

Tutorial

Using Cognitive Screening Tests in Audiology

Jing Shen,^a Melinda C. Anderson,^b Kathryn H. Arehart,^b and Pamela E. Souza^a

Purpose: The population of the United States is aging. Those older adults are living longer than ever and have an increased desire for social participation. As a result, audiologists are likely to see an increased demand for service by older clients whose communication difficulty is caused by a combination of hearing loss and cognitive impairment. For these individuals, early detection of mild cognitive impairment is critical for providing timely medical intervention and social support.

Method: This tutorial provides information about cognition of older adults, mild cognitive impairment, and cognitive screening tests, with the purpose of assisting audiologists in identifying and appropriately referring potential cases of cognitive impairment.

Results: Topics addressed also include how to administer cognitive screening tests on individuals with hearing loss, how to use test results in audiology practice, and the potential of using cognitive screening tests for evaluating the benefit of clinical interventions.

Conclusions: As health care professionals who serve the aging population, audiologists are likely to encounter cases of undiagnosed cognitive impairment. In order to provide timely referral for medical assistance as well as an optimized individual outcome of audiologic interventions, audiologists should be trained to recognize an abnormality in older clients' cognitive status.

We are living in an era with a population whose average age is increasing. According to the U.S. Department of Health and Human Services, in 2009, 13% of people in the United States were ages 65 years and older. This percentage is projected to increase to 19.3% by 2030. This change translates to a substantial surge of older adults, from 40 million to 72 million. Further, the "oldest old" population (i.e., age 85 years and above) will double from 6 million to 10 million in the coming 20 years (U.S. Department of Health and Human Services, 2015). Because the likelihood of cognitive decline increases with age, this shift in the distribution of the aging population increases the proportion of audiology clients who may be affected by age-related health issues, including degradation in cognitive abilities.

How Does Aging Affect Cognitive Abilities?

Cognition is a general concept that encompasses multiple mental abilities (e.g., memory, attention, reasoning) for acquiring knowledge and interacting with the environment. A normal level of cognition is crucial for an individual's

everyday functioning. For example, we rely on our long-term memory to record important events in our lives, we focus our attention in order to read a book in a noisy environment, and we engage our reasoning ability for solving a complex task. While it is a common impression that cognition declines with aging, this is true for some cognitive abilities but not for others.

A theoretical framework that often has been used to describe cognitive aging is based on the psychometric research that categorizes two dimensions of intelligence, called *fluid intelligence* and *crystallized intelligence* (Horn & Cattell, 1967). Fluid intelligence is the capability to think logically and solve problems in novel situations. Crystallized intelligence is the ability to use skills, knowledge, and experience. Table 1 contains a list of specific cognitive abilities that are associated with fluid intelligence and crystallized intelligence (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Cunningham, Clayton, & Overton, 1975; Engle, Tuholski, Laughlin, & Conway, 1999; Fry & Hale, 1996; Primi, 2002). This framework is particularly useful when considering age-related changes. Fluid intelligence tends to decline with increased age, and crystallized intelligence remains steady or even improves with age (Horn, 1982; Salthouse, 2010).

Many psychologists believe several components of fluid intelligence drive the decline of general cognitive functioning in older adults. These abilities include processing speed (Finkel, Reynolds, McArdle, & Pedersen, 2007; Salthouse, 1991, 2000), working memory capacity

^aNorthwestern University, Evanston, IL

^bUniversity of Colorado, Boulder

Correspondence to Jing Shen: jing.shen@northwestern.edu

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Table 1. Examples of cognitive abilities.

Dimension of intelligence	Cognitive ability	Definition	Probable decline with aging?
Fluid intelligence	Working memory	The ability to retain information in memory while simultaneously processing the same or new information.	Yes
	Processing speed	The speed of responding to a perceptual stimulus with simple content, such as a short segment of sound or a digit that presented visually.	Yes
	General sequential reasoning	The ability to take multiple steps to reach a solution to a problem based on stated rules, premises, or conditions.	Yes
	Inhibitory control	The capability to voluntarily inhibit or regulate automatic responses.	Yes
Crystallized intelligence	Lexical knowledge (vocabulary)	Extent of vocabulary that can be understood in terms of correct word meanings.	No
	General knowledge	Depth of knowledge that is accumulated through learning	No

(Salthouse, 1990; Verhaeghen, 2011), and inhibitory control (Hasher, Lustig, & Zacks, 2007). Slower processing speed reduces the amount of information that can be stored in the system in a limited time frame. Lower working memory capacity contributes to poor performance on many cognitive tasks, such as reasoning and problem solving, because less of the relevant information is available when it must be integrated to make a judgment (Charness, 1981; Horn, 1975). A decreased ability to inhibit irrelevant information leads to more errors and slower responses on tasks that require an individual to filter out distracting information (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008).

