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Cognitive screenings in otolaryngology? The time has come

Abstract

The demographics and communicative disorders which traverse aging, neurocognitive disorders and auditory problems are staggering. Lancet Public Health[1] estimates 57 million people globally with dementia in 2019 and by 2050 there will be 153 million cases. People seek counsel from hearing care professionals (HCPs) because of complaints and observations such as they cannot understand speech-in-noise (SIN), and/or they are not sure what someone just said, and/or they cannot recall the details of a recent conversation. For many, the complaints and observations of hearing and listening disorders are the same as, and may overlap with complaints and observations of, mild cognitive impairment and other neurocognitive disorders.

In this article we review the current knowledge related to cognition and audition; we explore the practical reasons for incorporating cognitive screening into otolaryngology clinics, with specific regard to patients with hearing and listening problems. We review and explore auditory and cognitive disorders and we specify that these are not silos. That is, they may (and often do) occur in-isolation or in-tandem. We will review multiple studies which demonstrate that for some people, some of the time, early detection of neurocognitive anomalies may help facilitate an improved cognitive trajectory via hearing aid amplification, cochlear implantation, and through attending to modifiable risk factors.

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Abbreviations: PCPs, primary care physicians; MCI, mild neurocognitive disorders; HCPs, hearing care professionals; NCDs, neurocognitive disorders,

Introduction

Unfortunately, the US health system is not currently poised to identify and treat "at risk" patients during the early phase of neurocognitive disorders (a.k.a. mild cognitive impairment, MCI, and Mild Neurocognitive Disorders, MiNCD) despite significant evidence that patients with auditory and other sensory deprivation are at increased risk for NCDs. Of note, traditional cognitive health specialists (neurologists, psychologists, neuropsychologists, gerontologists, geriatricians etc) most often manage patients during later stages of dementia (a.k.a Major Neurocognitive Disorders, MaNCDs). Primary care physicians (PCPs) are burdened with extremely limited time-per-patient which precludes them from routinely screening or referring for cognitive concerns. Sabbagh, Boada, Borson et al.,[2] report that primary care physicians (PCPs) do not have the support to implement "widespread evaluation of cognitive and functional performance…"

In contrast to traditional cognitive health specialists, hearing care professionals (HCPs) including otolaryngologists, audiologists and hearing aid dispensers manage patients with auditory sensory deprivation and are uniquely positioned to identify patients who present with an index of suspicion for early NCDs. As such, "sensory-based clinics" (such as ENT, audiology, and hearing aid dispensing clinics) represent "high yield" locations to screen for cognitive function. Further, when an auditory deficit (hearing or suprathreshold listening) is identified, sensory-based clinics are well-positioned to offer risk-modifying treatments via amplification (hearing aids, assistive listening devices, cochlear implants, brain-stem implants, etc.) as well as providing guidance on the well-established modifiable risk factors (see below) and referring as needed to traditional cognitive health specialists.

Dementias are typically slowly progressing diseases, which typically develop over decades. Cognitive decline begins without overt or observable manifestations in activities of daily/independent living. It is during the early phase of MiNCD in which identifying reversible etiologies and modifiable risk factors has the greatest potential to alter the trajectory of dementia development. Early identification and risk factor modification represents a critical public health strategy to maintain cognitive health among Americans.

Background literature review

Lemke[3] emphasized that early diagnosis, management, and treatment of NCDs are important to identify reversible etiologies and exacerbating factors which if not recognized may rapidly and significantly cascade.

Edwards, Xu, Clark et al.,[4] reported The Advanced Cognitive Training in Vital Elderly study of 2802 people followed for approximately ten years. They stated "cognitive training improves cognitive performance and delays functional impairment…" Speed Training focused on computerized, visual perceptual exercises, which appeared to lower dementia risk by 29% compared to controls.

