Intuitively, one would think that there would be a larger sSRT difference between these two groups (normal and SNHL) of participants. Lee et al demonstrated in their study that background noise was sufficiently intense to be the factor limiting the audibility of the speech signal (250-4000 Hz), for normal and SNHL subjects, both groups performed equivalently.[8]

Humes explained that at lower noise levels, the high frequency hearing loss of the individual reduced the audible bandwidth of both speech and noise. In order to compensate for this reduced bandwidth of audibility, the signal-to noise ratio needed to be increased. Additionally, it was possible that the degree of hearing loss and the configuration of the audiograms of the SNHL group greatly influenced the test results.

CONCLUSION

Arabic HINT test can be applied perfectly to SNHL subjects. In quiet condition: Lists 3 and 16 were the best

and using only one List was sufficient for accurate measurements. In noise 0 condition: List 21 was better than List 20 and using only one List was sufficient for accurate measurements. In noise 90 condition: List 9 was better than List 10 as regards the deviation from the overall mean but using two Lists was sufficient for accurate measurements. In noise 270 condition: both Lists 27 and 28 were equal as regards SE scores but using two Lists was sufficient for accurate measurements. We recommend the previous Lists as the best Lists of Arabic HINT for calculating sSRT in SNHL subjects. Moreover, all Arabic HINT lists deviated within small SD from the overall mean across all subjects that deviation was within one dB (A) in quiet condition or one S/N ratio in noise conditions which suggested that all Arabic HINT Lists are valid and available for SNHL subjects for test and retest using different lists in different retest sessions.

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