At the same time, neuroscience research has tried to explain age-related cognitive changes according to neural plasticity and compensatory mechanisms (for reviews, see Eyler, Sherzai, Kaup, & Jeste, 2011; Greenwood, 2007). Neuroimaging data show that the aging brain goes through neuronal atrophy in multiple areas, particularly in the prefrontal cortex. This anatomical degeneration is accompanied by changes in activation pattern and strength in those brain areas. A combination of these anatomical and functional changes is associated with older adults' performance in tasks involving working memory (Moscovitch, & Winocur, 1995; Reuter-Lorenz et al., 2000; Tulving, Kapur, Craik, Moscovitch, & Houle, 1994) and inhibitory control (Dempster, 1992; Hasher, Stoltzfus, Zacks, & Rypma, 1991; Nielson, Langenecker, & Garavan, 2002).

It is worth noting that converging evidence from cognitive psychology and neuroimaging research also sheds light on the large variability across older individuals in terms of cognitive abilities (e.g., Baltes & Baltes, 1990; Cabeza, Anderson, Locantore, & McIntosh, 2002; Christensen et al., 1999; Reuter-Lorenz et al., 2000). In fact, while some older adults may demonstrate cognitive performance that is equivalent to younger peers, others may demonstrate earlier or more rapid deterioration in cognitive abilities. Mild cognitive impairment (MCI) is a clinical label used for describing decline in one or more cognitive abilities (such as memory and attention) that is severe enough to raise clinical concern.

While individuals with MCI may have complaints about degraded cognitive abilities, their daily function is largely preserved at this stage (Albert et al., 2011; Petersen et al., 2014). MCI is thought to be an intermediate phase of cognitive impairment that often, but not always, precedes dementia (a severe cognitive impairment that interferes with daily life). A high percentage of MCI cases, however, convert to dementia in a few years after the diagnosis (e.g., 80% in 6 years; Petersen et al., 1999). Potential causes of MCI include degenerative, vascular, depressive, and traumatic diseases and/or a mix of these diseases (Albert et al., 2011).

The prevalence of MCI increases with age (Aronson et al., 1991; Luck, Luppia, Briel, & Riedel-Heller, 2010; Ritchie & Kildea, 1995). Therefore, the increase in the number of older adults, particularly the "oldest old" category (i.e., age 85 years and above), will lead to more cases of cognitive impairment in the general population and consequently to a greater number of audiology clients with MCI. According to survey data, the prevalence of MCI is reported to be between 20%–40% in adults ages 65 years and above in most world regions (Ward, Arrighi, Michels, & Cedarbaum, 2012) and approximately 25% for community-living older adults in the United States (Katz et al., 2012; Manly et al., 2008; Petersen et al., 2010). Compared to the prevalence of dementia (about 5%–7%; Prince et al., 2013), MCI occurs five times more frequently than dementia in the older population. In addition, MCI is associated with many disorders that have high incidence in the aging population, such as cardiovascular and cerebrovascular diseases (Kivipelto et al., 2001; Lopez et al., 2003; Tervo et al., 2004), diabetes (Cheng, Huang, Deng, & Wang, 2012), and hearing loss (Gurgel et al., 2014; Lin, Yaffe et al., 2013). As a consequence, it is very likely for nongeriatric health care professionals to encounter older individuals with MCI who have not been prediagnosed.

In these scenarios, the clinician's ability to recognize potential cases of MCI early in the progression is a critical step for providing timely medical intervention and social support for these individuals, who have a higher risk of

developing dementia. In fact, recent clinical guidelines across several developed countries are in agreement regarding the benefits of early detection of cognitive impairment (Prince, Bryce, & Ferri, 2011). The list of benefits includes optimizing current medical management, improving clinical outcomes, planning for the future, and reducing future costs. Interventions including medication and cognitive training can slow down the cognitive deterioration and improve quality of life (Gates, Sachdev, Singh, & Valenzuela, 2011; Petersen et al., 2001; Robinson, Tang, & Taylor, 2015; Simon, Yokomizo, & Bottino, 2012). To this end, timely diagnosis and early treatment is most beneficial to the patients and their family as it aims to maintain a higher level of functioning when damage to neuronal circuits is not yet extensive and the impairment of daily living is still mild (e.g., Seltzer et al., 2004; Waldemar et al., 2007). In the long term, it can reduce total costs by lowering medical expenses, which are associated with the impairment and comorbidities, and delaying the time to nursing home admission. Further, early detection may facilitate more timely access to social support, allow planning for future care, and help the individuals and their families to cope with the potential progression to dementia (Moniz-Cook, Agar, Gibson, Win, & Wang, 1998; Woods et al., 2003).

Why Are Audiologists Well Positioned for Recognizing Cognitive Decline?

