

Auditory and Vestibular Research

Comparison Between Persian Dynamic Spatial Quick Speech in Noise Test and Persian Hearing in Noise Test in Adults with Sensorineural Hearing Loss

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Highlights

- P-DSQSIN is a new tool for assessing binaural hearing ability
- P-DSQSIN offers simpler setup, easier use, and faster scoring than P-HINT
- P-DSQSIN models real SNHL hearing challenges more precisely than P-HINT

Abstract

Background and Aim: Speech perception is severely impaired by sensorineural hearing loss (SNHL) and background noise. This study compared two newly developed Persian speech-in-noise tests, the Persian dynamic spatial quick speech in noise (P-DSQSIN) test and the Persian hearing in noise test (P-HINT), to evaluate the clinical utility of both in adults with SNHL.

Methods: Fifty subjects with moderate to moderately severe SNHL (aged 18–50) and twenty-five normal hearing (NH) subjects (aged 18–25) participated. They were assessed using both the P-DSQSIN and P-HINT. Additionally, the Persian spatial hearing questionnaire (P-SHQ) and the Persian speech, spatial and qualities of hearing scale (P-SSQ) were used to correlate objective test results with subjective perceptions of speech difficulties in noise.

Results: Significant differences ($p < 0.05$) were found between the two groups across tests and questionnaires. The P-DSQSIN test demonstrated several advantages over P-HINT concerning clinical use, including setup complexity, ease of administration, and scoring. The results of the two tests showed a moderate positive correlation ($r = 0.693$, $p < 0.001$). In the SNHL group, the results revealed moderate significant positive correlations between the P-DSQSIN SNR loss and P-HINT SNR with the P-SHQ ($r = 0.538$, $p < 0.001$ and $r = 0.427$, $p = 0.007$) and P-SSQ questionnaire scores ($r = 0.647$, $p < 0.001$ and $r = 0.348$, $p = 0.015$).

Conclusion: Both tests assess the listener's ability to hear in background noise. However, the P-DSQSIN test is a more sensitive measure of speech perception in noise than the P-HINT in subjects with SNHL.

Keywords: sensorineural hearing loss, dynamic, spatial processing, quick speech in noise test, hearing in noise test

Introduction

Background noise in everyday environments can significantly hinder the ability to hear, particularly when trying to perceive speech. To simulate real-world listening conditions, speech-in-noise (SIN) tests have been developed. For individuals with sensorineural hearing loss (SNHL), perceiving speech in noisy environments can be especially challenging, making SIN tests valuable tools for assessing their hearing capabilities in clinical settings [1,2].

Various SIN tests are available for clinical use and can be categorized based on whether they use a constant or variable signal-to-noise ratio (SNR). Constant SNR tests measure the correct response percentage at a fixed

SNR, predetermined by the audiologist, which remains constant throughout the test. Examples of constant SNR tests include the speech perception in noise (SPIN) test and the connected speech test (CST). In contrast, variable SNR tests assess the SNR by adjusting the intensity of either speech or noise. Prominent examples of variable SNR tests include the Bamford-Kowal-Bench SIN Test (BKB-SIN), the quick speech in noise (QSIN) test, the hearing in noise test (HINT), and the words-in-noise (WIN) test [3-6].

The quick speech in noise (QSIN) test, developed by Etymotic Research, was introduced commercially in 2001. It was specifically designed to provide a fast and reliable method for assessing a listener's ability to perceive speech in noise by measuring SNR loss, rather than the percentage of correct responses [6]. The QSIN test is widely regarded as one of the most sensitive tools for evaluating speech understanding in noisy environments [7]. It is characterized by a short test duration and effectively quantifies real-world SNR loss. The SNR loss score in the QSIN test indicates the additional SNR that an individual with hearing loss requires in comparison to a person with normal hearing in order to correctly identify 50% of sentences. This is referred to as the SNR-50 [6, 7].

The HINT was first released commercially on CD in the early 1990s, with a later version available as a hardware and software system (HINT for Windows). Both versions were developed by MAICO diagnostics [8] and Nilsson et al. [9]. Similar to the QSIN, the HINT measures SNR but uses an adaptive procedure to determine the Reception Threshold for Sentences (RTS), which represents the level at which a listener can correctly repeat 50% of the presented sentences. The resulting score reflects the SNR required to achieve this 50% correct performance [10].

