The Cognitive and Behavioral Consequences of Hearing Loss, Part 2: Evaluation and Treatment

Although unrecognized hearing loss can affect quality of life and play a role in cognitive impairment, it may be reversible and/or treatable.

By Ronald Devere, MD

It is well known that hearing loss can have a significant impact on quality of life. More recently, however, studies have revealed that hearing loss greater than 25db can also lead to cognitive impairment. Moreover, cognitive decline occurs at a much faster rate in individuals with hearing loss. Given the influence of hearing in overall cognitive health, it is increasingly important that neurologists appreciate its possible role in dementia and integrate evaluations for hearing loss into practice. In addition, because hearing loss is potentially treatable in many individuals, physicians should be aware of management options and be prepared to assist patients in utilizing them.

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History and Evaluations for Hearing Loss

Patients with cognitive symptoms should be evaluated for hearing loss, even those who have not noted this problem. Before the evaluation, it is essential for the physician to take a thorough history. To determine if a patient has a peripheral hearing disorder, some questions to ask include:

- When did hearing decline begin?
- When did cognitive changes begin, and do they relate to hearing changes?
- Has the hearing loss deteriorated, fluctuated, or improved since onset?
- Is there a tendency to increase the TV volume and ask people to speak louder?
- Is there trouble following conversation with background noise or over a loud phone line?
- What is your current or previous occupation, and did you have exposure to a noisy environment?
- Have you had any music training and has this been affected by your hearing changes?

The following questions may help determine whether a patient has a central cerebral disorder:

- Do you have trouble locating sounds, such as alarms, mobile phones, or many people speaking in the same room?
- Do you only have problems understanding speech but other sounds are well recognized?
- Do you have trouble understanding a person's tone of voice, such as being angry or upset?

Auditory tests for evaluating patients include the pure tone audiometry and auditory-evoked potentials tests, both

of which are simple and assess cochlear and ascending auditory pathways in patients with cognitive impairment. The risk of cognitive decline and dementia with hearing loss appears to increase only at hearing thresholds of greater than 25db, which is also known as the threshold that hearing loss begins to impair verbal communication.[1]

Measurements of speech-in-noise perception more closely reflect the "real world" hearing impairment than pure tone audiometry. If these measurements are out of proportion to basic hearing loss tests, it is likely that auditory cortical processing is impaired.

Neuropsychological tests that measure attention and focus may also offer a good auditory evaluation for individuals with hearing impairment, particularly when it comes to verbal and visual categories. Neuropsychologists also have access to cognitive testing that does not require good hearing. According to one study, the most cost-effective option identified for the public as it relates to possible hearing loss is a one-stage audiometric screen.[2]

Importantly, if the patient's history is significantly positive for hearing impairment, he or she should be referred to an ear, nose, and throat (ENT)/audiology specialist, who can detect and treat excessive ear wax and structural changes of the ear drum, among other areas that a neurologist could not evaluate.

Treatment Options for Hearing Loss

Several options are available for addressing hearing loss. Following is a brief summary of therapies.

Amplification. Hearing aids have been available for many years, but little has been written about the benefits of hearing aids in cognitive decline. One recent study evaluated self-reported hearing loss, the use of hearing aids, and cognitive decline in 3,670 elderly participants over a 25-year period.[3] Four percent of patients had major hearing loss, 31% had moderate hearing loss (following a conversation with more than two people in a noisy background), and 65% had no hearing problems. In relationship to cognitive decline, the authors used patient history and Mini-Mental State Evaluation (MMSE) scores.

The average age of hearing loss cases was 76 years for moderate hearing loss and 81 years for major hearing loss, as compared to 73 years for the group with no hearing loss. Individuals reporting hearing loss not using hearing aids declined more rapidly on the MMSE than the control group, with a mean difference of -1.5 points over the entire follow-up, while those with hearing loss and using hearing aids had no difference in MMSE score compared to controls.[3]

These results suggest that self-reported hearing loss is independently associated with accelerated cognitive decline in community-dwelling older adults. When other factors were taken into account, such as depression, social network, and psychotropic consumption, the differences in cognitive changes were similar across all groups. This suggests that the use of hearing aids may improve mood, increase social interaction, and enable participation in cognitive stimulation abilities, which can lead to slower cognitive decline.

