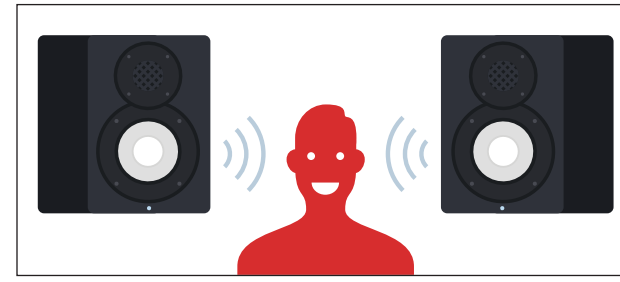
Speech-in-Noise Testing: Pivotal and Rare

By Douglas L. Beck, AuD, F-AAA, CCC-A

This article addresses multiple reasons why hearing care providers (HCPs) should provide speech-in-noise (SIN) assessment, what those assessments reveal, how to implement that information in clinical decision-making, and how the results correlate with other clinically significant protocols and issues. Although performing SIN assessments improves patient satisfaction and promotes patient loyalty[1] and despite The American Academy of Audiology (AAA)[2], The American Speech-Language-Hearing Association (ASHA)[3] and The International Hearing Society (IHS)[4] allowing SIN assessments in their Scope of Practice guidelines, it appears that fewer than one in five HCPs routinely include SIN assessment in their audiometric evaluation.[5]

Depending on which articles and authors we refer to, it is well-accepted that there are some 38 million people in the USA with demonstrable hearing loss on an audiogram. As hearing loss increases, so too, does the need for an improved signal-to-noise ratio (SNR). Some people may need sound louder to make it audible. However, as sensorineural hearing loss (SNHL) increases, so too, does distortion, which indicates that many people with hearing loss need sound clearer, too. In addition, estimates indicate there are 23-26 million people in the United States[6,7] who have hearing difficulty, or for whom it is difficult to understand SIN, yet, they have no demonstrable hearing loss. It appears likely that many of these 23-26 million people may benefit from an improved SNR, despite having no hearing threshold loss.[4,7,8] These patients are often referred to as having sub-clinical hearing loss or functional hearing loss or supra-threshold listening disorders (STLDs). These patients are very likely to 'pass' a simple hearing screening and may be sent home with well-intentioned but incomplete and perhaps damaging interpretations like, *"The good news is your hearing is normal."* The reason this may be damaging is that hearing screenings are not designed to detect listening and communication difficulties or speech-in-noise problems. Hearing screenings are most often a pass/fail measure of loudness detection across multiple frequencies and 23-26 million Americans may pass a typical hearing screening despite having undetected significant auditory difficulties. As such, when a person complains about SIN problems, they need (in my opinion) a comprehensive audiometric evaluation including a listening and communication assessment and a SIN assessment, and improved listening strategies and for appropriate candidates, a trial with technology that may facilitate an improved SNR. When the HCP administers a comprehensive audiometric evaluation with a listening and communication assessment and a SIN assessment, the probability of detecting these same problems increases.



www.shutterstock.com

THE ESSENCE OF SIN ASSESSMENT

The goal of SIN assessment is to determine the SNR at which the patient repeats 50% of the digitized, recorded stimuli correctly. This metric is referred to as the "SNR-50." Of note, the protocol used to determine the SNR-50 varies with different SIN assessment measures, but the concept is similar to determining pure-tone thresholds in that the HCP seeks the 50% correct response as the "true" or representative threshold response (for pure tones, HCPs use 5- and 10-dB steps, per Hughson & Westlake, 1944).[9] Another term used to describe the SNR-50 is the SRT-50, which is the Speech Reception Threshold required to achieve 50% correct. This author does not recommend using the term "SRT-50" because it can be confusing, given the more common spondee-based SRT.

