A Deeper Dive into Cognition & Audiology: 2022

Emerging relationships between audition and cognition

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Approximately 55 million people (globally) have acquired dementia and that number is expected to triple in the next 28 years (by 2050).[1] Despite disappointment regarding the pharmacologic treatment of Alzheimer's disease (there are as-of-yet no drugs which cure or reverse Alzheimer's Disease,)[1,2] when cognitive disorders are screened, diagnosed, and managed early, the opportunity to positively alter the trajectory of cognitive decline increases. In this article, we'll examine some lesser-known factors and recent peer reviewed findings which may impact our understanding of the relationship between cognition and audition.

The familiar terms mild cognitive impairment and dementia have been updated. The most recent Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5) uses the terms mild neurocognitive disorder (MiNCD) and major neurocognitive disorder (MaNCD), respectively.[3] Stokin et al[4] report the term mild cognitive impairment (MCI) was originally applied exclusively to elderly study participants. However, the contemporary term mild neurocognitive disorder (MiNCD) includes acquired cognitive disorders across all ages. They report MiNCD has typically been thought of as an intermediate step between normal cognitive aging and dementia. Further, the term dementia has been replaced with the less pejorative major neurocognitive disorder (MaNCD). MiNCD typically includes self-acknowledged or caregiver observation of memory complaints. In 2022, some 15% (or more) of people aged 60 and older have MiNCD and approximately 10-12% of the people with MiNCD develop dementia each year.[5]

The distinction between MiNCD (previously referred to as mild cognitive impairment) and MaNCD (previously referred to as dementia and may include Alzheimer's disease, Dementia with Lewy Body, FrontoTemporal dementia, and more) might be drawn when the person with previously diagnosed MiNCD can no longer independently attend to activities of daily living (ADL) including (but not limited to) toileting one's self, dressing, preparing food 0and eating, driving, and taking care of their own personal hygiene. Specifically, when one is no longer able to personally manage and accomplish previously successfully self-managed ADLs, and when there are no other limits, impediments or competing mental disorders which might be responsible for no longer self-managed ADLs, these negative changes may indicate MaNCD.

BioMarkers

According to the National Institute on Aging (NIA)[6] biomarkers are indicators of what is happening within the body. Biomarkers can be found and measured in blood, other body fluids, organs, tissues, and more. For example, elevated cholesterol measures often serve as a biomarker indicating an elevated risk for heart attack. Of course, CT and MRI scans are very useful to determine the status of the brain and other structures. Positron Emission Tomography (PET scans) measure specific activity across brain regions and can reveal normal and abnormal chemical activity.

Three types of PET scans are particularly useful in dementia and related studies:

1. Amyloid PET scans measure a protein called beta-amyloid. This is useful as increased beta-amyloid concentrations are consistent with amyloid plaques which are a hallmark of Alzheimer's disease (AD). However, people may have amyloid plaques and never develop signs or symptoms of AD.
2. Tau PET scans detect tau protein. Tau forms tangles within nerve cells in Alzheimer's disease and many other dementias. Tau PET scans are used primarily in research settings. Higher concentrations of tau may facilitate

tangles within nerve cells in various dementias.

3. Fluorodeoxyglucose (FDG) PET scans are used to measure energy use in the brain. People with dementia often have abnormal patterns of energy use (for example, decreased glucose use) in specific regions of the brain.

Other common biomarkers include cerebrospinal fluid biomarkers (CSF) which can be acquired through a lumbar puncture. The most significant CSF biomarkers for AD measure beta-amyloid 42, tau, and phospho-tau. CSF biomarkers help diagnose Alzheimer's and other dementias.

Teunissen et al[7] report blood-based biomarkers for AD may soon become a reality. They state impressive data has emerged with remarkable consistency. They report in The Lancet that amyloid and tau proteins in cerebrospinal fluid (CSF) were detected via PET scans. The authors query when and how these biomarkers will be brought to clinical practice to help diagnose AD and other dementias.