Livingston, Huntley, Sommerlad et al.,[5] state 60% of dementia risk is due to deoxyribonucleic acid (DNA). However, the remaining 40% of dementia risk is due to twelve modifiable risk-factors; less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, low social contact, air pollution, alcohol consumption and traumatic brain injury. They report that people "have a huge potential" to reduce their personal risk of dementia and they stated that preventing, intervening and caring for those with dementia, "…will vastly improve living and dying for individuals with dementia and their families, and thus society…" Sabbagh, Boada, Borson et al.,[2] reported that early identification may reveal manageable/reversible etiologies such as metabolic or endocrine disorders, mood and sleep disorders, iatrogenicity and more. Likewise, they noted early diagnosis allows the patient and their loved ones to better prepare financially and emotionally for the future.

Although most people don't realize when they might have mild hearing loss or a suprathreshold listening disorder,[6] it has been reported that among people with hearing loss, MaNCDs (in particular Alzheimer's Disease, AD) occur more often and progress more rapidly than for those without hearing loss.[7]

Potential mechanisms linking cognition and audition

Glick & Sharma,[8] Beck, Bant and Clark[9] and Powell, Oh, Reed et al,[10] suggest possible hypothetical mechanisms through which audition and cognition may be linked.

Sensory Deprivation suggests long-term auditory sensory deprivation causes physical changes in the brain which negatively impacts cognitive processing. *Information Degradation* suggests cognitive/information processing demands (such as listening effort, memory, attention, executive function etc) increase as sensory information decreases. Beck & Clark[11] wrote "Cognition matters more as audition decreases - and - audition matters more as cognition decreases." As such, to accurately and rapidly engage in information processing, and to assign meaning to an attenuated sensory input, cognitive load (i.e., stress on the entire cognitive system) increases. *Common Cause* suggests a shared underlying mechanism, such as neurovascular blood-flow, diabetes, hypoglycemia, poly-pharmacy etc., which might negatively and simultaneously impact both auditory and cognitive systems.

Patient demographics

When older adults report they cannot understand speech, and that understanding speech is even more difficult while listening in noise (i.e., cocktail party effect), or they are unsure of, or cannot recall conversational details, professionals and concerned others often presume hearing loss as the likely culprit. Of course, suspecting hearing loss makes good clinical and intuitive sense. Approximately one-third of adults age 65+ has demonstrable hearing loss, as do two-thirds of adults age 75+ years. Specifically, of the 335 million Americans some 38 million adults have hearing loss on an audiogram. However, also of importance are the typically undiagnosed additional 26 million Americans with no audiometric hearing loss who complain about understanding speech in noise and general hearing difficulty. The 26 million may have etiologies founded in suprathreshold listening disorders (STLDs) including; attention deficit disorders (ADD), attention deficit hyperactivity disorders (ADHD), dyslexia, auditory processing disorders (APDs), auditory neuropathy spectrum disorders (ANSDs), hidden hearing loss/cochlear synaptopathy, traumatic brain injury (TBI), MiNCDs, MaNCDs and more.[12]

Wolfgang[13] reports that for older adults, dementia risk doubles with mild hearing loss, triples with moderate hearing loss and increases five-fold for people with severe hearing loss. *That is, the population most likely to be screened for cognitive disorders, overlaps significantly with people who are most likely to have hearing loss and suprathreshold listening disorders.* These issues clearly underscore the necessity of a complete audiometric evaluation and appropriate management prior to engaging a cognitive screening. Nonetheless, the majority of cognitive screeners are given orally/verbally without benefit of a complete audiometric evaluation. Generally, the test administrator reads and orally/verbally states the test stimuli/question to/for the subject and the subject responds. However, it is extraordinarily rare for the test administrator to know whether the subject has hearing loss, or like the 26 million people noted above, has a suprathreshold listening disorder, or both, or neither (as both conditions are invisible) which may impede the subject from comprehending the details of the stimuli/question.

Audition & cognition

Kricos[14] cautioned communication difficulties in older adults may occur in-tandem, or in-isolation with/from other significant anomalies. Hearing loss, STLDs and NCDs can parade as each other, can mask each other, can occur in tandem, in isolation, and are often un-diagnosed, misdiagnosed or not treated at all. Of particular note, hearing loss and cognitive issues are not silos. Hearing loss does not indemnify one from suprathreshold listening disorders or NCDs. Individuals may have hearing loss and cognitive disorders, or one, or the other, or neither.