While the clinical diagnosis for MCI has to be made by a physician based on a comprehensive evaluation of a patient (Albert et al., 2011), audiologists are well positioned for assuming the role of detecting any cognitive problems and providing appropriate referrals. First, in contrast to many medical visits, which are extremely time limited and crammed with case history questions that cover a wide range of medical concerns, audiologists have the opportunity to (and are encouraged to) have more detailed conversations with older individuals during their counseling. For instance, the average duration of an office visit is 20 minutes with primary physicians and 21 minutes with specialized physicians (Shaw, Davis, Fleischer, & Feldman, 2014). In contrast, in the audiology clinic, there is an average of 1.2 hours of counseling during the first two months of the hearing aid fitting process (Kochkin et al., 2010). In addition to a positive effect of counseling on successful hearing aid adoption (Brooks, 1979; Ross, 2000), those conversations with an older client may provide valuable information regarding any cognitive difficulty the individual may have.

Moreover, the conversations between audiologists and clients are usually focused on communication abilities, which are strongly influenced by cognition. A discussion about the individual's difficulty understanding speech is likely to reveal potential problems in cognitive abilities. Cognitive abilities, including working memory and executive functions, decline with aging (e.g., Salthouse, 1991; Verhaeghen, 2011) and are strongly involved in the speech communication process (e.g., Rönnerberg et al., 2013). For

many older listeners, cognitive decline is a critical factor (along with peripheral and central hearing loss) in causing difficulty understanding speech, particularly in challenging environments (Besser, Koelewijn, Zekveld, Kramer, & Festen, 2013; Frisina, 2009; Humes, 2007; Moore et al., 2014; Pichora-Fuller, 2003; Wingfield & Stine-Morrow, 2000). In order to provide quality services encompassing hearing loss, cognitive abilities, and general functioning (e.g., Li-Korotky, 2012), information about cognitive functioning is indeed an important element for constructing a comprehensive view of an older individual's speech communication difficulty.

Further, the link between hearing loss and cognitive decline may lead to a higher incidence of cognitive impairment in audiologic caseloads compared to that in the general population. Research findings have suggested that hearing loss in older adults is associated with lower cognitive functions (Lin, 2011), higher rate of cognitive decline (Gurgel et al., 2014; Lin, Yaffe et al., 2013), and all-cause dementia (Gurgel et al., 2014; Lin et al., 2011; Uhlmann, Larson, Rees, Koepsell, & Duckert, 1989). For example, Lin, Yaffe et al. (2013) obtained data from 1,984 community-dwelling older adults. The data include baseline audiometric measures and cognitive testing scores ranging over 10 years. They demonstrated that the risk of cognitive impairment was associated with the severity of baseline hearing loss even after controlling for demographic and medical factors (e.g., sex, race, education, cardiovascular disease). Individuals with hearing loss had a 24% higher risk of developing cognitive impairment compared to those without hearing loss. In audiologic practice, this finding will translate to approximately a 24% higher incidence of cognitive impairment from the prevalence in the general population.

Where Does Cognitive Testing Fit in the Audiologic Battery?

For audiologists who would like to be able to identify potential cognitive impairment without significantly increasing appointment time, there are many methods that may be easily integrated into current clinical procedures. Remensnyder (2012) offers several general strategies. Audiologists can include questions in the audiologic history to ask about memory, depression, and history of head injury. Audiologists should also pay attention to any aberrant communication, such as memory difficulty and inappropriate affective reactions. Potential warning signs to watch out for may also include impairment in one or more cognitive domains (e.g., inability to learn and retain new information, difficulty in finding words or making decisions), frequently missed appointments, and confusion over simple instructions (Robinson et al., 2015). It is also helpful to communicate with clients' family members to collect information on any difficulties in communication and/or change of behavior that may be indicative of a cognitive disorder (Kiessling et al., 2003; Remensnyder, 2012). These strategies can provide valuable information about the potential

cognitive decline an individual may have. In fact, this information is crucial for deciding whether the case meets one of the MCI criteria, which is self- (or informant-) reported cognitive changes in comparison with the individual's previous level. Further, it can help the clinician in making decision about whether a direct measure of cognition is needed.

There are many cognitive screening tests available to directly assess and quantify cognitive functioning (Cordell et al., 2013; Lerner, 2013; Lin, O'Connor, Rossom, Perdue, & Eckstrom, 2013). Tests that are commonly used include the General Practitioner Assessment of Cognition (GPCOG; Brodaty et al., 2002), Mini-Cog (Borson, Scanlan, Brush, Vitaliano, & Dokmak, 2000), Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), and Saint Louis University Mental Status Examination (SLUMS; Tariq, Tumosa, Chibnall, Perry, & Morley, 2006). Table 2 provides information on these commonly used and well-studied tests. These tests have several common characteristics that make them appropriate for clinical use. First, the tests sample all major cognitive abilities, such as memory and attention. Second, they are time efficient and only take a short period of time (usually 5–10 min). Third, the tests are validated with good psychometric properties (e.g., sensitivity and specificity). Last, the tests are typically administered with pencil and paper, so they are easy to administer and interpret with a minimum amount of training (and the training resource is readily available from public websites).

