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Amplification for adults with hearing difficulty, speech in noise problems - and normal thresholds

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Introduction

Most physicians and audiologists know that hearing difficulty (HD) and/or the inability to understand speech-in-noise (SIN) are chief complaints for some 38 million people with sensorineural hearing loss (SNHL) in the United States. These are neither trivial nor rare complaints. Rather, they represent a nearly universal descriptor of the most typical auditory complaints of most people with SNHL. However, few professionals are likely aware that these same "supra-threshold" complaints are voiced by an additional 26 million people who have hearing thresholds within normal limits (WNL), when tested with a standard audiologic test battery in quiet. People who consult physicians and audiologists complaining of HD or SIN problems in the presence of thresholds WNL often present a dilemma for hearing professionals. Specifically, they have normal hearing on standard tests, but still complain of SIN and HD problems. Of course, the given scenario begs the question, "What is the appropriate resolution for these problems?"

Persons with supra-threshold complaints and normal thresholds are often counseled about taking advantage of "happy talk" strategies. That is, they are generally told something along the lines of "The good news is you have normal hearing…" and they are instructed to use better lighting, and perhaps to focus on visual cues and/or visual redundancy, and to reduce the distance between the talker and the listener and more. However, although these strategies may offer some benefit, they may also frustrate patients further and may not be accepted as being particularly helpful or realistic solutions to their problems. Of note, when adults report they only have difficulty in challenging acoustic situations or difficulty understanding SIN, they are usually reporting accurate and sophisticated observations. Further, because they are adults, it is likely they have already tried many of these same apparent and obvious solutions without substantial success and have only come to see hearing care professionals after having exhausted these same solutions.

Unfortunately, many supra-threshold complaints are overlooked, or are not treated seriously, and may be explained as due to "normal aging" or ignored. Thus, many of these individuals "slip through the cracks" or fail to receive early intervention for their HDs and/or SIN problems. Delays in diagnosis and treatment often perpetuate these patients' problems and can affect the overall quality of life (QoL) for them and their families. Physicians and audiologists can and should do more for people with supra-threshold auditory complaints.

Best practices

Many physicians and audiologists practice with an eye toward detecting otologic diseases which may require medical or surgical interventions, and as anticipated, the vast majority of these same problems (i.e., those in need of medical or surgical attention) are identified by the standard audiologic battery (i.e., air- and bone-conduction pure tones and speech audiometry in quiet). Unfortunately, this same battery often fails to detect listening difficulties and may not accurately reflect how patients function in their daily lives. Therefore, many patients are likely not identified or informed about available tools designed to improve signal-to-noise ratios (SNRs) which could alleviate or reduce their HD or SIN problems. Indeed, hearing loss is not the primary concern for people with normal thresholds who complain of hearing difficulty or SIN problems, the primary issue is measuring, documenting and improving the signal-to-noise ratio (SNR) required to understand SIN. Importantly, improving the SNR is "always helpful to a listener."[1] Had these same individuals been tested and managed according to the American Academy of Audiology (AAA) or the American Speech Language Hearing Association (ASHA) Best Practice (BP) guidelines,[2] it is likely their HD and/or SIN problems would be discovered, documented, and scheduled for appropriate treatments in a timely manner.

Patients' complaints of HD and SIN problems in the absence of peripheral hearing loss are not new, and are in fact, quite common. The research literature reveals many studies have reported patients' complaints of HDs in the presence of normal thresholds in 10 to 50% of their subjects, especially in older persons (e.g., Saunders and Haggard,[3]; Gates et al.,[4] Chia et al.,[5] Hannula et al.,[6] Tremblay et al.,[7] Spankovich et al.[8])

Clearly, HDs and SIN problems are not limited to abnormal audiometric thresholds. According to Beck, Larsen, and Bush,[9] people with hearing thresholds WNLs may have supra-threshold auditory deficits due to or associated with any of the following: central presbycusis, auditory disability with normal hearing, obscure auditory dysfunction (OAD), King-Kopetzky Syndrome, auditory dysacusis, auditory processing disorders (APDs), idiopathic discriminatory dysfunction, hidden hearing loss (HHL), cochlear synaptopathy (CS), tinnitus, neurocognitive disorders, dyslexia, attention deficit disorder (ADD), attention deficit hyperactivity disorder (ADHD), traumatic brain injury (TBI), spatial hearing disorders (SHDs), aging, dementia, cognitive decline, presbycusis (sensory, neural, synaptic, auditory fiber, and/or central causes), noise-induced hearing loss (NIHL), mild cognitive impairment (MCI), receptive aphasia, and Alzheimer's Disease among others.