Both the QSIN and HINT tests involve listeners repeating five or more words per sentence, as opposed to the SPIN test, which requires repetition of only the final word in each sentence [10]. This approach provides multiple opportunities for response within each sentence, reducing the overall test duration compared to tests that rely on a single word per sentence [11]. Furthermore, sentence-length SIN tests, such as the QSIN and HINT, are considered superior to traditional word-length tests that use a percent-correct scoring method. Unlike percent-correct tests, sentence-length tests provide a more accurate measurement of the SNR required for speech understanding, which cannot be reliably predicted from an audiogram alone [12].

Despite the availability of SIN tests for several decades, many clinicians remain hesitant to use them regularly due to concerns about selecting the appropriate test, understanding the procedures, and interpreting the results. While for some clinicians, SIN tests are a routine part of clinical practice, for others, they remain less familiar or untried. In Iran, the use of such tests has been even more limited, as testing resources have only recently been developed. The Persian version of the QSIN test was developed and standardized by Shayanmehr et al. [13], and the Persian version of the HINT was developed and standardized by Darouie et al. [14].

The P-DSQSIN application, first introduced by Ashrafi et al. [15], includes special features that enhance its utility, such as the ability to move sentences between the two ears. This allows the listener to perceive the signal source moving from one side to the other, while the babble noise sources remain fixed at 90-degree angles on both sides. Using this software, sentences can be divided into temporally identical parts, and each part can be presented (virtually) under the headphones from different angles, with at least one-degree intervals. This test is capable of examining spatial hearing skills, including orientation, localization, the phenomenon of release from masking, and speech perception in noise [15].

The existence of the P-DSQSIN test, along with other SIN tests, provides important information for clinicians to more accurately assess speech understanding, plan auditory rehabilitation, and make evidence-based decisions about hearing aid selection, thereby improving the expected gain of amplification [15]. The utility of these objective measures is further solidified when cross-referenced with subjective patient reports obtained via validated questionnaires, such as the abbreviated profile of hearing aid benefit (APHAB) questionnaire [10].

Although there are several tools available to assess spatial auditory function, comprehensive validation of the main adaptive tests currently in use remains essential. The QSIN and HINT tests use adaptive procedures to provide clinically relevant measures, such as SNR and RTS, which fundamentally differentiates them from static assessments [10]. Consequently, a thorough understanding of these basic methods is essential, especially as the current trajectory of SIN research increasingly takes advantage of these dynamic features. The purpose of this study compared two newly developed Persian speech-in-noise tests, the P-DSQSIN test and the Persian hearing in noise test P-HINT, to evaluate the clinical utility of both in adults with SNHL.

Methods

Participants

The participants in this study included two groups: those with normal hearing (NH) and those with SNHL. The NH group comprised 25 subjects (13 males, 12 females) aged 18 to 25 years (Mean \pm SD: 21.42 \pm 1.69 years). Their mean pure tone average (PTA) thresholds across the frequency range of 250 to 8000 Hz were 12 \pm 3.69 dB in the right ear and 10.42 \pm 2.33 dB in the left ear, with normal middle ear status confirmed by Type A tympanometry.

The SNHL group consisted of 50 subjects (36 males, 14 females) aged 18 to 50 years (Mean \pm SD: 32.46 \pm 3.51 years) presenting with bilateral, symmetrical moderate to moderately severe sensorineural hearing loss. Their mean PTA across the frequency range of 500 to 4000 Hz was 62.25 \pm 7.49 dB in the right ear and 57.61 \pm 12.64 dB in the left ear. The NH group was selected from among students of the Faculty of Rehabilitation, Shahid Beheshti University of Medical Sciences, and the SNHL group was selected from among the referrals to the audiology clinic of the faculty of rehabilitation and Loghman hospital using a convenience sampling method.