Stokin et al[4] report age, sex, occupation, education, and the presence of apolipoprotein E (APOE) are major risk factors for neurocognitive disorders (NCDs). They report physical exercise and mentally stimulating activities have been associated with a lesser risk of NCDs. Bejanin et al[8] concluded that APOE ε4 allele carriers showed earlier declines in episodic memory, earlier clinical diagnosis of symptomatic AD and earlier changes in AD biomarkers. The authors stated the APOE ε4 allele can modulate the clinical expression and biomarkers of AD in a genetic form of the disease, such as in Down syndrome (DS). They report the APOE ε4 allele is associated with amyloid pathology, greater hippocampal atrophy, and memory impairments in people who often present with earlier clinical symptoms and pathogenesis of sporadic AD.

Beyer and colleagues[9] measured four plasma biomarkers in a cohort of 68 people diagnosed with AD (average age at study entry 69 years) and 240 controls (average age at study entry 66 years) for 17 years to determine the relationship between those specific plasma biomarkers and AD. Approximately two-thirds of AD subjects and just over one half of the controls were female. Of note, the apolipoprotein E gene (APOE ε4 genotype) was positive in 49% of the AD group and 28% of the control group. Although APOE is a strong risk factor, it does not mean the carrier will develop AD.[10] Beyer and colleagues demonstrated that amyloid beta (Aβ) misfolding in heparin plasma at baseline in combination with present glial fibrillary acidic protein (GFAP) was associated with AD and appears to have improved utility as a possible early screening for AD, thereby avoiding more invasive and expensive tests such as PET scans and lumbar punctures.

Biomarkers offer an exciting and incredible opportunity to improve earlier NCD detection, diagnosis, and treatment. However, until they are proven, verified, validated, and easily accessible, further research and development is needed to bring these opportunities into the mainstream.

Hearing Loss

Peters and colleagues reported in 1988 (some 34 years ago!)[11] that cognitive decline among people with hearing loss was greater than for those without hearing loss. They reported that patients with AD and hearing loss, had more rapid cognitive decline than patients without hearing loss. Lemke[12] reported early diagnosis and management of hearing loss and dementia are extremely important to identify reversible causes, as well as exacerbating factors and other psychiatric problems which may cascade to even greater significance if not identified and managed early. She reports hearing loss is present in 1/3rd of people between ages 65-74 years and is present in some 75% of people 75 years and older. Lemke notes that using the standard Mini Mental State Examination (MMSE) is problematic in elderly people as oral/verbal instructions are given throughout the MMSE, the tester is often not allowed to repeat the instructions if the subject asks for a repeat, and two items of the MMSE clearly address speech comprehension. As such, hearing loss and suprathreshold listening disorders (such as ADD, ADHD, dyslexia, APD, ANSD, cochlear synaptopathy, hidden hearing loss, MiNCD, MaNCD, TBI, COVID-19 long hauler brain fog, etc…) potentially compromise cognitive screenings when given orally/verbally (through spoken words), particularly in elderly patients, in the absence of an audiometric evaluation[13] Digital cognitive screening tests (for example, Cognivue Thrive) are available and are administered without auditory stimuli, thereby presenting an attractive alternative for candidates with hearing and listening disorders. Another advantage is digital self-scoring removes the opportunity of/for tester bias.

Livingston et al[14] report approximately 60% of one's risk of developing dementia is due to their deoxyribonucleic acid (DNA). However, 12 risk-factors account for the remaining 40% of dementia risk. The identified risk-factors include; less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, low social contact, air pollution, alcohol consumption, and traumatic brain injury. Overall, the single largest risk factor identified was hearing loss, with a population attributable factor of 8.2%. The authors report that although behavior change is difficult, individuals "have a huge potential" to decrease their risk of dementia. Livingston and colleagues report we should be ambitious about prevention and keeping people with dementia physically healthy, which is advantageous regarding cognition. They report actively preventing, intervening and caring for those with dementia, "…will vastly improve living and dying for individuals with dementia and their families, and thus society…"

Gaeta et al[15] report that hearing loss is associated with cognitive decline in older adults. As such, they evaluated the impact of amplification on cognitive screening tool outcomes. They report 30 adults with hearing loss who were screened with the MMSE. They tested the adults in three conditions; without amplification, with amplification and with a personal listening device (PLD). The authors report significantly improved performance on the MMSE was noted while the subjects were using amplification (via hearing aid or the PLD). They report amplification and other communication assessments and strategies should be considered (prior to) administering and interpreting cognitive screening measures. Indeed, failure to account for hearing or listening status may lead to invalid results, over-referral for further assessment, and other significant errors.