Shen, Anderson, Arehart & Souza[15] reported audiologists are likely to encounter people with undiagnosed NCDs. As such, audiologists should train, recognize and provide timely referral to optimize outcomes for their patients. They reported that conversations between patients and audiologists are often 4 to 5 times the length of the conversation held with physicians, and the lengthy conversation is focused on hearing, listening, communication ability, aural rehabilitation, amplification outcomes realistic expectations and other detailed conversations which may trigger an NCD index of suspicion. Beck, Weinstein and Harvey[16] address HCPs as gatekeepers and as such stated HCPs should be trained to recognize memory and communication changes which may represent early warning signs of dementia. They stated "audiologists must be knowledgeable and comfortable with dementia screenings…" and when appropriate, should refer to "clinicians with expertise in diagnosing and evaluating persons exhibiting signs of dementia, such as memory lapses, behavior changes, social disengagement, and other NCDs."

Altering the trajectory via hearing aid amplification

Peracino[17] reports that a delay in the onset of dementia by one year for each person would decrease the global prevalence of dementia in 2050 by approximately ten percent. He notes that as hearing loss seems to hasten age-related cognitive decline, more aggressive hearing loss treatment may delay NCDs.

Amieva, Ouvrard, Giulioli et al.,[18] reviewed 3,670 participants (ages 65 years+) over a 25-year period in a prospective population-based study. The Mini Mental State Examination (MMSE) was used to determine cognitive status. Participants who self-reported hearing loss and hearing aid use, and people who reported no hearing loss, demonstrated less and slower cognitive decline than people who self-reported hearing loss and did not wear hearing aids. The authors concluded that self-reported hearing loss is associated with accelerated cognitive decline in older adults and hearing aid use may attenuate the rate of progression and depth of cognitive decline.

Glick & Sharma[8] reported on cortical neuroplasticity and cognitive function in 28 adults with age-related hearing loss. Hearing loss participants significantly benefitted from 6 months of hearing aid amplification (compared to 13 controls). The authors reported there was a reversal in cross-modal re-organization of the auditory cortex by vision, as well as gains in speech perception and improved cognitive performance. They report that clinical intervention with real-ear verified premium amplification may facilitate improved cortical organization, functioning and may provide cognitive benefit.

Bucholc, McClean, Bauermeister et al.,[19] reported that the provision of hearing aids is associated with improvements in cognition, communication and socialization. They highlighted that people with MCI who use hearing aids had significantly lower risk of developing all-cause dementia. Further, people with hearing loss who did not use amplification had higher rates of depression, psycho-

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social disorders, anxiety and an increased risk of incident dementia. The authors note that hearing aid use was independently associated with reduced dementia risk. Also of interest, they stated that the conversion time from MCI to dementia may be lengthened via hearing aid amplification (note: Thaipisuttikul, Jaikla & Satthonh[20] report that people with lower cognitive screening scores per the MMSE and MOCA, were more likely to convert. The one-year conversion percentage from MCI to dementia is approximately 18 percent.)

Sanders, Kant, Smit & Stegman[21] reported on the effect of amplification based on more than 3000 patient records across 17 studies between 1990 and 2020. They noted that the largest domain benefit across six of the studies was determined to be within executive function. The authors recommended additional research through randomized clinical trials.

Gaeta, Azzarello, Baldwin, et al.,[22] evaluated the impact of amplification on cognitive screening tool outcomes. Thirty adults with hearing loss were screened using the Mini-Mental State Examination (MMSE) in three conditions; without amplification, with amplification, and with a personal listening device. Significant improvements in MMSE performance were noted while using either amplification system. Of note, they reported that communication assessments and amplification strategies should be explored and implemented before administering or interpreting cognitive screening measures.

Beck[6] reported that a comprehensive audiometric evaluation (hearing thresholds, speech understanding in quiet, speech understanding in noise, etc.) is of paramount importance in thoroughly understanding and accommodating what may appear to be hearing, listening, aphasia, language problems, MiNCD or MaMCD and more. Vastly experienced psychologists, speech-language pathologists, physicians and audiologists are unable to accurately estimate/guess the type and degree of hearing loss (or other expressive/receptive communication disability) via "trained clinical observation, tuning forks, whisper tests or self-report etc." The entire concept of guessing the type and degree of disability is highly flawed, unnecessary, dangerous and disingenuous. He highlighted that assuming a clinician can "infer the degree of hearing loss or the listening/speech-in-noise ability of a patient through simple observation or discussion is analogous to guessing CBC, CT or MRI results."