Common inclusion criteria for both groups were: being native Persian speakers (monolingual), right-handedness (confirmed by the Persian version of the Edinburgh handedness questionnaire), normal otoscopic examination, normal middle ear status (Type A tympanometry), and possessing a diploma or higher educational qualification.

Specifically, criteria for the NH group included normal pure-tone thresholds equal to or less than 15 dB HL across all tested frequencies from 250 to 8000 Hz on audiometry and speech discrimination scores equal to or greater than 90% in both ears. For the SNHL group, inclusion criteria mandated symmetrical, bilateral moderate (41–55 dB) or moderately severe (56–70 dB) SNHL persisting for a minimum of three years and speech discrimination scores equal to or less than 60% [10,16].

Procedure

All participants were subjected to full audiological history, otoscope (Heine model otoscope made in Germany results) and basic audiological evaluation, including pure tone audiometry (AC40 model audiometer made in Denmark), speech audiometry and tympanometry (AT-235 model tympanometry made in Denmark). Then, the people participating in this study completed questionnaires P-SHQ and P-SSQ.

The P-SHQ, validated by Delphi et al. [17], serves as a tool for assessing spatial hearing function in clinical and research settings in Iran. The questionnaire is structured to assess critical spatial auditory tasks, such as localization, distance estimation, and binaural discrimination. High internal consistency (Cronbach's alpha = 0.99, $r = 0.84$) confirms that the resulting total scores provide a reliable measure of the severity of spatial auditory processing impairment in patients. It contains 24 questions about spatial auditory skills in locating different sound sources such as vehicles, children's voices, women and men in different environments and situations. The score of each question in P-SHQ was from 0 (the situation would be very difficult for the listener) to 100 (the situation would be very easy for the listener). The total score of this questionnaire is expressed as a percentage, and in normal individuals this score is closer to 100 [17].

The P-SSQ which has undergone rigorous psychometric validation by Lotfi et al. (Cronbach's alpha = 0.97, $r = 0.81$), is established as a pivotal self-assessment instrument within the field of audiology. A crucial attribute that underscores the relevance of this questionnaire for the present study is its explicit focus on binaural processing mechanisms [18].

The instrument comprises 47 items organized across three distinct domains: speech perception, spatial auditory, and hearing quality. Response scoring is determined by a 0-to-10 scale, where 0 represents the minimum perceived ability and 10 represents the maximum. The protocol for administering this instrument mandates a structured interview format. Overall, the SSQ's inherent structure renders it an appropriate tool for evaluating the multifaceted communication abilities of individuals with hearing impairment, particularly because its targeted assessment of binaural processing skills allows for the sensitive detection of even marginal functional deficits [18].

After completing the above-mentioned questionnaires, all participants were administered the P-DSQSIN test. The test was conducted using the P-DSQSIN application on an HP EliteBook 2560p laptop with calibrated Sennheiser HD 215 headphones. The test was administered binaurally through headphones (virtually). The sentence lists followed the guidelines from the QSIN user manual by Killion et al. [12]. One of the five standard equivalent sensitive lists was randomly selected as a practice list, after which clinical testing began.

Each list consisted of six sentences of similar difficulty. The signal presentation level (consisting of 6 nonsense sentences with 5 key words) was at a comfortable level for both groups. The SNR was decreased in 5 dB steps from 25 to 0 dB. The babble noise was used in this test. The participant's task was to repeat as many of the five key words from each sentence as possible. The SNR50 (the signal-to-noise ratio at which the participant repeated 50% of the words correctly) was calculated using the formula: $SNR50 = 17.50 - \text{number of correct words}$ and The SNR loss was calculated using the formula: $SNR \text{ loss} = 6.50 + SNR50$. The test took about one minute per list [15,19].

Then, all participants were administered the P-HINT. The test was conducted using the P-HINT software on an HP EliteBook 2560p laptop with calibrated Sennheiser HD 215 headphones. The test was administered binaurally through headphones (virtually). The P-HINT consists of 12 lists, each containing 10 sentences of similar difficulty. The sentences were selected from elementary Persian textbooks [14]. The test follows the guidelines outlined in the HINT user manual by Nilsson et al. [9]. A practice list was randomly chosen from the 12 available lists before clinical testing.