There is not as yet a known causal association between hearing loss and cognitive decline, although epidemiologic evidence suggests an association likely exists. In agreement with Livingston and colleagues (above), Powell et al[16] state up to 8% of global dementia cases are attributable to untreated hearing loss. They suggest three possible pathways linking hearing and cognition. The first is Sensory Deprivation which suggests that long-term auditory sensory deprivation causes physical changes in the brain, which negatively impacts cognitive processing. The second is Information Degradation which suggests that cognitive processing demands (such as listening effort, memory, attention, executive function, etc) are increased as sensory information is decreased/degraded, in order to assign the correct meaning to sounds (such as speech). The third is Common Cause which suggests a shared underlying mechanism, such as neurovascular or vascular factors which could impact both auditory and cognitive systems.[17] Powell and colleagues note that if the association between hearing loss and cognitive decline is determined to be causal, a targeted intervention based on the management of hearing loss may play a fundamental role in preventing dementia.

Speech in Noise

The most common complaint from people with hearing loss and people with suprathreshold listening disorders (such as auditory processing disorders, auditory neuropathy spectrum disorder [ANSD], cochlear synaptopathy, etc…) is the inability to understand speech in noise (SIN). The American Academy of Audiology (AAA), The American Speech-Language-Hearing Association (ASHA), and The International Hearing Society (IHS) all state their Best Practice (BP) recommendations include Speech-In-Noise (SIN) testing.

Unfortunately, fewer than 1 in 5 hearing care professionals routinely acquires this information.[18] Nonetheless, SIN ability appears to be highly associated with incident dementia for people ages 60 and older.[19] In a study of 82,000 dementia-free participants enrolled in the UK Biobank Study, proportional hazard models examined whether SIN ability is associated with an increased risk of incident dementia. After 11 years of follow-up, 1,285 of the original cohort developed dementia. Poor SIN ability was associated with a 61% hazard ratio increased risk for developing dementia, as compared to others with normal SIN ability (Hazard Ratios measure how often something happens in a group compared to another group). The authors reported SIN hearing impairment is independently associated with incident dementia, thereby offering further evidence of the impact of auditory deficits as potentially modifiable risk factors for dementia.

Modifiable Risk Factors for Cognitive Decline

As noted above, Livingston and colleagues identified 12 modifiable risk factors for dementia (less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, low social contact, air pollution, alcohol consumption, and traumatic brain injury). They also report lifelong education, and specifically higher childhood education, reduces the risk of dementia. They note early life cognitive stimulation is very important and perhaps the later effects of cognitive stimulation result from those same people (i.e., those who were stimulated earlier) seeking additional stimulation and education. However, they also note it is difficult to specifically attribute the individual impact of education versus the individual's cognitive ability from lifelong cognitive function and/or activity.

Obesity

Nianogo et al[20] report the most significant modifiable risk factors for dementia have changed. The most significant three factors are:

1. Mid-life obesity
2. Physical inactivity
3. Low educational attainment

Based on more than 378,000 respondents, Slomski[21] reports the single largest risk factor for AD and related dementias (ADRD) is obesity. Approximately one-third of the reported ADRD cases involved multiple risk factors. Of note, the authors wrote in JAMA Neurology "Alzheimer risk reduction strategies may be more effective if they target higher-risk groups and consider current risk factor profiles."

Dual Sensory Loss

Sexton et al[22] report hearing and vision impairments are highly prevalent in people with dementia. Bimodal sensory degradation worsens quality of life and typically results in less socialization and increased isolation. Of course, mild-to-moderate (and worse) hearing and vision difficulties can generally be successfully managed through appropriate professional skills and products.