Due to a much higher prevalence of MCI compared to dementia (Prince et al., 2013; Ward et al., 2012), audiologists are more likely to see clients with MCI than those with severe dementia. Therefore, it is worth noting that some screening tests may be more sensitive to MCI than others. For example, GPCOG, Mini-Cog, and MMSE are designed for dementia screening and they all perform very well for this purpose (Cordell et al., 2013). They are, however, less sensitive to MCI compared to other tests, such as MoCA and SLUMS (Nasreddine et al., 2005; Tariq et al., 2006). Moreover, the ceiling effect (i.e., near-perfect performance of most individuals) that is likely to occur with tests such as GPCOG, Mini-Cog, and MMSE could reduce the variability in the measures of cognitive abilities and diminish their ability to differentiate potential MCI cases from normal individuals (e.g., Arevalo-Rodriguez et al., 2015). On the other hand, research has suggested that MoCA's good sensitivity can reduce ceiling effects (Gill, Freshman, Blender, & Ravina, 2008; Hoops et al., 2009; Zadikoff et al., 2008) and skewed distributions (Pendlebury, Cuthbertson, Welch, Mehta, & Rothwell, 2010) that are observed with MMSE. Therefore, for the value of cognitive screening, tests such as MoCA (and likely SLUMS, pending more research evidence) should be considered in audiology clinic settings.

We take MoCA as an example here to introduce the details of a cognitive screening test. As a test specifically developed for detecting MCI, MoCA covers a wide range of cognitive abilities, including short-term memory,

visuospatial ability, executive functions, attention, working memory, and language (see Table 3 for tasks and associated cognitive domains). While MoCA has been studied in various clinical populations (including vascular cognitive impairment, Parkinson's disease, and Huntington's disease), the majority of research was done on Alzheimer's disease (AD) and MCI patients (see Table 4 for details of these studies; for a review, see Julayanont, Phillips, Chertkow, & Nasreddine, 2013). The domain subtest scores in MoCA (e.g., Visuospatial, Executive Functions, Memory) can be used for differentiating subgroups of patients with various degrees of cognitive impairment (Julayanont et al., 2013).

Although the research group that developed MoCA reports high sensitivity (100%) and specificity (87%) of the test (Nasreddine et al., 2005), that study (with a normal control group of 90 healthy Canadians) has been criticized as not taking into account demographic factors (Rossetti, Lacritz, Cullum, & Weiner, 2011). In fact, the normative data collected in the United States by Rossetti et al. (2011) only have a mean MoCA score of 23.36 (collapsed across all age and ethnic groups), which is lower than the original cutoff score of 26. A number of other studies also provide converging evidence that the recommended cutoff score of 26/25 (26 for >12 years of education and 25 for ≤12 years of education) yields high sensitivity (>80%) but low specificity (≤60%; see Table 4 for details). Furthermore, both high sensitivity (97% and 89%) and high specificity (95% and 84%) have been demonstrated with a lower cutoff score of 23/22 (Lee et al., 2008; Luis et al., 2009). Therefore, clinicians who use the MoCA for screening should consider this lower cutoff score in order to optimize specificity.

Figure 1 illustrates the distribution of MoCA scores of 28 older adults with mild-to-moderate sensorineural hearing loss who were tested in our laboratories (at Northwestern University and the University of Colorado) with an IRB-approved protocol. This group had an average age of 75.6 years (range 60–89 years). These individuals all presented as typical older adults who are interested in seeking hearing care (see the audiograms in Figure 1). The group mean score was 26.35, which was consistent with the normative data in the U.S. (controlled for age and ethnicity; Rossetti et al., 2011). Although none of the participants self-identified as having cognitive problems, 11% of the group scored below 23, which is the cutoff score with the optimal sensitivity and specificity (Lee et al., 2008; Luis et al., 2009) and 28.6% of the group scored below 26, which is the original cutoff score. This dataset highlights the high probability for audiologists to see older clients who may have undetected MCI.

How Can We Take Caution When Testing Cognition in Individuals With Hearing Loss?

While the epidemiology data suggest the comorbidity of hearing loss and cognitive impairment (Gurgel et al., 2014; Lin et al., 2011; Lin, Yaffe et al., 2013), a potential confounding factor that has not been ruled out by these

Table 2. Information about several most commonly used cognitive screening tests (for more details, see Cordell et al., 2013, for a review).