The noise level for the NH group, was set at 65 dB and for the SNHL group, was set 5 dB above the stimulus level throughout the test. The sentences were initially presented at a -5 dB SNR. The intensity of the sentences was adjusted according to the participant's responses: If the participant repeated 100% of the words correctly, the presentation level was reduced by 4 dB. If the participant gave an incorrect response, the presentation level was increased by 4 dB. The SNRs of the first four sentences were averaged to determine the starting presentation level for the fifth sentence. After that, the adaptive procedure continued, with 2 dB steps applied until the tenth sentence. The RTS for the list was determined by averaging the SNR of sentences 5 through 10 [14]. The participants were instructed to listen carefully and repeat as much of the sentence as possible. They were encouraged to guess if unsure. The expectation was for 100% repetition of each sentence. The score was calculated using the formula: $RTS - \text{noise level (dB)} = SNR \text{ (dB)}$ [14]. The test took about one and half minute per list.

Statistical analysis:

The Kolmogorov-Smirnov statistical test was used to examine the normal distribution of the data. Given the normal distribution of the data to compare the results between the two groups, the independent samples T-Test was used, and to compare the correlation between the tests and the questionnaires, the Pearson correlation test was used. Statistical analysis of the data was performed with SPSS version 17 software, and the significance level for all tests was considered to be less than 0.05. Statistical analysis.

Results:

In the P-DSQSIN test, the SNR loss scores, measured in decibels, were categorized into four ranges: 0-3, 3-7, 7-15, and above 15. In the NH group, 24 participants (96%) scored within the 0-3 range, while 1 participant (4%) scored within the 3-7 range. In the SNHL group, 16 participants (32%) scored within the 7-15 range, and 34 participants (68%) scored above 15. A comparison between the two groups for SNR loss values was performed using an independent-samples t-test. The mean SNR loss values for the NH group (1.84, $SD = \pm 0.27$ dB) were significantly different ($p < 0.001, t = 4.39, df = 73$) from those in the SNHL group (12.53, $SD = \pm 1.57$ dB) Table 1.

In the P-HINT a comparison between the two groups for SNR 50 values was also conducted using an independent-samples t-test. The mean SNR loss for the NH group (-6.42, $SD = \pm 1.61$ dB) was significantly different ($p < 0.001, t = 5.84, df = 73$) from that in the SNHL group (2.55, $SD = \pm 1.09$ dB) Table 1.

In the NH and SNHL groups, the mean \pm SD of the total scores for the P-SSQ questionnaire were 9.63 ± 1.64 and 6.47 ± 1.33 , respectively. Similarly, for the P-SHQ questionnaire, the mean \pm SD of the total scores were 87.92 ± 7.52 percent for the NH group and 53.18 ± 5.08 percent for the SNHL group.

To assess the correlation between the results of the tests and questionnaires in the SNHL group, the Pearson correlation test was used, and the results are presented in Table 2. In the SNHL group, the results revealed a significant positive correlation ($r = 0.693, p < 0.001$) between the P-DSQSIN and P-HINT tests. Additionally, the results revealed moderate significant positive correlations between the P-DSQSIN SNR loss and P-HINT SNR with the P-SHQ ($r = 0.538, p < 0.001$ and $r = 0.427, p = 0.007$) and P-SSQ questionnaire scores ($r = 0.647, p < 0.001$ and $r = 0.348, p = 0.015$).

Discussion

Speech perception in noisy environments is one of the most common complaints among individuals with SNHL who use traditional hearing aids [19,20]. The present study aimed to evaluate the newly developed Persian versions of the DSQSIN and HINT tests in adults with SNHL and to compare their performance across several key factors that are critical when selecting a speech-in-noise test. These factors included test setup requirements, ease of administration, scoring techniques, and test duration. The results indicated that the P-DSQSIN test outperformed the P-HINT test in terms of setup requirements, ease of administration, and scoring methods. Although both tests used sentences as the test material, the P-HINT required the listener to repeat the entire sentence correctly, which added a greater burden on the listener [12,14,15]. In contrast, the P-DSQSIN scored based on the number of target words (five words) that needed to be correctly repeated, thus reducing the response burden for participants [15].