The benefits of SIN assessment go beyond improving patient satisfaction and promoting patient loyalty. SIN assessment allows the HCP to:

1. Quantify the magnitude of the SNR problem experienced by the patient.
2. Objectively compare/contrast the patient's unaided and aided SIN ability, which may be useful for comparing over-the-counter (OTC) and prescription-based hearing aids.
3. Help select patient-specific hearing aid technology which may reduce or overcome the specific patient's SNR deficit in many listening situations.
4. Select additional SNR enhancing technologies such as T-coils, Loops, Bluetooth systems, FM, digital remote microphones,

Dr. Douglas L. Beck is a senior editor at *The Hearing Journal*. He is among the most prolific authors in audiology with 221+ publications, interviews, and op-eds published by the American Academy of Audiology, *Hearing Review*, *Audiology Online*, and others. His work has addressed a wide variety of audiology and professional topics, including op-eds, audiology, language, pediatrics, cognition, hearing aids, amplification, psychology, neuroscience, anatomy and physiology, counseling, and more. Dr. Beck has delivered more than 1,000 lectures, keynote addresses, webinars, and other professional presentations. He continues to consult for multiple clinical, scientific, and other organizations.

Table 1. Killion's (2002)[16] recommended interpretation of QuickSIN scores

0-3 dB SNR loss	Normal
4-7 dB SNR loss	Mild
8-15 dB SNR loss	Moderate
>15 dB SNR loss	Severe

and assistive listening devices, to address specific and problematic listening situations.

5. Provide more realistic counseling and improved patient-based outcomes.
6. Better adhere to AAA, ASHA and IHS Scope of Practice guidelines.
7. Achieve greater professionalism, resulting from a more informed and comprehensive understanding of the specific SIN problem and potential solutions for the individual patient.

BRIEF HISTORIC REVIEW

Carhart & Tillman (1970)[10] urged that comprehensive audiometric evaluations should include a SIN assessment. Specifically, they concluded that people with sensorineural hearing loss (SNHL) were often "excessively disturbed" by background noise (i.e., competing speech sounds; words, sentences etc). They reported SNHL not only elevates thresholds and disrupts speech intelligibility in quiet, but also significantly impacts SIN assessment.

Wilson (2011)[11] reported observations on more than 3,000 veterans and noted that speech performance in quiet does not predict speech performance in noise. He reported that if one desired to evaluate how the individual performs in noise, the assessment should be determined based on a test that challenges the auditory system in a manner which approximates functional listening ability, such as a SIN assessment. He also reported that of the 3000+ people in his study, some 70% had good-to-excellent word recognition scores (WRS) in quiet, yet only 7% has normal SIN scores. In other words, having a good-to-excellent WRS score does not predict or indicate good-to-excellent SIN ability.

Lindley (2015)[12] reported that an unaided SIN assessment at conversational level offers a greater understanding of what the patient is experiencing. In his report of 48 patients considering amplification, 40% had normal or near-normal performance in noise. Of the remaining 60%, 33% had a mild SIN problem, 22% had a moderate SIN problem, and 4% had a severe SIN problem. Lindley's regression analysis indicated the combined effects of age, word recognition in quiet and hearing loss accounted for just over half the variation of SIN scores. As such, SIN cannot be predicted from other measures, it must be intentionally assessed.

Clark, Huff, and Earl (2017)[13] reported the primary difficulty people with hearing loss complain about is not loudness, but rather the inability to understand SIN. They report SIN assessments increase face validity of the clinical test protocol while availing valuable information for the HCP. SIN assessment avails to the HCP the patient's specific depth of the problem and indicates appropriate technology and reasonable outcomes-based expectations. Clark, Huff, and Earl reviewed the responses from 1,200+ audiologists and determined that fewer than 15% regularly assess SIN ability.

Mueller (2016)[14] notes that greater than 90% of patients complain about SIN ability.[5] Ironically, although patients most often complain about SIN they are most often tested via speech in quiet (SIQ). Mueller reports his survey results from 107 audiologists which revealed that 10% use SIN assessments routinely and 20% reported using SIN assessments "some of the time." Mueller offers an excellent review of some of the most common SIN assessments. He reports the Words in Noise (WIN) Test was introduced in 2007 (Wilson, Carnell, and Cleghorn, 2007).[11] The WIN uses 4 dB increments, the background is multi-talker babble and the resultant scores are quite similar to the QuickSIN results.[15] Of note, of the subjects who performed abnormally on the WIN, 46% had *SIQ scores of 92% or better*. Mueller reported differences in SIN assessments include words versus sentences, background noises, adaptive versus fixed signal-to-noise ratios (SNRs), presentation levels and more. He reviews the advantages of the QuickSIN and reviews the essential test protocol.

