The Impact of Minimal to Mild Sensorineural Hearing Loss in Adults

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Abstract

The relationship between the pure-tone audiogram and the categorization of normal hearing or a mild hearing loss fails to account for other important non-audiometric factors that impact hearing ability for approximately one-third of adults. In order to obtain a complete hearing profile of our patients who present with normal hearing or a mild hearing loss, it is necessary to consider more than simply the results of the pure-tone audiogram. Both subjective hearing handicap via questionnaire and suprathreshold auditory measures (especially in background noise) have been shown to be sensitive to deficits not captured by the pure-tone audiogram. Viable treatment options with demonstrated benefit, such as mild-gain amplification, should be considered for this population.

Hearing loss is a pervasive disorder that affects upwards of 36 million adults in the United States (National Institute on Deafness and other Communicative Disorders, 2010), with prevalence rising with increasing age (Cruickshanks et al., 1998; Nash et al., 2011). Also, as degree of hearing loss increases, the greater the detrimental impact on an adult’s ability to understand speech, particularly in background noise or a competing message (Wiley et al., 1998). Unfortunately, the story is not that simple: degree of hearing loss based on the pure-tone audiogram is well-known to be a poor predictor of both self-perceived hearing ability (i.e., hearing handicap) and speech-in-noise ability (Fabry, 2015; Jerger, 2011). Many audiologists can relate to the situation in which a patient presents with substantial hearing complaints and speech-in-noise test results that are not supported by their pure-tone audiogram.

The use of categories or adjective descriptors to define degree of hearing loss based on pure-tone thresholds has enjoyed wide acceptance within the profession of audiology (Jerger, 2013). The most common classification scheme to describe degree of hearing loss was introduced by Goodman in 1965 and later modified by Clark in 1981 (see Table 1). Goodman (1965) introduced the use of adjective descriptors to define degree of hearing loss based on the amount of threshold elevation of a pure-tone average (PTA), most commonly the average of thresholds at 500, 1000, and 2000 Hz. Based on evidence that a loss of as much as 15 dB negatively impacted speech, language, educational, and social outcomes in children, Clark (1981) introduced a “slight” hearing loss category for thresholds falling in the 16–25 dB HL range. The slight hearing loss category, however, is rarely, if ever, used to describe the degree of hearing loss for adults. The rationale for this scheme is based on the assumption that descriptors such as “mild” provide a means of indicating the amount of communication difficulty an individual experiences due to a given amount of pure-tone threshold loss. For example, an individual with “normal” hearing should have no communication difficulties, whereas an individual with a “mild” hearing loss will experience difficulty with only soft or distant speech signals (Roese & Clark, 2007). In general, as degree of hearing loss increases, so do deficits in suprathreshold auditory abilities (e.g., Hornsby, Johnson, & Picou, 2011) and self-reported hearing handicap (e.g., Ventry & Weinstein, 1982; Wiley, Cruickshanks, Nondahl, & Tweed, 2000). The inherent problem associated with this scheme, however, is that descriptors of hearing loss fail
to accurately predict either suprathreshold auditory abilities (e.g., speech understanding in background noise) or hearing handicap (Gates, Cooper, Kannel, & Miller, 1990; Hannula, Bloigu, Majamaa, Sorri, & Mäki-Torkko, 2011; Jerger, 2011; McArdle & Wilson, 2009) for many adults. In addition, the conventional audiometric evaluation only considers a portion of the audible frequency range of human hearing and fails to consider ultra-high frequency hearing (e.g., > 8000 Hz). The reliance on the pure-tone audiogram to describe hearing loss is particularly problematic for adults with pure-tone thresholds in the normal to slight and/or mild range, as hearing-related concerns or complaints may be dismissed by the audiologist or hearing health care professional.

Table 1. Descriptors to Define Hearing Loss Based on the Pure Tone Thresholds and/or Pure Tone Average (500, 1000, & 2000 Hz).