Test name	Testing time (min)	Number of test items	Abilities tested	Advantages	Availability of the test
General Practitioner Assessment of Cognition (GPCOG)	Patient: 2–5 Informant: 1–3	9	<ul style="list-style-type: none"> • Orientation • Visuospatial abilities • Executive functions • Retrieval of recent information • Delayed verbal recall 	<ul style="list-style-type: none"> • Developed for and validated in primary care • Little or no educational bias • Informant component is useful 	<ul style="list-style-type: none"> • Freely available from Alzheimer's Association website
Mini-Cog	2–4	2	<ul style="list-style-type: none"> • Recall • Visuospatial abilities 	<ul style="list-style-type: none"> • Developed for and validated in primary care • Little or no educational bias • Multiple languages available • Short administration time 	<ul style="list-style-type: none"> • Freely available from Alzheimer's Association website
Mini-Mental State Examination (MMSE)	7–10	11	<ul style="list-style-type: none"> • Orientation • Registration • Attention/calculation • Recall • Naming • Repetition • Comprehension (verbal and written) • Writing • Construction 	<ul style="list-style-type: none"> • Most widely used and studied worldwide • Often used as reference for comparative evaluations of other assessments 	<ul style="list-style-type: none"> • The clinical version is developed by PAR Inc. and can be purchased from the company's website
Montreal Cognitive Assessment (MoCA)	About 10	13	<ul style="list-style-type: none"> • Attention/concentration • Executive functions • Memory • Language • Visuospatial abilities • Abstraction • Calculation • Orientation 	<ul style="list-style-type: none"> • Designed for detecting mild cognitive impairment (MCI; higher sensitivity than MMSE) • Tests a wide range of abilities • Multiple languages available 	<ul style="list-style-type: none"> • Freely available from the MoCA website
Saint Louis University Mental Status Examination (SLUMS)	About 7	11	<ul style="list-style-type: none"> • Attention • Numeric calculation • Immediate and delayed recall • Animal naming • Digit span • Visuospatial abilities • Figure recognition/size differentiation • Immediate recall of facts from a paragraph 	<ul style="list-style-type: none"> • Higher sensitivity than MMSE for detecting MCI • No educational bias • Tests a wide range of abilities 	<ul style="list-style-type: none"> • Freely available from the Saint Louis University website

studies is the decreased performance on verbally administered cognitive tests as an artifact of testing. In other words, those individuals who have hearing loss may fail the cognitive screening test simply because they cannot hear the tester well (instead of actually having lower cognitive abilities). There are a number of lab-based behavioral studies focusing on the impact of hearing ability on cognitive test performance (Dupuis et al., 2015; Jorgensen, Palmer, Pratt, Erickson, & Moncrieff, 2016; Uhlmann, Teri, Rees, Mozlowski, & Larson, 1989). The findings suggest hearing difficulty may partially contribute to lower scores of cognitive tests. Dupuis et al. (2015), in particular, tried rescoring the MoCA test and excluding the items that heavily rely on hearing abilities (e.g., sentence repetition, auditory digit span). This method increased the passing

rate of the hearing loss group. Jorgensen et al. (2016) tested young normal hearing participants with simulated hearing loss (to avoid the confounding of cognitive decline) and demonstrated lower performance on the MMSE when hearing difficulty was inflicted.

On the other hand, this artifact of verbal testing cannot fully explain the association between hearing loss and cognitive decline (e.g., Dupuis et al., 2015; Uhlmann, Teri et al., 1989). The rescoring method used by Dupuis et al. (2015) did not completely remove the difference between the groups. The hearing loss group still had fewer individuals who passed the test compared to the normal hearing group. Uhlmann, Teri et al. (1989) used a written version of the MMSE to test dementia patients with and without hearing loss. They found the format change did not improve

Table 3. Montreal Cognitive Assessment test items and associated cognitive domains (Julayanont et al., 2013)

Test items	Tasks	Cognitive domains
Trail Making Test-B (TMT-B)	Drawing a line connecting numbers and letters in ascending order.	Executive functions Visuospatial
Copy of the Cube	Copy the drawing of a cube.	Visuospatial Motor coordination
Clock Drawing Test	Draw a clock and set the time to 10 after 11.	Visuospatial Inhibition
Naming	Name three animals (camel, lion, rhinoceros) based on pictures.	Semantic memory
Immediate Recall	Memorize and recall a list of five words.	Memory
Digit Span (forward and backward)	Repeat the numbers in the same/opposite order as you hear them.	Working memory
Letter A Tapping Test	Tap when you hear the letter A in a sequence of letters.	Attention Inhibition
Serial 7 Subtractions	Count by subtracting 7 from 100.	Working memory
Sentence Repetition	Repeat the sentence back exactly as you hear it.	Language skill Working memory
Letter F Fluency	Tell me as many words as you can think of that start with the letter F.	Lexical knowledge Working memory Inhibition
Abstraction	Explain what each pair of words has in common (e.g., how an orange and a banana are alike).	Semantic knowledge Executive functions
Delayed Recall Orientation	Recall the five words that were memorized earlier.	Memory Predictor of daily functions

test scores of the hearing loss group, which were consistently lower than those of their peers with normal hearing. It is likely that in addition to the lower cognitive abilities associated with hearing loss, the artifact of verbal testing also has a negative impact on cognitive test scores.

Therefore, when testing older individuals with hearing loss, it is important to implement procedures for reducing the influence of hearing and minimizing the possibility of false positives. For example, cognitive testing should be given with face-to-face seating positions in a quiet room to prevent negative effects of noise (Dupuis et al., 2013). Personal amplification devices should be used for clients who do not use hearing aids. If testing is done across multiple sessions, hearing devices should be documented (and kept consistent) across sessions.