Some physicians and audiologists may not be familiar with recent research and clinical experience that have identified a recently recognized auditory disorder, cochlear synaptopathy (CS) or hidden hearing loss (HHL), that could be a cause of or contributor to HDs and

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SIN problems in people with otherwise normal hearing.[10] CS/HHL involves problems with the ribbon fibers that synapse the cochlear hair cells to the auditory nerve fibers and this condition is receiving considerable research attention.[10,11] Although there is presently no empirically validated test battery to diagnose CS/HHL, researchers are evaluating several measures which may soon prove useful in making such diagnoses.[11–13]

How are HD and SIN problems discovered and documented?

Traditional audiology-based and validated self-assessment tools (e.g., the Client-Oriented Scale of Improvement, COSI; the Hearing Handicap Inventory for Adults, HHIA; the Hearing Handicap Inventory of the Elderly, HHIE; the Personal Assessment of Communication Ability, PACA; and the Abbreviated Profile of Hearing Aid Benefit, APHAB) can be used to assess common hearing problems and difficulties that occur in daily life.[14] These self-assessment tools query patients about the perceived quantity and quality of their hearing difficulties and/or SIN problems. These measures may also be helpful for identifying HD and SIN problems in patients with thresholds WNL.

Speech-in-noise tests

In addition to self-assessment measures, several objective SIN tests having high validity and test reliability are available for use with adults and can be administered in only a few minutes per test. Among the most popular SIN tests are the Bamford-Kowal-Bench Speech-in-Noise test (BKB-SIN), the Words in Noise Test (WIN), the Hearing in Noise Test (HINT) the Quick-SIN and the Speech Perception in Noise (SPIN) test (for a review of many of these tests, see Wilson.[15] Several protocols are used in SIN testing. Stimuli may be presented via fixed or adaptive protocols and may include natural sentences, spondees, or monosyllabic words. Multi-talker babble (four or more talkers) is a preferred noise competitor because its speech/linguistic composition is more representative of typical restaurant, cocktail party, train station, and other noisy llistening situations rather than, speech spectrum, white, and other artificial noises that lack linguistic information and are generally easier to ignore.[16] Regardless, of the particular test selected, we recommend local normative values should be determined.

To approximate SIN problems in the real world, SIN measures are acquired in a calibrated sound field using speakers (not headphones, not insert ear phones). The Signal-to-Noise Ratio required to achieve a 50% correct response rate is referred to as the "SNR-50." Based on clinical observations and reports based on the QuickSin, adults with thresholds WNL should achieve an SNR-50 of 0, 1, or 2 dB. People with mild-moderate sensorineural hearing loss typically have an SNR-50 of 6, 7 or 8 dB. However, some patients with thresholds WNL report significant problems understanding speech, and these people should be evaluated with SIN tests to determine their SNR-50, For example, if a patient has audiometric thresholds WNL, one might expect an SNR-50 of about 1 or 2 dB; however, if that same patient presents with an SNR-50 of 8 or 9 dB, then they clearly have significant difficulty understanding SIN. The goal for the clinician (after ruling out medical and/or surgical conditions) is to improve the SNR-50 as much as possible. For example, given normal thresholds and an SNR-50 of 8 dB, this would indicate the need for tools which can improve the SNR-50 by approximately 6 dB. Of note, simply providing amplification may not be enough as many amplification technologies amplify the background noise along with the primary speech signal, rendering a louder sound with a negligible change in the SNR. Therefore, anticipated improvements in the SNR-50 must be verified and validated using the same test conditions as used in the unaided measures.

Wilson[17] reported the SIN ability of 3024 veterans from 20 to 80 years of age with pure-tone averages between 15-70 dB HL. Because neither speech in quiet nor pure-tones predicted listeners' SIN ability, Wilson recommended including SIN testing in every audiologic diagnostic assessment. However, although AAA and ASHA Best Practice (BP) statements recommend SIN testing as part of comprehensive adult audiologic evaluations, fewer than 15% of audiologists perform it routinely.[2,18] Thus, audiologists should reconsider using SIN tests, especially with patients complaining of HD and/or SIN problems in the presence of normal thresholds.