<table>
<thead>
<tr>
<th>dB HL</th>
<th>Degree of Hearing Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10–15</td>
<td>Normal Hearing</td>
</tr>
<tr>
<td>16–25</td>
<td>Slight Hearing Loss*</td>
</tr>
<tr>
<td>26–40</td>
<td>Mild Hearing Loss</td>
</tr>
<tr>
<td>41–55</td>
<td>Moderate Hearing Loss</td>
</tr>
<tr>
<td>56–70</td>
<td>Moderately-Severe Hearing Loss</td>
</tr>
<tr>
<td>71–90</td>
<td>Severe Hearing Loss</td>
</tr>
<tr>
<td>90+</td>
<td>Profound Hearing loss</td>
</tr>
</tbody>
</table>

Note. *(added by Clark, 1981)

**Self-Perceived Hearing Handicap**

Given the general inability of the pure-tone audiogram to adequately predict subjective hearing complaints in adults, how prevalent is hearing handicap among adults with a mild hearing loss? Wiley et al. (2000) examined hearing handicap using the Hearing Handicap Inventory for the Elderly–Screening Version (HHIE-S; Ventry & Weinstein, 1983) in a population-based study of hearing loss in Beaver Dam, Wisconsin (Epidemiology of Hearing Loss Study[EHLS]). HHIE-S scores were measured for 3,178 adults 48–92 years of age. The authors found a 29% prevalence of hearing handicap (scores > 8) for adults with a mild hearing loss (thresholds > 25 and ≤ 40 dB HL). Sindhusake et al. (2001) reported similar results for 2,015 older adults 55–99 years of age from the Blue Mountain Hearing Study. Again, using the HHIE-S, the prevalence of hearing handicap (scores > 8) was 39% for their adults with a mild hearing loss (thresholds > 25 and ≤ 40 dB HL).

Variability tends to be a hallmark of hearing handicap among adults, demonstrating the varying reactions to mild hearing loss. Newman, Jacobson, Hug, and Sandridge (1997) measured hearing handicap using the Hearing Handicap Inventory for Adults (HHIA; Newman, Weinstein, Jacobson, & Hug, 1990) in a group of adults 18–64 years of age with mild hearing loss (PTA ≤ 40 dB HL in the better ear). The average HHIA score was 42/100, with 75% of adults reporting some degree of hearing handicap (scores ≥18). The standard deviation, however, was 34 points, representing HHIA scores ranging from 8–75. This wide range of scores demonstrates that some adults in the group reported essentially no hearing handicap (scores < 18) while others reported greater severities of hearing handicap (scores > 42). The wide range of HHIA scores from a group of adults with the same mild degree of hearing loss underscores the poor ability of the pure-tone audiogram to predict hearing handicap.

For adults with hearing in the normal range, the prevalence of hearing handicap is somewhat more variable, depending on the method or questionnaire used. Gates et al. (1990)
measured self-reported hearing difficulty in the Framingham Cohort of older adults 60–95+ years of age. A single question, “Do you feel you have a hearing problem?” was asked of the 1,662 subjects. Of the 683 older adults who self-reported hearing difficulty, 20.2% had pure-tone thresholds in the normal range (<26 dB HL PTA). Similarly, Hannula et al. (2011) examined self-reported hearing problems among adults 54–66 years of age living in Finland. The authors asked their subject four questions including: (Q1) “Do you have difficulty hearing?” and (Q2) “Do you find it very difficult to follow a conversation if there is background noise?”. When just considering subjects with normal hearing (PTA 500-4000 Hz < 20 dB HL), 29% of subjects reported “hearing difficulties” (Q1) and 42% reported “difficulties in background noise” (Q2). The results from Gates et al. (1990) and Hannula et al. (2011) are indicative of the fact that what might be considered “normal” by the Goodman (1965) classification scheme does not accurately predict a lack of hearing handicap perceived by the individual.