Mueller presents Killion's (2002)[16] recommended interpretation of QuickSIN scores, which have become (in my opinion) the clinical standard for interpreting SIN ability. (See Table 1.)

HCPs often ask why not use an SNR-100? Conversations in noise involve context including knowledge of the topic, vocabulary, probable familiarity with the person speaking, visual cues, speech reading, etc. As such, theoretically, the listener potentially only needs to accurately perceive some 50% of the target words through audition because the redundant visual and other contextual cues allow the listener to "fill-in" and understand/comprehend the entire message. This is the rationale for the 50% protocol.

REAL-WORLD SNRS

It is difficult to estimate or anticipate universal, representative, realistic, and repeatable SNRs across real-world environments. SNRs are dynamic; the primary talker and the backgrounds constantly vary in all acoustic environments. A quiet café with two people can quickly become a noisy café with 14 talkers. Same environment, different acoustics. The same is true for classrooms, airports, and cocktail parties. Everything depends on everything. The ability of the listener to discern SIN varies with hearing, hearing loss, information processing ability, accents, vocabulary, intention, attention, cognitive status, emotional status, psychological status, SNR, reverberation, sound absorption, damping, distance, monaural versus binaural hearing, and more.

Wu, Stangl, Chipara et al. (2018)[17] reported on 20 older adults with mild-to-moderate hearing loss. Participants recorded their daily sound environments on digital recorders for more than a month and participants filled-in multiple surveys. The recordings were analyzed for 894 listening situations. The authors report that as noise increased from 40 to 74 dBA, the speech levels increased from 60 to 74 dBA, indicating that the SNR decreased from 20 dB to 0 dB as noise increased.

They reported approximately two-thirds of the recordings had SNRs between 2 and 14 dB.

Smeds, Wolters, and Rung (2015)[18] reported on 20 adult hearing aid users, between ages 18-81 years. The goal of their study was to report estimated SNRs in realistic sound environments. They reported that for speech in babble the average SNR was approximately 5 dB.

Although a universal representative SNR is elusive, it seems reasonable to anticipate that for many people SNRs of 5-10 dB should be expected across typical day-to-day acoustic scenes.

As such, it seems reasonable to determine the ability of a patient to understand unaided SIN and aided SIN with whatever technology they wear to better appreciate how they will function with their individual technology in their daily lives, given an SNR of 5 to 10 dB.

SNR AND HEARING AID FITTING GUIDELINES

As the chief complaint from most patients is the inability to understand SIN, the end goal of amplification is not always to simply *make things louder*. For many people (perhaps most), the end-goal is to *make sound clearer.* Similarly, the goal is not merely hearing, it is listening; the ability to apply meaning to sound, to comprehend sound, to understand SIN.

Beck & Clark (2009)[19] reported "audition matters more as cognition declines and cognition matters more as audition declines." They reported patients live in a world where cognition, attention, memory and hearing interact and each plays a critical role in listening. They noted that when hearing is compromised the cognitive and associated system(s) must work harder to make sense of the attenuated or distorted input.

Beck & Flexer (2011)[20] addressed the difference between hearing and listening. They reported hearing can be measured in the absence of comprehension. However, listening is a learned skill. Listening is the ability to attribute meaning to sound and requires an appropriate SNR, vocabulary, working memory, knowledge of where to focus one's attention, cognitive ability and more. Beck & Flexer reported listening is a cognitive event and "listening is where hearing meets brain."

Dillon (2012)[21] addressed the correlational relationship between hearing loss and the SNR required for patients to understand SIN. He reported, in general, that for every 10 dB of hearing loss, the SNR needs to improve by 3 dB. This is an ***extremely important observation***. In other words, as hearing loss increases, so too does the need for an improved SNR.