Altering the trajectory via cochlear implants

Among the most important work performed by HCPs is evaluating people for cochlear implantation (CI). However, this too, is an area which would benefit from more information about the individual's audiometric profile, cognitive status and realistic expectations from CI implantation and rehabilitation, including cognitive rehabilitation and more. Beck reports (personal knowledge as a research scientist at the House Ear Institute, Los Angeles, 1984) in the early 1980s, before the FDA approved CIs for adults, psychological evaluations during CI evaluations were common. Although some research centers regularly evaluate cognition during CI evaluations, community-based CI clinics have not adopted cognitive screening in a meaningful way.

Miller, Miller & Marrone[23] reported a lack of published data regarding aural rehabilitation with CIs regarding cognitive function in older adults. They recommended additional studies to provide guidance for optimizing the management of severe hearing loss in older adults with CIs. Andries, Van Rompaey, Van de Heyning & Mertens[24] reported that for the CI population, a cognitive test battery *presented visually* is likely more appropriate for CI candidates and users, as compared to more traditional oral/verbal presentations.

Naples, Castellanos & Moberly[25] proposed cognitive screening should be considered during routine evaluation of CI candidacy. They reasoned that hearing loss is associated with cognitive decline in an apparent dose-dependent manner and recent studies suggest positive associations of hearing rehabilitation with cognitive abilities and communication and speech recognition outcomes are influenced by the cognitive abilities of the user. Naples, Castellanos & Moberly supported the need to integrate cognitive testing into adult CI evaluations with thoughtful consideration and to improve long-term outcomes beyond the provision of sound.

For some HCPs and CI candidates, obtaining pre-operative audiometric evaluations is a significant challenge. Andresen, Vohra & Galaiya[26] investigated test-retest integrity of standard speech perception methods for 1,437 CI candidates/patients, median age 60 years from 1985 and 2019. They reported that CI candidacy and postoperative outcomes are typically assessed with tests that vary across centers, thereby limiting analysis across institutions and time (such as pre-op versus post-op). Although pair-wise test comparisons demonstrated limited agreement across different tests in the same session, correlations between different tests revealed large differences. Moreover, transformation functions were predictive of mean scores but were less predictive of individual scores.

Cochlear implant (proof of concept field study)

However, a pragmatic question must be addressed prior to examining the possible correlation between CIs, aural rehabilitation and cognitive abilities. The question is "Would cognitive screening be tolerated by hearing care professionals and their patients?"

As such, three community-based cochlear implant (CI) centers (two in Texas, one in Michigan) performed an observational pilot study of seventeen adult (average age 62 years) newly-implanted CI recipients with a Cochlear™ Nucleus® with Slim Perimodiolar electrode (CI532/CI632) or a Cochlear™ Nucleus® with Slim Straight electrode (CI522/CI622). The audiologists who performed pre-implant evaluation/audiometric testing and cognitive screenings were all licensed and experienced. Patients were recruited through invitations to participate as an addendum to their routine CI candidacy evaluation. The evaluation was conducted in accordance with human subjects' ethical standards and third-party IRB approval was obtained. Patient written consent was also obtained (for more details see "Effects of an Evidence-Based Model for Cochlear Implant Aftercare Delivery on Clinical Efficiency and Patient Outcomes." Porps, Bennett, Gilden, Ravelo, Buck, Reinhart and Hong. Submitted for Publication, 2022)

A non-oral/verbal cognitive screening was used pre, and 6 months post-op (Cognivue Thrive[@], Cognivue Inc, Victor, USA) based on an FDA-registered automated, self-administered, digital test, which evaluates three cognitive domains; executive function; working memory, and visuospatial processing without sound.