In a previous study evaluating 1,984 cases over six years, the use of hearing aids was associated with lower rates of cognitive decline in individuals that reported hearing loss.[4] However, this study had low statistical power, a small number of individuals, and a much shorter follow-up time. Another study showed improvement in cognition and hearing after cochlear implantation.[5]

Auditory Training. Difficulty understanding speech, especially with background noise, is one of the most common complaints of older hearing-impaired adults. A better-than-normal speech-to-noise ratio is required to achieve long-term benefits. In a 2014 report,[6] authors incorporated the following features in their auditory training:

1. The training was word-based to place focus on meaningful words.

Prevent Worsening of Hearing Loss

Most treatment strategies for hearing loss are nonpharmacological. Before any long-term therapies are implemented, neurologists should also consider the following steps to immediately decrease the worsening of already existing hearing loss.

1. Reduce or eliminate exposure to loud noises that can damage hearing, inhibit social interaction, and impair the ability to hear warning sounds such as smoke alarms and oncoming traffic.
2. Control vascular risk factors that may minimize vascular changes contributing to hearing loss and cognitive decline.
3. Refer the individual to an ENT specialist to determine some of the causes of hearing loss, which can include whether the deficit is conductive, sensorineural, or a central auditory problem. Conductive problems can be caused by excess wax in the ears or otosclerosis. Sensorineural problems can be due to age-related hearing loss (presbycusis), endocrine disorders such as hypothyroidism, noise damage, and even certain medications (e.g., antibiotics, loop diuretics, and some chemotherapy medications). Central auditory processing disorders are mostly associated with problems at the level of the brain and result in speech discrimination problems (e.g., word deafness), requiring a full neurological workup.

2. It was based on closed-set identification of words under computer control, enabling automation of presentation, scoring, and feedback.
3. Multiple speakers were included.
4. It was conducted with a noisy background, the most difficult listening situation for older adults.
5. Both auditory and written feedback occurred, with the correct and incorrect responses provided to the listener after incorrect responses.

The written representation of the auditory stimulus reinforces the link between the acoustic representation of the stimulus in the impaired periphery and the intact representation of the written word in the brain. In a series of laboratory studies,[6] the authors observed the following:

1. Older listeners could improve their open-set recognition of words in noise after training.
2. Training was generalized to other speakers saying the same trained words.
3. Improvements from training lasted as long as six months but diminished over time.
4. Similar improvement occurred when the feedback was entirely written (displaying correct and incorrect responses on the computer screen) or a mixture of written and auditory responses (re-hearing the correct and incorrect words after incorrect responses) but not when the feedback was eliminated entirely.
5. The word-based training was transferred to novel sentences and speakers when the sentences were composed primarily of words used during training. Of note, 50 to 600 words spoken by multiple speakers in background noise occurred during training.

The authors decided to examine a range of possible training dosages and duration for this word-based auditory training system in older individuals with hearing impairment. Participants in the treatment groups completed training two days a week for 7.5 weeks or three days a week for five weeks. In a given cycle, the total number of training sessions and the number of stimulus exposures were the same across dosages. These treatment groups completed three cycles of training with post-training evaluations after each cycle to examine the effects of training duration. A total of 55 participants were randomly assigned to three groups: 16 in a two-times-per-week training group; 19 in a three-times-per-week group, and 20 in a no training control group (age range between 61 and 79 years). All participants had mild to moderately severe sensorineural hearing loss, and hearing aids were not used as an exclusion or inclusion.[6]

This study, along with earlier studies, supports the efficacy of a word-based approach to auditory training in adults with hearing impairment. Training two to three times per week would be sufficient to show significant improvements on the open-set recognition of trained speech materials in noise.

The authors are planning a home-based version of this auditory training protocol. How this therapy relates to cognitive function has not been studied.

> "As lifespans continue to increase, it is very possible that both hearing loss and its effect on cognitive decline will become more pronounced."