Regarding the test materials, the sentences used in the P-HINT were sourced from first-grade children's books or equivalent sources, with uniform sentence lengths ranging from three to six words [14]. In contrast, the sentences in the P-DSQSIN test included words that were not highly predictable from the surrounding context. These sentences were designed to have fewer contextual cues, which makes the test more challenging and relevant to real-world conditions of speech perception in noise [15]. In terms of test duration, administering the QSIN test list took approximately one minute, whereas the HINT test list required about one and a half minutes [10, 21,22], meaning the QSIN test required about 30 seconds less than the HINT test. Though small, this time difference may be significant in clinical settings where time constraints are a concern.

In terms of ease of administration, the HINT uses an adaptive method, where the SNR adjusts depending on the listener's responses. This means that the noise level increases or decreases based on whether the listener's response is correct or incorrect [9,14]. On the other hand, the QSIN test employs a descending paradigm, where the SNR gradually decreases throughout the test, with lower scores reflecting each reduction in SNR. This approach simplifies the scoring process compared to the adaptive method used in the HINT [10,23].

Regarding scoring techniques, the HINT uses a RTS (response time score) that provides flexibility in tracking changes in performance over time [9]. However, the HINT lacks the precision that the QSIN provides through the calculation of the SNR ratio in decibels using the simplified Spearman-Kärerequation ($17.5 - \text{Correct score}$). This difference in scoring methods highlights the enhanced precision of the QSIN test, which is particularly useful in clinical settings where accuracy in speech-in-noise testing is critical [10,15].

The results of the present study indicated that in the NH group, both the P-DSQSIN and the P-HINT tests showed statistically significant differences when compared to their respective normative values. The mean SNR loss for the P-DSQSIN in listeners with SNHL was 12.53 ± 1.57 dB, which was approximately 11 dB higher than the mean for the NH group (1.84 ± 0.27 dB). This finding is consistent with previous studies examining speech-in-noise performance differences between individuals with normal hearing and those with hearing loss. These studies found that tests like QSIN provide similar separations between the recognition performances of normal hearing listeners and those with hearing loss [10,23].

In contrast, the mean SNR for the P-HINT in the SNHL group (2.55 ± 1.09 dB) was about 8 dB higher than the mean for the NH group (-6.42 ± 1.61 dB). This result differs from Essawy et al. [24], who reported a 2.5 dB difference between normal and sensorineural hearing loss subjects. This discrepancy could be attributed to two main factors: first, the participants in the current study had moderate to moderately severe hearing loss, and second, the participants in Essawy et al.'s study were given extensive practice on the task, which was not the case in the present study, where participants had only one practice list prior to clinical testing. Additionally, Essawy et al. tested under multiple listening conditions, including speech in quiet, noise at various azimuths (0° , 90° , and 270°), which may explain the smaller difference observed in their results.

The present findings suggest that the P-DSQSIN test, which relies more on acoustic cues, was able to create a greater separation in recognition performance between listeners with normal hearing and those with hearing loss compared to the P-HINT, which incorporates more contextual cues. This aligns with the findings of Wilson et al. [25], who found that speech-in-noise tests that depend more on acoustic cues (such as QSIN) provide a greater performance distinction between normal hearing listeners and those with hearing loss. The HINT, in contrast, was more likely to show similar performance between normal hearing and hearing loss listeners, due to its reliance on contextual information that can enhance cognitive processing in listeners with SNHL.

Furthermore, significant positive correlations were found between the SNR loss in P-DSQSIN and the P-SHQ and the P-SSQ scores in the SNHL group. These correlations (P-SHQ: $r = 0.538$, $p < 0.001$ and P-SSQ: $r =$

0.647, $p < 0.001$) suggest that the P-DSQSIN test closely aligns with subjective measures of real-world speech-in-noise performance. Similarly, significant positive correlations were observed between P-HINT SNR and the P-SHQ ($r = 0.427$, $p = 0.007$) and P-SSQ scores ($r = 0.348$, $p = 0.015$). These results are consistent with Sultan et al. [10], who also found moderate correlations between speech-in-noise test scores and subjective questionnaires. However, these findings differ from those of Grant and Walden [26], who reported weaker correlations between similar tests.