While the adjustments in testing and scoring procedures have yielded small effects, it is worth noting that only a small number of studies on this topic have been

conducted. Further research on an alternative testing method for individuals with hearing loss (e.g., through a nonauditory modality) may prove helpful in increasing utilization of cognitive screening tests in audiology settings.

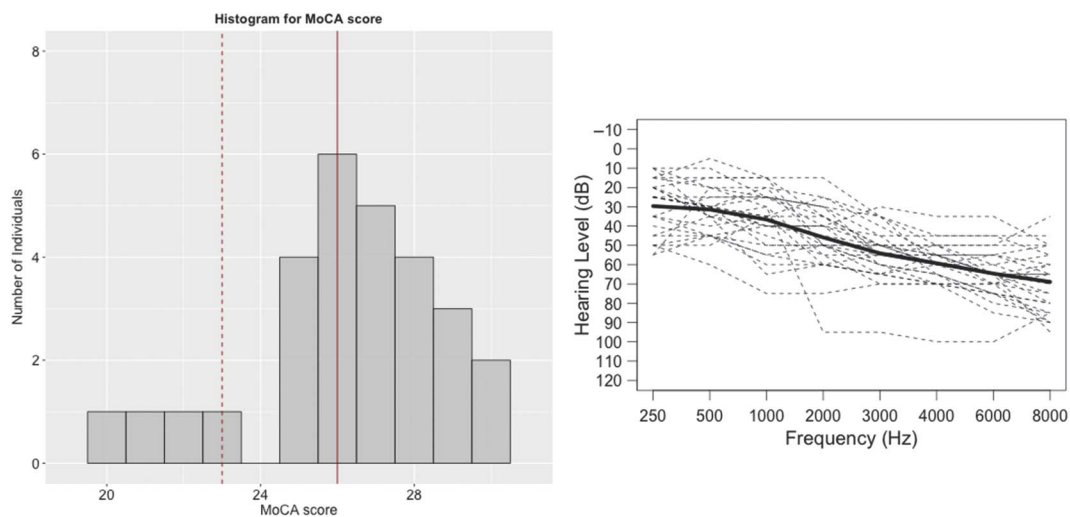
How Should Audiologists Use Cognitive Screening Test Results?

As the clinical diagnosis for MCI has to be made by a physician based on comprehensive information about a patient (Albert et al., 2011), what should audiologists do as gatekeepers who may encounter clients with cognitive impairment? Some procedures are necessary when severe cognitive impairment is presented, such as talking to the client and family members about the link between cognition and hearing, timely referral for full evaluation of dementia/MCI (see also Beck, Weinstein, & Harvey,

Table 4. Montreal Cognitive Assessment (English version) studies in mild cognitive impairment (MCI)/Alzheimer's disease (AD) patients.

Authors	Participants	Conditions to be screened	Cutoff point	Sensitivity	Specificity
Nasreddine et al. (2005)	90 Normal Controls (NC), 94 MCI, 93 AD	MCI vs. NC AD vs. NC	26 (and 25 for ≤ 12 years of education)	0.90	0.87
Smith et al. (2007)	12 Controls, 23 MCI, 32 Dementia (Dem)	MCI vs. Control Dem vs. Control	26 (and 25 for ≤ 12 years of education)	0.83 (MCI vs. Control) 0.94 (Dem vs. Control)	0.50
Luis et al. (2009)	74 NC, 24 MCI, 20 AD	MCI vs. NC	23 (and 22 for ≤ 12 years of education) 26 (and 25 for ≤ 12 years of education)	0.96 0.97	0.95 0.35
Larner (2012)	85 NC, 29 MCI, 36 Dem	MCI/Dem vs. NC	26 (and 25 for ≤ 12 years of education)	0.97	0.60

Figure 1. Data of 28 older participants with hearing loss. Left panel: Montreal Cognitive Assessment (MoCA) score distribution. The solid vertical line marks 26, which is the original cutoff score for passing the MoCA. The dashed vertical line marks 23, which is the lower cutoff score, which provides a better specificity. Right panel: Individual audiograms are shown as the thin dotted lines, group average as the thick solid line.



2016), and, as appropriate, sharing with other health care professionals (e.g., primary physician, geriatrician, and neuropsychologist) the individual's hearing and cognitive screening information. In order to provide appropriate referrals for the clients who do not pass the screening test, audiologists can benefit from a protocol with details about the referral procedure. First, it is important to compile a list of local health care providers who specialize in cognitive and memory disorders. Geriatricians, neuropsychologists, and neurologists are usually good resources to consider as they have clinical expertise on evaluating and diagnosing cognitive impairments. It is particularly beneficial for audiologists to establish a long-term relationship with these health care professionals and to work with older clients with hearing and cognitive impairment in a holistic manner. Furthermore, the protocol should include detailed criteria about when to refer a client. These referral criteria should be based on the performance on the cognitive screening tests and the reports from the client and family members. The potential impact of hearing loss should also be taken into account. Last, strategies that can help with successful referral should be incorporated into the protocol. Cognitive and memory impairments are likely to be associated with stigmas of aging and mental health problems. Therefore, it is critical to destigmatize the referral and humanize the health care professional during the conversation with the client (for more details, see Harvey, 2008).