Upon completion of the CI evaluation, patients and audiologists were given a survey regarding cognitive testing during the visit. Patients were generally receptive to cognitive testing and found the screener easy to use. Nine patients were motivated to take the cognitive screener, three were cautious but willing, five were ambivalent and none were resistant.

Patients reported that the screener was extremely easy (41%) or somewhat easy (53%) to perform, and one patient (6%) reported the screener was somewhat difficult. Of the 17 audiologists, 13 reported they were extremely comfortable and 4 were somewhat comfortable in explaining the purpose of the test to the patient. Sixteen of the

audiologists found it extremely easy to motivate the patient to participate in cognitive testing. Regarding discussing test results with the patient, most audiologists reported it was very easy (41%) or easy (41%), two were neutral about explaining test results and one audiologist felt overwhelmed. These preliminary findings suggest that routine cognitive screening in CI evaluations is well-tolerated by patients and their hearing care providers.

Biomarkers (diagnostic indicators) 2022

The National Institute on Aging[27] reports that biomarkers indicate what is happening within the body. The ongoing search for significant and accurate biomarkers may facilitate an opportunity to provide "game-changing" early and reliable NCD detection, diagnosis, and treatment. An affordable and efficient biomarker test with sensitivity and selectivity that truly impacts specific decision making will hopefully soon be a reality. A biomarker test specific to and predictive of NCDs would impact diagnosis, counseling, earlier intervention and speed of intervention, as well as outcomes, and more. Generally, biomarkers are physical, quantifiable factors which might be found in blood, CSF, other fluids, organs, tissues etc. or their presence might be observed via CT, MRI and/or Positron Emission Tomography (PET scans). PET scans have provided revealing foundations upon which to build/discover useful dementia biomarkers. PET scans can measure a protein called beta-amyloid, often a well-known hallmark of Alzheimer's Disease. However, some people have significant amyloid plaques, yet never manifest Alzheimer's. PET scans can also detect tau proteins, which form tangles within nerve cells, as observed in multiple dementias.

Stokin, Krell-Roesch, Peterson et al.,[28] report APOE ε4 allele is associated with amyloid pathology, greater hippocampal atrophy and memory impairments in people who manifest early clinical symptoms and pathogenesis of sporadic Alzheimer's Disease (AD). However, Beyer, Stocker, Rujescu, et al.,[29] report the APOE ε4 genotype was positive in only 49% of the AD group and was present in 28% of the control group (see Beck, 2022 for a more in-depth discussion).

Strikwerda-Brown, Hobbs, Gonneaud et al.,[30] reported a longitudinal cohort study of 580 participants with data collection spanning 2003 to 2021. Participants were older adults (67 to 76 years) without cognitive impairment. PET scans of amyloid B and tau were monitored. Participants were separated into four groups; amyloid positive, tau positive (A+ T+), both negative (A- T-), amyloid positive, tau negative (A+ T-) and amyloid negative, tau positive (A- T-) based on neurodegeneration assessed via temporal cortical thickness. Some 2.5 years later, just under two-thirds (range 33 to 88%) of "A+ T+" participants progressed to mild cognitive impairment as did fewer than 20% of the other biomarker groups. The authors stated that given "A+ T+" and neurodegeneration as measured in their studied population, most older individuals developed Alzheimer's symptoms within 2 to 3 years. Although biomarkers are developing rapidly, there are no as-of-yet universally-accepted bio-markers for dementia, although we anticipate this will change in the near future. Likewise, pharmaceuticals to effectively treat/manage the majority of NCDs are not yet available.

Discussion

In this survey article we have explored multiple topics which argue that otolaryngology, audiology and hearing aid dispensing each have an important role to play in cognitive health. The importance of auditory sensory perception with regard to cognition and neurocognitive disorders is apparent, although an exact singular mechanism is as-of-yet not clearly defined. Aural rehabilitation via hearing aids and Cis and cognitive-based outcomes reveals important long-term benefits for appropriately selected and fitted patients. The usefulness and efficacy of cognitive screenings for hearing aid and CI candidates is emerging and we therefore urge implementation of cognitive screenings to better understand and impact the needs, abilities and clinical path for the patients we are honored to serve.

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Conflicts of interest

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