Both the QSIN and HINT tests provide valuable insights into a listener's ability to perceive speech in noisy environments. According to the British Society of Audiology (BSA) practice guidance, the QSIN test is more readily available and widely used in routine clinical settings compared to the HINT, which is more commonly used in research due to its complex setup and scoring procedures [10,23,25]. Despite this, the HINT remains a highly researched and valuable tool for distinguishing small performance differences among individuals [10,23].

In this study, age and gender were considered as background variables, but their effect on test outcomes was not systematically controlled. The lack of control for these variables may limit the generalizability of the results. Future studies should ensure that these variables are accounted for to draw more definitive conclusions. The current study did not specifically assess the impact of different severities of hearing loss (moderate vs. moderately severe) on performance in P-HINT and P-DSQSIN test. Future studies should explore how these different levels of hearing loss affect test outcomes, as severity may influence speech perception in noise. It would be beneficial for future research to evaluate these tests under real-world conditions, where noise levels and acoustic environments vary. This would provide a more comprehensive understanding of their effectiveness in everyday listening situations and their predictive value for real-world auditory challenges.

Conclusion

This study found that the P-DSQSIN test demonstrated a greater ability to differentiate between individuals with normal hearing and those with sensorineural hearing loss compared to the P-HINT test, indicating its higher sensitivity. While moderate correlations with subjective questionnaires (P-SHQ and P-SSQ) were observed, further research is needed to better understand the relationship between test results and real-life speech-in-noise perception. The P-DSQSIN also offers advantages in terms of ease of administration, shorter duration, and simplified scoring, making it a more practical choice for clinical settings. Future studies should establish specific clinical norms for both tests to improve their application in practice.

Ethical Considerations

Compliance with ethical guidelines

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Authors' contributions

AJ: Study design, acquisition of data, statistical analysis, interpretation of the results, drafting the manuscript;

AM: Study design and Supervision, interpretation of the results, revision of the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1. Comparison of signal to noise ratio loss in the dynamic spatial- quick speech in noise test and signal noise ratio 50 in the hearing in noise test between the normal and sensorineural hearing loss groups (n=75)

Group	DSQSIN SNR loss (dB) Mean \pm SD (Min - Max)	P*	HINT SNR 50 (dB) Mean \pm SD (Min - Max)	P
NH (n=25)	1.84 \pm 0.27 (0.5 - 3.5)	<0.001	-6.42 \pm 1.61 (-11.18 - -3.49)	<0.001
SNHL (n=50)	12.53 \pm 1.57 (3.5 - 26.5)		2.55 \pm 1.09 (0.36 - 6.14)	

Abbreviations: SD: standard deviation ; DSQSIN: Dynamic spatial- quick speech in noise HINT: Hearing in noise test ; SNR: Signal to noise ratio; df: Degree of freedom ; NH: Normal hearing ; SNHL: Sensorineural hearing loss ; dB: Decibel
*Shows an independent sample t test

Table 2. Correlation between dynamic spatial- quick speech in noise and hearing in noise test with speech spatial qualities and spatial hearing questionnaire scores in sensorineural hearing loss group (n=50)

Variable	DSQSIN Test SNR loss(dB)	HINT SNR50 (dB)	Total score of SSQ	Total score of SHQ
DSQSIN Test SNR loss(dB)		r= 0.693 p < 0.001	r= 0.647 p < 0.001	r= 0.538 p < 0.001
HINT SNR50 (dB)	r=0.693 p* < 0.001		r=0.348 p =0.015	r=0.427 p =0.007
Total score of SSQ	r=0.647 p < 0.001	r=0.348 p= 0.015		r=0.614 p < 0.001
Total score of SHQ	r=0.538 p < 0.001	r=0.427 p =0.007	r=0.614 p < 0.001	

Abbreviations: DSQSIN: Dynamic spatial- quick speech in noise ; HINT: Hearing in noise test ; SNR: Signal to noise ratio ; SSQ: Speech, spatial and qualities of hearing scale ; SHQ: Spatial hearing questionnaire

*Shows a Pearson test