Cognitive Behavioral Training

Hearing impairment is associated with mental stress and anxiety that affects everyday functioning and quality of life. (See sidebar on the following page.) Various behavioral techniques have shown varying degrees of efficacy. In 1995, Anderson et al[7] studied 24 elderly hearing-impaired individuals with an average hearing loss of 38.5db who either received behavioral therapy or served as untreated controls. All participants used hearing aids, and the treatment period was five weeks. Results showed that behavioral treatment helped elderly individuals cope with their hearing impairment.[7] This was evident in a video interview and self-reported data in daily visual analytical recordings. The ability to stay relaxed in a demanding auditory situation was significantly improved for the treated group. Follow-up telephone interviews with participants revealed that those in the treatment group were better at coping with hearing loss than the controls one month after treatment.

The small group format in this study also allowed the researchers to focus on each individual and customize the treatment according to the functional analysis. This was especially evident during relaxation training, self modeling, and in homework assignments. One drawback of the study, according to the authors, was the lack of assessing individual's behavior in their own environment and not just in a structured interview. Overall studies suggest that behavioral changes are relevant for coping with hearing loss and that more and larger studies should be conducted in which the effects of treatment on behavior and social isolation are further evaluated.

Cognitive behavioral therapy has also shown some benefit in individuals with hearing impairment. In a 2015 study, researchers evaluated the effect of cognitive behavioral therapy specifically tailored to reduce mental stress.[8] The etiology of the hearing impairment was not important, and those with congenital hearing impairment would not likely

Social Isolation and Hearing Loss

Hearing loss hampers one's ability to communicate efficiently, impairs the ability to maintain personal relationships, and can cut individuals off from their environment in which they were once actively involved. The psychological stress associated with reduced ability to communicate with others may further motivate the development of social isolation. In a 1982 study, researchers studied 80 male veterans over 65 who noted gradual hearing loss after age 53 of unknown cause.[1]

All participants underwent a complete audiological evaluation, including a self-assessment of their hearing handicap and scales, which measured quantitatively the degree of subjective and objective social isolation.

The study surprisingly showed that loss of hearing and social isolation had a stronger correlation with subjective rather than objective measures.[1] These findings suggest that the social consequences of hearing loss are common and just as important as impaired communication. Moreover, self-assessment of the hearing impaired is also significant as it relates to quality of life.

A more recent detailed study evaluating 2,461 individuals of a large California county five different times over 20 years found that hearing impairment was more common in men and increases with age.[2] Those with moderate hearing loss were twice as likely to be depressed.

1. Weinstein BE, Ventry IM. Hearing impairment and social isolation in the elderly. J Speech Hear Res. 1982 Dec;25(4):593–599.
2. Strawbridge WJ, Wallhagen MI, Shema SJ, Kaplan GA. Negative consequences of hearing impairment in old age: a longitudinal analysis. The Gerontologist. 2000 Jun;40(3):320-326.

be different from those with acquired hearing loss. In the pilot study, the authors looked at two groups, evaluating their mental stress before and after the study.

The first group consisted of individuals between 18 and 70 years of age who were economically active and provided medical documentation of hearing loss by audiogram. This group included 15 participants (median age: 50) and average hearing loss from 7.5db to 82db, while three cases had unilateral hearing loss. This group was the intervention group, with participants receiving a weekly two-hour cognitive behavioral therapy course over eight weeks. All participants received the course material containing lecture notes in print with supplemental reading and a description of homework to be done between sessions. Each two-hour session included reviewing the participants' homework, followed by further lectures and discussion of the ongoing homework.

Group 2 was similar, with 18 cases (median age 52) with pure tone hearing impairment (ranging from 20-100db) who attended a course for the hearing impaired. The course lasted nine days over six months and consisted of lectures about hearing loss and psychosocial consequences of hearing loss. The course discussed technical hearing devices and how to use them as well as governmental subsidizing arrangements. It also included stress management methods. In both groups, hearing impairment was assessed as slight (26-40db), moderate (41-60db), severe (over 61db), and profound (81db and above). The self-administered anxiety and depression scale was used to assess levels of mental distress.

The mean anxiety score in the intervention group was 6.9 compared to 4.7 in the second group. The mean depression score in the intervention group was 4.5, versus 2.9 in the second group. After the therapy program was completed in both groups, the depression score in group 1 did not change, but in group 2 it increased to 3.1. The mean anxiety score in the intervention group dropped to 4.5 and increased to 6.2 in the second group. It appeared in this study that anxiety considerably improved in the intervention group and worsened in the second group.