In addition, audiologists should use multiple strategies to reduce cognitive load for those older clients whose hearing loss is accompanied by a measurable cognitive decline (Kricos, 2006; Pichora-Fuller, 2003; Remensnyder, 2012; Souza, 2014). For instance, hearing aid features that reduce cognitive load (e.g., automatic directivity, automatic program change and telecoil activation, verbal prompts) may be particularly beneficial for these clients.

Clear and brief instructions (written and graphic) should be provided to clients and caregivers, because the written materials provided with new devices are not easily digested by many patients and particularly not by those with cognitive challenges. More frequent visits can be helpful for reinforcing new skills with the hearing device. These clients should be counseled to have a realistic expectation of the benefit of the amplification device and be encouraged to use good communication strategies. Auditory-cognitive rehabilitation (e.g., classroom and/or computer-based training) is also a great option for supporting these individuals in hearing aid use and management of communication difficulty. While these strategies are generally good practice in audiology, they may be particularly beneficial for those older clients with cognitive difficulty.

Although audiologists may frequently encounter cases with comorbidity of hearing loss and cognitive impairment (Ives, Bonino, & Traven, 1995; Lin et al., 2011; Lin et al., 2004), it is difficult to gauge the impact of cognitive decline on hearing difficulty without measuring cognitive functioning. In a hypothetical scenario, two older individuals could have the same degree of hearing loss coupled with different levels of cognitive functioning. In this case, cognitive screening is a critical tool for audiologists to be able to treat these two clients differently in order to optimize their individual outcomes. Future research is certainly needed to determine the efficacy of different treatment plans for older individuals with hearing loss and cognitive decline.

Hearing aids are the most common treatment for age-related hearing loss and are used by many older listeners. In fact, new hearing aid users are in their late 60s on average (Kochkin, 2009). Recent research has suggested a relationship between cognitive ability and hearing aid setting in older users. With wide dynamic range compression, which is a common processing feature in

most digital hearing aids, listeners with lower working memory capacity have more difficulty understanding speech processed by wide dynamic range compression with fast release time than with slow release time (Davies-Venn & Souza, 2014; Foo, Rudner, Rönnerberg, & Lunner, 2007; Lunner & Sundewall-Thorén, 2007; Ohlenforst, Souza, & MacDonald, 2015; Souza, Arehart, Shen, Anderson, & Kates, 2015; Souza & Sirow, 2014). Although cognitive ability, such as working memory capacity, is a significant factor for choosing individual release time setting, the time and resources needed to quantify cognitive ability are potential barriers for implementing cognitive tests in a clinical setting. While there is little evidence on using measures from cognitive screening tests for directing the clinical choice of hearing aid fitting (however, for preliminary data, see Shen et al., 2015), this is a question that bears clinical significance and warrants future research.

Can Cognitive Screening Tests Be Used for Evaluating the Benefit of Clinical Interventions?

Although the underlying mechanism(s) of the connection between hearing loss and cognitive decline is still elusive (for a review, see Wayne & Johnsrude, 2015), many audiologists are interested in whether audiologic interventions have a positive impact on preserving cognitive functioning in older clients (Weinstein, 2015). While cognitive screening test scores have frequently been used by studies evaluating the effect of hearing aid use on cognition, the findings are largely mixed. Using various cognitive tests and questionnaires, some studies found older individuals' cognitive functioning was not improved by hearing aid use (Tesch-Römer, 1997; Van Hooren et al., 2005), while others showed the opposite pattern (Acar, Yurekli, Babademez, Karabulut, & Karasen, 2011; Amieva et al., 2005; Mulrow et al., 1990). Two of these studies have employed MMSE as a cognitive measure and found positive effects of hearing aid use (Acar et al., 2011; Amieva et al., 2005). It is worth noting that the impact of hearing status on cognitive scores may introduce a false positive effect because the studies that showed effects of hearing aid use on cognition administered the tests aurally without any specific procedure to reduce the impact of hearing difficulty (Acar et al., 2011; Amieva et al., 2005; Mulrow et al., 1990). Therefore, the improvement in performance that was associated with hearing aid use could be explained by reduction of hearing difficulty instead of underlying cognitive improvements.