Hearing handicap was also reported for normal hearing older adults from the EHLS study (Wiley et al., 2000). The authors found a prevalence of 8% for older adults with normal hearing (PTA ≤ 25 dB HL). More recently, Tremblay et al. (2015) examined self-reported hearing difficulties in a subset of adults 21–67 years of age from the Beaver Dam Offspring Study (BOSS; Nash et al., 2011) who had pure-tone thresholds within the normal range (< 20 dB HL 500-8000 Hz). Of the 2,783 participants in the original BOSS population, 686 had normal pure-tone thresholds bilaterally. Hearing difficulties were assessed using four questions from the HHIE-S. Participants reporting hearing difficulties based on the Tremblay et al. (2015) criterion represented 12% of those with normal hearing and 2.9% of the entire BOSS cohort. The risk factors associated with hearing difficulties in this population were also noted. Participants reporting hearing difficulties were more likely to report a history of noise exposure, symptoms of depression, and having seen a doctor for a hearing problem (Tremblay et al., 2015), suggesting non-audiometric factors play a role in self-perceived hearing handicap.

Clearly the prevalence of hearing handicap varies with the age of the population and the definition used. The fact remains, however, that up to approximately one-third of adults with normal hearing and mild hearing loss report hearing difficulties or hearing handicap both in general and in background noise demonstrating that there is more to self-perceived hearing abilities than simply pure-tone sensitivity (Jerger, 2011). Indeed, many studies have found relationships between hearing handicap and multiple non-audiometric factors including: central auditory processing deficits (Fire, Lesner, & Newman, 1991; Jerger, Oliver, & Pirozzolo, 1990); reduced health-related quality of life (Chia et al., 2007; Dalton et al., 2003; Gopinath et al., 2012b); reduced physical health, specifically walking speed (Tomoka et al., 2015); emotional distress (Eriksson-Mangold & Carlsson, 1991; Gopinath et al., 2012a); and depressive symptoms (Higson, Haggard, & Field, 1994; Saito et al., 2010; Tremblay et al., 2015).

**Suprathreshold Auditory Deficits**

The ability of adults to communicate with the world is not simply defined by pure-tone threshold sensitivity. Indeed, few adults present clinically with complaints of difficulty hearing soft tones. Rather, adults typically present with complaints of difficulty understanding speech in acoustically complex environments—with the most common complaint being that of difficulty understanding speech in background noise. For adults that present with subjective hearing complaints in the presence of normal hearing or a mild hearing loss, deficits often emerge on suprathreshold auditory measures that challenge or tax the auditory system.

The phenomenon of subjective hearing handicap and suprathreshold auditory deficits in the presence of a normal pure-tone audiogram was first described by Kopetzky in 1948 (Hinchcliffe, 1992). In more recent decades, numerous reports have been published describing an adult population with both subjective complaints of “hearing problems” in background noise and suprathreshold auditory deficits (e.g., speech-in-noise deficits, temporal and frequency resolution deficits, etc.), yet pure-tone hearing thresholds in the normal range. For example, Higson, Haggard,
and Field (1994) compared performance on multiple suprathreshold auditory tasks for a group of normal hearing (thresholds 250-4000 Hz ≤ 20 dB HL) adults 15–55 years of age who had sought help for difficulty understanding speech in background noise. Higson et al. (1994) found significantly poorer speech recognition thresholds in noise, poorer dichotic listening performance, and poorer masked thresholds for adults with hearing complaints compared to a control group without complaints.

More recently, Badri, Siegel, and Wright (2011) examined ultra-high frequency thresholds and auditory filter shapes in a group of adults 20–50 years of age that self-reported hearing complaints (i.e., obscure auditory dysfunction) as compared to a control group. Both groups had clinically normal hearing (thresholds .258kHz < 15 dB HL). The authors found wider than normal auditory filters and elevated ultra-high frequency thresholds for the adults with hearing complaints as compared to the control group.