Hearing aids can improve HDs and SIN problems

Fitting hearing aids to patients (even those with thresholds WNL) based on their perceived HDs is not a new concept.[19] Physicians and audiologists need to know that many people with HDs and SIN problems, including those with near-normal thresholds, may benefit from contemporary hearing aids fitted to BP standards. Most patients with normal or near-normal thresholds, who complain of HD and/or SIN problems and try hearing aids, elect to purchase them at the end of their trial periods.[20]

Beck & Le Goff[21] found statistically significant improvements in word recognition scores and in SNRs for 25 older adults (mean age = 73 years) who wore sophisticated hearing aids with directional technology, narrow-band beam-forming directionality, and multi-speaker-access-technology (MSAT) when tested in two different types of noise originating from three different locations. They reported that statistically significant improvements were obtained with MSAT, which improved SIN scores and SNRs (6.3 dB on average).

Roup, Post & Lewis[22] described results for 20 normal-hearing adults (19-27 years of age) with no self-reported HDs and 19 normal-hearing adults (18-58 years of age) with self-reported HDs. All were fitted binaurally with mild-gain, receiver-in-the-canal (RIC) hearing aids for a four-week trial with directional and noise reduction algorithms engaged. SIN measures were acquired pre-and-post hearing aid fitting and most reported that the hearing aids helped in quiet (67%) and in noise (71%).

Ohlenforst, Wendt & Colleagues[23] demonstrated that noise reduction protocols in contemporary hearing aids can reduce listening effort (as measured via peak pupil dilation, PPD), and noise reduction was found to increase word and sentence recognition in four-talker background noises, in various signal-to-noise ratios (SNRs). The authors emphasized the importance of attending to and measuring listening effort and speech in noise.

Beck, Ng & Jensen[24] reported contemporary hearing aids have been shown to improve word recall in noise, improve SNRs, improve recall of words heard in noise, reduce listening effort, and facilitate higher satisfaction and more.

Similarly, mild-gain amplification may prove to be useful for some patients with CS/HHL based on anecdotal evidence and personal experience which indicates that some patients with CS/HHL symptoms derive improvement for their complaints of HDs and tinnitus. Another potential treatment for CS/HHL uses auditory training to help alleviate symptoms in these patients.[25] Although considerable research needs to be conducted regarding the diagnosis

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and treatments for CS/HHL, physicians and audiologists should know that mild-gain amplification is a viable treatment option for some of these individuals with HDs, but whose hearing thresholds are WNL.

Remote microphone systems

Hearing aids alone may not be enough to correct HDs and SIN problems for some patients. In that case, remote microphone (RM) systems can provide additional SNRs and other benefits. RM systems are radio devices that capture audio signals of interest and deliver them via radio frequency (RF) transmission to a radio receiver coupled to listeners' hearing aids or other receivers. RM systems are inexpensive and are available with most modern hearing aid systems and can substantially improve SNRs (in some cases by 10 to 20 dB), reduce reverberation, and minimize deleterious effects of distance.[26,27] Although historically, most RM systems transmitted audio signals via a frequency modulated (FM) radio signal, modern RM systems deliver audio signals from the microphone to radio receivers via digital RF transmission. These modern RMs can eliminate interference from other nearby RF systems, reduce noise and static which occasionally accompanies FM signals, offer a wider bandwidth, increase the sophistication of processing applied to transmitted signals, and produce excellent speech recognition in noise.[28,29] Some RM users' SIN results approach those obtained by people with relatively normal-hearing ability.[30]

RM systems can be coupled to many commercially available hearing aids and will significantly improve speech recognition in noise relative to the "no RM" condition at SNRs commonly encountered in real-world situations.[29,31,32] RM systems perform well for people with APD, dyslexia, autism spectrum disorder, and attention and other learning disorders. RM systems also have therapeutic benefits including improved cortical auditory-evoked potential, auditory brainstem response, frequency discrimination, binaural temporal resolution, frequency pattern recognition, and auditory working memory. RM systems have also been shown to improve attention, learning, and behavior, participation in class, self-esteem, and psychosocial development. RMs can enhance listening and provide substantial benefit to hearing-impaired persons, even in the most deleterious acoustically challenging listening environments with noise and reverberation. Adults with traumatic brain injuries (TBIs), particularly veterans, also benefit from improved SNRs provided by RMs.[30]