Along the same lines, findings from another recent study on older cochlear implant users should be considered (Mosnier et al., 2015). Mosnier et al. (2015) collected various cognitive measures (including the MMSE) from 94 older patients who received cochlear implants. Written instruction was provided to minimize the influence of hearing loss. Comparing scores before and 12 months after implantation, significant improvement was found in the groups that had abnormal baseline test scores on most of the

cognitive tests, including the MMSE. The authors did note that the effect of treatment might have come from a combination of improved hearing and cognitive training (as a part of the aural rehabilitation program after implantation). This could also explain the lack of cognitive effect among hearing aid users, as aural rehabilitation is less common for this population.

Building on this literature, future work should address a few issues in the hope to move us forward in using cognitive screening tests to assess the efficacy of clinical interventions. First, the combined effect of multiple treatments (e.g., hearing aids plus aural rehabilitation) needs to be evaluated. Second, the effects of hearing treatment may vary depending on an individual's baseline cognitive status. By targeting those older individuals who have measurable cognitive impairment, studies may be able to detect the effects from clinical interventions. Third, tests other than the MMSE (e.g., MoCA, SLUMS) should be used to provide better sensitivity of cognitive assessment.

Summary

While cognitive screening tests are clinical tools that have been used in geriatric and neuropsychiatric settings, they are receiving increased recognition from audiologists (Kricos, 2006; Weinstein, 2015). As the current demographic change is bringing in more older clients who are likely to have impaired hearing as well as cognition, audiologists should know more about abnormal cognitive changes with aging, their impact on communication, and the use of cognitive screening tests.

While screening for cognitive communication disorders is currently within the scope of practice in audiology (American Speech-Language-Hearing Association, 2004), many audiologists may still feel uncomfortable with addressing cognition in their practice. The critical barriers are the lack of information and/or skills for cognitive screening and access to resources for proper referral. To this end, the field of audiology needs workshops and conference sessions on how to recognize cognitive abnormality and screen for cognitive impairment, audiologists need to educate themselves on the proper procedures with someone who fails the test, and universities need to include cognition as a major thematic component in audiology graduate training programs.

On the other hand, the adoption of cognitive screening testing is by no means an easy and immediate process. It is a realistic expectation that a cognitive screening test is not included in the test battery in most audiology clinics due to practical reasons, such as limited appointment times. This situation is also not likely to change unless any direct benefit of cognitive screening tests is demonstrated on the outcome of audiology service. As a consequence, an audiologist's awareness of any cognitive difficulty becomes even more crucial at this point for those older clients who may have a dual impairment of both hearing and cognition. In summary, the present article provides the following recommendations for audiologists.

In the Diagnostic Process

- Be aware of the comorbidity of hearing loss and cognitive impairment.
- Keep in mind that cognition plays a critical role in communication activity.
- Include questions in the audiologic history to ask about memory, depression, and head injury.
- Pay attention to information from family members or caregivers that may indicate a cognitive problem.
- Consider using cognitive screening tests with older clients who may have cognitive impairment (see Table 5 for a suggested list of steps when implementing a cognitive screening test).
- Make sure to accommodate hearing difficulty when using a cognitive screening test. A personal amplification device can be helpful.
- Have a protocol in place with instructions about what to do when an older client does not pass the cognitive screening test (e.g., who the appropriate referral sources are).

In the Rehabilitative Process

- For older clients who have cognitive decline, use hearing aid features that reduce cognitive load (e.g., automatic directivity, automatic program change and telecoil activation, and verbal prompts).
- Provide clear and brief instructions and more frequent visits for reinforcing new skills with the hearing device.
- Counsel these clients (and their families) to have a realistic expectation of the benefit of the amplification device and encourage them to use good communication strategies.
- Recommend auditory–cognitive rehabilitation, such as classroom and/or computer-based training.

While there is a need for more clinical trials on the effect of screening for cognitive impairment on clinical outcomes of medical treatment (Lin, O'Connor et al., 2013),

Table 5. A suggested list of steps when implementing a cognitive screening test.

Deciding what cognitive screening test to use based on the client population and time available.
Obtaining the cognitive screening tool (see Table 2).
Being familiar with the characteristics that are potential warning signs for mild cognitive impairment (reported decline in cognitive functioning, observed memory, and other cognitive difficulties).
Administering the test (with appropriate accommodation to hearing difficulty).
Talking to the client who fails the screening about getting more help for memory/cognitive concerns.
Making a referral to a geriatrician (or other specialists, depending on the availability of the specialties).

audiologists are particularly interested in seeing more research data on using these tests on older populations with hearing loss. Several questions deserve future research.

- Could administration of cognitive screening tests help with optimizing individual outcomes of audiologic intervention? For example, how could the treatment plan be tailored to take into account an individual's cognitive impairment (in addition to any hearing difficulty)? Could measures from a cognitive screening test be used in making clinical decisions such as hearing aid fittings?
- How should audiologists test older adults with hearing loss while minimizing the impact of hearing difficulty? What are the possible testing methods that may provide more accurate testing results on this population?
- How should audiologists use cognitive screening tests to assess efficacy of clinical interventions? This question needs to be evaluated with different screening tests, with individuals who have hearing loss and cognitive impairment, and with multiple intervention strategies.

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