Participants in the intervention group were supervised more consistently, and the program structure consisted of a series of inseparable distinct steps. Group 2 programs contained a series of topics that were related but were not progressively presented, so as to guide and supervise the participant in specific behavioral explorations. The authors stated that when mental stress develops and it is apparent, the individual makes use of maladaptive coping strategies.[8] It is critical that the individual is supervised consistently over time in order to be able to change her or his coping habits. The intervention in this study was designed to train the participants to be more community assertive. The intervention group showed that levels of avoidant communication strategies decreased significantly in the intervention group and remained unchanged in the second. Additional studies with more individuals and randomized controlled studies with longitudinal follow-up are needed.

Cognitive therapy can also be combined with auditory training to benefit hearing loss, as shown in a 2015 study.[9] The authors discussed three high-quality training studies:

1. Randomized controlled trial of speech discrimination in a quiet environment that trained adults with mild hearing loss (study 1);
2. A study that trained speech discrimination in a noisy background in hearing aid users (study 2); and
3. Double-blind placebo controlled trial that directly trained working memory in hearing aid users (study 3).

The role of cognition becomes more apparent when communicating in adverse conditions, such as when listening to speech in fluctuating background noise or competing talkers. Speech-in-noise performance is associated with cognition, and cognition becomes increasingly important as the complexity of the listening task increases.[10]

Across all three studies, hearing loss was described by the better ear pure tone threshold as either mild (21-40db) or moderate (41-70db).[9] Participants were between 50 to 74 years old. Training was home delivered via laptops or Internet. Study 1 was a randomized controlled study in which a four-week speech discrimination training program was performed for the immediate trained group at weeks one through four, and a delayed treatment group at weeks five through eight provided a control group. Tests and self-reported questions were classified as complex if executive processes were needed and simple if they were not. No significant related improvement for speech perception was noted in this group.

For tests of cognition, however, no pre-or post-training improvement was shown for simple tasks (digit span and a single attention test), but for complex tasks that indexed executive processing, there was significant post-training improvement in divided attention and working memory. Thus, outcome measures need to be appropriately complex and challenging to be sensitive to the effects of auditory cognitive training. Taken together, these findings suggest that the value of auditory cognitive training to mediate cognitive skills may be more important than the improvement of sensory skills for communication in everyday life.

In study 2, the training duration was 3.5 hours. The study included a one-week control period, followed by a one-week training period in the intervention group only. This study showed a large post-training improvement for the group with moderate hearing in the auditory task and no improvement in the control group. There was no improvement in the easiest minimal hearing loss group and the severe hearing loss group. This study suggested that moderately impaired individuals using hearing aids were better able to allocate their available cognitive resources between the speech and memory tasks after training, and that outcome measures need to be appropriately challenging in order to be sensitive to post-training improvements.[9]

Study 3 assessed benefits to speech perception, self-reported communication, and cognition (working memory) outcome. It showed that working memory training can enhance working memory tasks that share similar structural features.[9] Auditory perceptual training programs combining auditory training with increased memory demands have shown generalized improvement in non-trained tests of memory, attention, and speed of processing in older adults in addition to neural timing and speech perception in noise.[11,12] It is not clear from these studies which element of training is responsible for the transfer of learning.

Conclusion

Studies clearly show that hearing loss can lead to cognitive impairment and can worsen already known cognitive impairment; multiple mechanisms are likely involved. More importantly, hearing loss is treatable in most cases, which can improve overall quality of life (social isolation, anxiety, depression, and cognitive impairment). In addition to partnering with our ENT/audiology colleagues, neurologists must take a more detailed auditory history in general, especially in those with cognitive complaints. We should also include caregivers and/or family members, because individuals with hearing impairment could possibly minimize their symptoms. If hearing loss history is suspicious or definite, a full auditory evaluation should be performed, and neurologists should refer the patient to ENT/audiology in addition to the workup.

The link between hearing loss and cognitive impairment is significant and warrants greater attention and inquiry.

As neurologists, we need to consider this topic in the discussion and evaluation of future cognitive decline and worsening of those already diagnosed with mild cognitive impairment and early dementia. As lifespans continue to increase, it is very possible that both hearing loss and its effect on cognitive decline will become more pronounced. Given the resistance many individuals have toward hearing aids or to the very notion of a hearing loss evaluation, neurologists should join educational efforts to increase awareness among the general public about the effects of hearing loss. ■

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