Byeon and colleagues[23] investigated the effects of single sensory impairment (SSI) and dual sensory impairment (DSI) on dementia and longitudinal changes of neuropsychological test scores. They evaluated 6,520 elderly individuals (58-101 years) and defined visual and auditory sensory impairment via self-report questionnaire. Based on self-reports, 932 had no impairment, 2,957 had SSI, and 2,631 had DSI. Subjects were evaluated every two years over a 6-year period. They report that upon entering the study, DSI was significantly associated with increased dementia prevalence. However, SSI upon entering the study was not associated with increased dementia prevalence. Over the 6-year period the incidence of dementia increased significantly in the DSI group. The authors suggest coexisting visual and hearing impairments facilitate dementia prevalence, dementia incidence and cognitive decline.

Kosters et al[24] report the primary barrier to gathering high-quality data on people with dual sensory impairment is the lack of standardized definitions for deaf-blind and dual-sensory loss. They report dual sensory screening processes need to be nuanced (i.e., more well-defined, more robust) and diagnostic technology for NCD should consider dual sensory issues prior to rendering a normative or non-normative cognitive status report/diagnosis.

Ehrlich et al[25] note vision impairment has generally not been included in dementia risk factors. However, vision impairment is a risk factor for accelerated cognitive decline and incident dementia, and 90% of vision impairment is preventable, or is untreated. They studied data from the 2018 Health and Retirement Study of US adults aged 50 and older, including 16,690 participants. Based on their analysis, they suggest 100,000+ dementia cases in the US could potentially have been prevented through healthy vision. They conclude that as the majority of vision impairment can be treated effectively and inexpensively, this may be a viable target to slow cognitive decline and prevent incident dementia.

Conclusions

As hearing care professionals in 2022, we have become increasingly aware of the vast literature addressing the emerging relationships between audition and cognition[13].

Kricos[26] was prescient when she reported (decades ago) the characteristics and sources of receptive communication difficulties in older individuals may occur in tandem, or in isolation with other significant anomalies. She often said (personal conversation with DLB) hearing loss and cognitive issues could mask, or parade, as each other. Kricos reported individuals may have both hearing loss and cognitive disorders, or one, or the other, or neither. Importantly, the fact that one has hearing loss does not rule out a suprathreshold listening disorder or a MiNCD. Receptive communication difficulties may be sensory, central, cognitive, psychological, emotional, etc. Kricos reported it was increasingly apparent that cognitive and auditory processing deficits associated with aging may contribute to communication difficulties.

As noted above, many of us anticipate biomarkers will soon be extraordinarily useful in the early identification and management of NCDs. Additionally, the timely and pragmatic identification of recognized and recently recognized modifiable risk factors already plays an enormous role in NCD risk management and risk reduction. It seems apparent that hearing loss, as well as speech-in-noise ability, vision and dual-sensory loss impede the processing of sensory information and contribute to social isolation, which, is itself, a risk factor for dementia.

As we explore and incorporate this knowledge into patient-centered care, we can achieve and contribute to a more holistic experience and perhaps help facilitate an improved trajectory for patients with suspected NCDs who are screened, diagnosed, and managed earlier.

About the Author

Dr. Beck began his career in Los Angeles at the House Ear Institute in cochlear implant research and intraoperative cranial nerve monitoring. By 1988, he was Director of Audiology at Saint Louis University. In 1996 he co-founded a multi-office dispensing practice in St. Louis. In 1999, he became President and Editor-In-Chief of AudiologyOnline.com, SpeechPathology.com and HealthyHearing.com. Dr. Beck joined Oticon in 2005. From 2008 through 2015 he also served as Web Content Editor for the American Academy of Audiology (AAA). In 2016 he also became Senior Editor for Clinical Research at the Hearing Review and also, Adjunct Clinical Professor of Communication Disorders & Sciences at SUNYAB. In 2019, he was appointed Vice President of Academic Sciences at Oticon Inc. Dr. Beck is among the most prolific authors in audiology with more than 211 publications. Although he officially retired from Oticon in March 2022, he became Vice President of Clinical Sciences for Cognivue, Inc., Victor, NY in April 2022. Dr. Beck continues to consult for a number of professional and private concerns. Hundreds of publications and videos are available for free at www.douglasbeck.com.

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