Physicians and audiologists are increasingly addressing the auditory needs of blast-exposed and TBI veterans. Often, these vets present with hearing thresholds WNL yet have HD, SIN, and/or tinnitus problems. In these situations, professionals should consider and measure patients' SIN ability (i.e., determine their SNR-50) listening and communication demands, auditory lifestyle, and other factors in order to diagnose and document their HD and SIN ability, which will facilitate the recommendation of tools which can produce successful outcomes[33]. Hearing aids, particularly those coupled to RMs, can help these individuals, even in the presence of thresholds WNL.[9,34] Many blast-exposed veterans complain of difficulty understanding SIN, rapid speech, and following instructions, often disproportionately to their peripheral hearing sensitivity.[35] FM and RM systems using Bluetooth are effective interventions for blast-exposed veterans with normal or near-normal hearing sensitivity, but HDs. These tools (and others which improve the SNR) should routinely be considered as a potential intervention approach along with mild-gain hearing aids for adults with APDs.[36]

People with HDs, including those with neurocognitive disorders and TBIs, often experience significant QoL benefits from sophisticated hearing aids coupled to FM and RM systems. These systems can reduce background noise, improve SNRs, enhance SIN outcomes, maintain and take advantage of realistic and naturally occurring binaural spatial cues that allow wearers to know where to focus their attention. These tools may soon be shown to serve a neuroprotective role against cognitive decline associated with hearing loss and some neurocognitive disorders.[9,37]

Discussion

Although clinicians generally do not advocate amplification for people with normal thresholds, many individuals with HDs and/or SIN problems perform better in social, professional, and recreational arenas when SNRs are improved via hearing aids, RMs, and other tools. In addition to some 38 million people in the USA with audiogram-based documented hearing loss, another 26 million adults may have HD or SIN problems, despite having hearing thresholds WNLs. Physicians need to know that once they have cleared patients medically, audiologists can documents their SIN and HDs by quantifying them using validated measures, improve their QoL via technology, assure that no damage is being done (using probe microphone real-ear measures), and allow patients a trial period to decide if the tools which provide improved SNRs are worth their time and money.

Sophisticated hearing aid technologies (i.e. MSAT) have been shown to improve the SNR by 6 dB or more. For many people, this represents a significant and useful improvement in SNR. Additionally, telecoils, digital remote microphones, BlueTooth and other wireless protocols can improve the SNR by an additional 10-15 dB or more. These technologies should be introduced and demonstrated to patients who complain of HD and/or SIN supra-threshold problems, despite normal or near-normal thresholds, to facilitate an improved QoL. who complain of HD and/or SIN supra-threshold problems despite normal or near-normal audiometric thresholds.

Person-centered care dictates that physicians and audiologists and patients engage in a decision-making process that encompasses the components of evidence-based practice founded on available research, expert opinion, and a demonstrated appreciation for patients' expressed experiences, needs, and concerns.[38] Unfortunately, the typical medical-centric audiometric test battery may not be sensitive enough to pick up and validate many patients' supra-threshold complaints.

It is no longer appropriate for physicians and audiologists to tell patients their hearing is normal when supra-threshold auditory deficits are not explored or documented.[39] Much like a cardiology-based stress test, SIN tests stress the auditory system and reflect performance in challenging situations. Traditional audiology tests only evaluate threshold conditions obtained under headphones in a sound-attenuating booth, which does not stress the auditory system or indicate how the person would perform under stress in the real world.

Almost everyone hears and listens better and is more relaxed in a quiet environment. People perceive and appreciate high-fidelity auditory sounds when acoustic information is received at favorable SNRs. Many individuals, even with normal thresholds, require or prefer enhanced SNRs and need improved access to auditory information to learn and participate in professional, social, recreational, and academic situations. Improving the brain's ability to listen and derive meaning from sound through technologies that improve the SNR can help remedy some persons' HD and SIN problems, reduce annoying effects of tinnitus, and ultimately enhance individuals' QoL. These technologies may soon prove to serve a neuroprotective role against

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cognitive decline associated with hearing loss and neurocognitive disorders.[40–42] Therefore, physicians and audiologists should allow and encourage patients to be properly diagnosed according to AAA and ASHA Best Practice models, and when appropriate, allow and encourage these same technologies to be reviewed and demonstrated to patients with thresholds WNL, to improve their SIN ability, reduce their HDs and improve their QOL.

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Conflicts of interest

The author declares there is no conflict of interest.

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