Many terms have been used to describe this population of individuals including: central presbycusis (Welsh, Welsh, & Healy, 1985); obscure auditory dysfunction (Badri et al., 2011; Higson et al., 1994; Saunders & Haggard, 1989), King-Kopetzky syndrome (Hinchcliffe, 1992); auditory dysacusis (Jayaram, Baguley & Moffat, 1992); central auditory processing disorder (Bamiou, Liasis, Boyd, Cohen, & Raglan, 2000; Jerger et al., 1990); idiopathic discriminatory dysfunction (Rappaport, Phillips, & Gulliver, 1993); hidden hearing loss (Schaette & McAlpine, 2011); and hearing difficulties (Tremblay et al., 2015). This constellation of subjective hearing complaints and suprathreshold deficits has also been shown to occur in various populations including: middle-aged adults (Bamiou et al., 2000; Grose, Hall, & Buss, 2006; Helfer & Vargo, 2009; Leigh-Paffenroth & Elangovan, 2011); older adults (Dubno, Horwitz, & Ahlstrom, 2002; Hannula et al., 2011; Rodriguez, DiSarno, & Hardiman, 1990); individuals with known lesions of the central auditory nervous system (Musiek et al., 2005; Rappaport et al., 1994); individuals with a history of traumatic brain injury (Bergemalm & Lyxell, 2005; Gallun et al., 2012); and individuals with a history of noise exposure (Kumar, Ameenudin, & Sangamanatha, 2012). For adults with minimal or mild hearing loss, age is often the driving factor accounting for suprathreshold auditory deficits. Age-related suprathreshold deficits have been reported for speech understanding in: (a) background noise (Dubno, Dirks, & Morgan, 1984; Dubno et al., 2002); (b) reverberation and time compression (Gordon-Salant & Fitzgibbons, 1995; Helfer & Wilber, 1990); and (c) accented speech (Gordon-Salant, Yeni-Komshian, & Fitzgibbons, 2010). For example, Helfer and Wilber (1990) found poorer speech recognition in reverberation for older adults with minimal hearing loss (high frequency thresholds ≤ 35 dB HL) compared to younger adults. Similarly, Dubno et al. (2002) found older adults with normal hearing to exhibit poorer speech-in-noise performance than younger adults when speech was presented in temporally challenging conditions (i.e., fluctuating noise). Middle-aged adults have also been shown to perform poorer on suprathreshold auditory measures than younger adults, including speech-in-noise performance (Helfer & Vargo, 2009), and temporal and auditory processing abilities (Grose et al., 2006; Leigh-Paffenroth & Elangovan, 2011). For example, Helfer and Vargo (2009) found significantly poorer sentence recognition performance for middle-aged females who self-referred for hearing assessment relative to a group of young adult females when speech and a speech masker were presented from the same location. Temporal processing abilities were also found to differ, with middle-aged females exhibiting significantly poorer results than younger females on the gaps-in-noise test (GIN; Musiek et al., 2005).

Clearly, suprathreshold auditory deficits are not driven entirely by pure-tone threshold loss. It is likely that the underlying pathophysiology that causes pure-tone threshold loss differs from the potential causes of suprathreshold deficits. Noise exposure, central auditory processing, and cognitive factors such as working memory, attention, use of context, and speed of processing, have all been shown to impact speech-in-noise abilities independent of pure-tone threshold loss.
Relationship Between Hearing Handicap and Suprathreshold Auditory Deficits

Our laboratory has recently addressed the issue of speech-in-noise abilities in adults with subjective hearing complaints and normal hearing. Preliminary data from a group of adults recruited on the basis of at least a mild hearing handicap (HHIA scores >18) demonstrated significantly poorer speech-in-noise performance on the Revised Speech Perception in Noise (R-SPIN) sentences (Bilger, 1984) relative to a group of control adults without hearing handicap (Post, Roup, & Lewis, 2016). Figure 1 clearly illustrates the difficulty adults with hearing handicap experience, particularly for low predictability sentences (i.e., sentences without context) across multiple signal-to-noise ratios (SNR). The adults with hearing handicap unmistakably represent a unique population from the control group despite having normal pure-tone audiograms (thresholds 250-8000 Hz ≤20 dB HL).

Figure 1. Mean R-SPIN Recognition Performance In Sound-Field (Speech at 0° and Noise at 180° Azimuth) for High Predictability Sentences (Left Panel) and Low Predictability Sentences (Right Panel) for the Control Group (n=20; Red Symbols) and Hearing Handicap (HH) group (n = 14; Gray Symbols). Error Bars Represent One Standard Deviation.