For example, if we assume patients with less than 25 dB HL thresholds are 'normal' (often a gross mis-statement) the HCP might conclude these patients don't need amplification. However, when a person presents with a flat 35 dB SNHL (representing a 10 dB sensation level hearing loss, or 'SL loss" regarding the 25 dB HL limit for normal hearing) the HCP can anticipate the patient will need an improvement of 3 dB in SNR to better understand SIN. This can be accomplished readily as many hearing aids with directional microphones can provide 2-3 dB improvement in SNR.[22] However, for patients with a 45 dB HL flat loss (a 20 dB SL loss), they would require a 6 dB improvement in SNR, which can rarely be accomplished with open domes. For the patient with a 55 dB HL flat loss (a 30 dB SL loss) he/she would require a 9 dB improvement in SNR, which is not commercially available (to my knowledge) in a stand-alone commercially available hearing aid. Indeed, a 55 dB HL hearing loss is the hearing loss level at which I strongly advocate and demonstrate FM, Digital Remote Mics, T-coils, Loops, Bluetooth, and other Assistive Listening Devices (ALDs).

Magnusson et al. (2013)[23] reported on 20 adults who were evaluated with bilateral open-fit hearing aids and compared those results to closed earmold fittings. They reported speech recognition was significantly improved with directional microphones using closed fittings (4.4 dB average improvement in SNR) and they reported that open fittings resulted in a greatly reduced benefit (1.6 dB average improvement in SNR) compared to unaided. Finally, those researchers reported that when directional microphones with closed earmolds were combined with noise reduction, an additional 0.8 dB advantage in SNR was obtained regarding SNR.

Although many historic and well-known hearing aid fitting formulas and probe microphone real ear measures (REMs) are based on pure tone thresholds, HCPs must acknowledge that these very important basic and foundational measures do not anticipate or reveal *functional* hearing or listening ability. Specifically, although Best Practice (AAA, ASHA, IHS) fitting protocols such as NAL-NL2[24] and DSL-5[25] are very important, as are REMs, without *functional* measures such as unaided versus aided SIN performance in noise, we really do not know the *functional* result.

SIN AND COGNITIVE SCREENINGS

The relationship between cognition and audiologic measures is emerging rapidly.[26] The AAA[2] and ASHA[3] state that cognitive screenings are within the Scope of Practice for audiologists.

Moore and colleagues (2014)[26] reported that the cognitive processing abilities of older adults is often associated with a reduced SIN ability. They reported that hearing metrics often do not align with SIN ability and they queried that poor SIN ability may represent a "first warning of a need for intervention."

Stevenson, Clifton, Kuzma, et al. (2022)[27] reported on the UK Biobank cohort results regarding SIN and cognition. Their analysis included more than 82 thousand dementia-free participants (ages 60 years+) who were followed for 10 years. They reported that participants with poor SIN abilities had an increased risk of developing dementia compared to those with normal SIN ability. Specifically, they reported that over the 10-year period those with poor SIN ability had a 61% Hazard Ratio for dementia (Hazard Ratios represent the correlation of two things over time). The authors reported SIN hearing impairment is independently associated with incident dementia. Beck (2023)[28] emphasized SIN assessment cannot be considered a surrogate for cognitive screening and a cognitive screening cannot be considered a surrogate for SIN testing. Both assessments should be applied judiciously, to people at risk, as they each provide unique and important information.

Jiang, Mishra, Shrestha (2023)[29] reported on 437,000 people ages 40-69 years of age. They compared unaided listening in people without hearing loss to unaided listening in people with hearing loss. They reported the unaided people with hearing loss had an increased risk of all-cause dementia

over time and there was no increased risk for people with hearing loss who wore hearing aids. They reported that their findings indicated *the urgent need* to address hearing loss to positively impact cognitive decline.

CONCLUSION

The time has come to incorporate SIN assessments in all comprehensive audiometric evaluations. Of course, 15 years ago McCardle & Wilson (2008)[30] stated very much the same thing. They noted that if HCPs are to provide ecologically valid care to our patients, SIN assessment should be embraced as a necessary measure in audiologic evaluations.

Carhart & Tillman (1970)[10] reported the same thing half a century ago. Roup, Custer & Powell (2021)[31] reported their outcomes support SIN assessment for all patients including those within the traditional normal hearing range.

SIN assessment is very likely the single most important functional test HCPs can offer people with hearing and listening complaints and the author (DLB) urges their immediate acceptance and implementation.

ACKNOWLEDGEMENT: The author would like to thank Michael Valente, PhD, Professor Emeritus of Clinical Otolaryngology at Washington University for his excellent and insightful comments and editorial review of this manuscript.

References for this article can be found at http://bit.ly/HJcurrent.