Note. Adapted from Post et al. (2016).

Treatment Options for Adults with Normal Hearing or Mild Hearing Loss

The most common approach to treatment of hearing handicap and suprathreshold auditory deficits in adults with normal hearing and/or mild hearing loss is signal enhancement. Signal enhancement can be accomplished in a variety of ways including: (a) environmental manipulation (e.g., reducing background noise); (b) use of clear speech (Helfer, 1998); and (c) use of technology including personal FM (frequency-modulated) systems to improve the SNR and personal amplification (i.e., hearing aids) to provide gain and improve the SNR. The use of hearing aids to treat mild hearing loss in adults is fairly straightforward—the provision of acoustic gain to compensate for pure-tone threshold elevation is easily accomplished and justified given the diagnosis of a “hearing loss”. Further, there is much research demonstrating the benefit of amplification for mild hearing losses in adults (Beamer, Grant, & Walden, 2000; Bennett, 1989; Humes, Christensen, Bess, & Hedley-Williams, 1997; Roup & Noe, 2009; for a review, see Johnson, Danhauer, Ellis, & Jilla, 2016). On the other hand, the use of hearing aids to treat adults with hearing handicap and suprathreshold auditory deficits when they have a normal pure-tone audiogram is somewhat controversial. Anecdotally, audiologists have been known to fit adults in this category with mild-gain hearing aids. The only published data demonstrating the benefit of amplification, however, is

1One hearing handicap subject had 25 dB HL thresholds at 2000 and 4000 Hz, and one hearing handicap subject had a 30 dB HL threshold at 500 Hz.

in children with normal hearing and an auditory processing disorder (Kuk, Jackson, Keenan, & Lau, 2008). The idea that adults with a normal pure-tone audiogram can be fit with mild-gain amplification to treat hearing handicap and suprathreshold auditory deficits is not without merit. Mild-gain (e.g., 5–10 dB) in the mid-to-high frequencies serves to enhance soft consonants in speech. Further, the use of directional microphone and noise reduction technology can improve the SNR and comfort for the listener in noisy environments.

Our laboratory has recently addressed the question of benefit from mild-gain hearing aids in adults with hearing handicap and normal pure-tone audiograms (thresholds 250–8000 Hz ≤20 dB HL). Preliminary data from a group of 14 adults recruited on the basis of at least a mild hearing handicap (HHIA scores >18) demonstrated subjective improvements in hearing handicap (see Figure 2) and objective improvements in speech-in-noise (R-SPIN) performance (see Figure 3) with the use of mild-gain hearing aids (Post et al., 2016). These preliminary results suggest that mild-gain hearing aids are a viable treatment option for some individuals with subjective hearing difficulties.

Figure 2. Mean HHIA Scores for Unaided (green) and Aided (gray) Conditions. Error Bars Represent One Standard Deviation.

Note. Adapted from Post et al. (2016).

Figure 3. Mean R-SPIN Recognition Performance In Sound-Field (Speech at 0° and Noise at 180° Azimuth) for High Predictability Sentences (Left Panel) and Low Predictability Sentences (Right Panel) for the Unaided (Green Symbols) and Aided (Gray Symbols) Conditions. Error Bars Represent One Standard Deviation.

Note. Adapted from Post et al. (2016).
**Conclusions**

It is not uncommon for adults to present clinically with subjective hearing complaints and suprathreshold auditory deficits despite a normal audiogram or a mild hearing loss. Further, there is a plethora of evidence demonstrating the poor predictive ability of the pure-tone audiogram regarding hearing impairment and hearing handicap than hearing loss per se. As James Jerger (2011, p. 490) so eloquently states, “We are left with the inescapable conclusion that there are more dimensions to hearing impairment and hearing handicap than hearing loss per se.” The reliance on the pure-tone audiogram by audiologists to categorize hearing loss, therefore, introduces a bias that likely diminishes the consideration of preventative hearing health care and/or treatment options for adults with normal hearing or a mild hearing loss. As a profession, we might ask ourselves if we are doing a disservice to our adult patients that seek care when we label their hearing as “normal” or “mild”.

**References**


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