

Cognition and Audition: Introductory Concepts

By Douglas Beck, AuD

IHS offers a diversity of options for obtaining continuing education credit: seminars and classroom training, institutional courses, online studies, and distance learning programs. This article represents yet another opportunity. Upon successful completion of the accompanying test on page 26, you will earn one continuing education credit. (Please check with your licensing board to verify acceptance of continuing education credit for this activity.) This article and test are also available on the IHS website at www.ihsinfo.org.

Introduction

As hearing professionals our ultimate goal is greater than simply making things louder. We need to facilitate listening success for our patients through counseling, aural rehabilitation, and of course, amplification. Hearing can and does exist in the absence of cognition. The auditory brainstem response, otoacoustic emissions, and acoustic reflexes can be acquired in the absence of cortical function. However, listening (i.e., applying meaning to sound) cannot occur without cognition. Naturally, amplification solutions vary with the specific needs of the patient but may include hearing aids, assistive listening devices, FM systems, brainstem and cochlear implants, bone-anchored hearing solutions, connectivity solutions, and more. Listening is the “hearing part” of cognition and having the ability to “listen well” is what our patients need and desire. Pichora-Fuller noted (2008) “Cognitive factors have recently been recognized to be important predictors of success with hearing aids...”

Cognition and audition may be thought of as two sides of the same “listening coin.” Readers of *The Hearing Professional* are very familiar with audition and presbycusis and the many challenges it presents with respect to speech recognition and listening in difficult situations as well as the disruptions and distortions in auditory percepts secondary to sensorineural hearing loss (SNHL).

This article will primarily address the other side of the coin (i.e., cognition) and the interaction between audition and cognition.

Top-Down and Bottom-Up Processing

Cognition is an abstract concept which means more or less “a sense of knowing.” Cognition is not “concrete,” it is dy-

namic. Using a concept to define an abstract concept is sort of like using a given word to define itself. Cognition does not exist in isolation, it requires context. As if all of that weren't obtuse enough, each person has a unique percept and personal context which has been influenced and shaped by a multiplicity of factors including personal experiences, the language(s) we speak, our vocabulary within that language, our education, our genetic DNA-based core, our beliefs, our family and the multiple societies within which we live, and more. All these things impact our knowledge and ultimately contribute to, and create, our “cognitive self.” Prior to arriving at our cognitive self we experience and acquire sensory input through audition, vision, tactile, smell and taste as discrete units, and groups of information upon which cognition is built. Just as reading occurs before writing and listening occurs (generally) before speaking, sensory input occurs (essentially, although not completely) prior to cognition. The accumulation of sensory input is referred to as “bottom-up” processing, meaning acquiring physical information (light, sound, heat, pressure, smells, tastes, etc.) from the world around us and internalizing it through sensory receptors and sensory systems into information our central nervous system can organize into meaningful percepts. As meaningful percepts are created internally and organized into language, time, thoughts, meanings, memories, and more, our brains organize, categorize, manipulate, and manage percepts from the original bottom-up stimuli. These management and organizational actions are “top-down” cognitive processes. Sensory input (i.e., bottom-up

Douglas Beck, AuD, is director of professional relations at Oticon and web content editor for the American Academy of Audiology. He earned his master's degree at the State University of New York at Buffalo and his doctorate from the University of Florida at Gainesville. Readers may contact Dr. Beck at dmb@oticonusa.com.

processing) essentially provides the foundation upon which our cognitive abilities are built as we age, gain experience and knowledge, and internalize and organize sensory input. There are “rate limiting” elements of cognition such as genetic insults and other anatomic and physiologic abnormalities which provide additional barriers and impediments which may govern or restrict cognitive development.

Auditory and cognitive abilities generally decrease as age increases (Rawool, 2007; Craik, 2007; NAAAS, 1999). Although age-related hearing loss (ARHL, i.e., presbycusis) and age-related cognitive decline have been noted since the ancient Greeks and Romans, neither is an inevitable consequence of aging and one cannot make accurate predictions about an individual based on group data relating to his/her age cohorts. There are many genetic, environmental, and lifestyle factors which contribute to and determine the ultimate outcome (Cruickshanks, 2010). Recently, the Alzheimer’s Association (2010) reported cognitive decline appears to be impacted by race and ethnicity. Based on a survey of more than 16,000 Americans, they demonstrated that overall, 10.5% of Americans aged 65 years and older have cognitive impairment. However, when reviewed by ethnicity and race, the percentage of Caucasians with cognitive impairment was approximately 9%, approximately 18% of Hispanics had cognitive impairment, and approximately 24% of African Americans had cognitive impairment.

Negative Synergy Theory

As we age, word finding difficulty increases, information processing speed slows, executive functions are slowed in difficult and challenging situations, and cognitive processing speed and reaction times slow (Craik, 2007). Unfortunately, for the older patient, negative synergy can be a significant problem. Negative synergy (Schum and Beck, 2008) occurs when two (or more) problems such as age-related hearing loss and age-related cognitive decline co-exist in the same person resulting in a far greater problem than would result from summing the two. In other words, “one plus one equals seven.”

Imagine a 29-year-old corporate attorney with a bilateral sensorineural hearing loss presenting with normal hearing thresholds through 1500 Hz, 55 dB thresholds at 2000, 3000 and 4000 Hz and 80 dB thresholds at 6000 and 8000 and with excellent word recognition scores. Her hearing loss certainly makes it difficult for her to communicate effectively in challenging and noisy listening situations. However, she is very bright and at 29, unlikely to have any substantial cognitive decline due to aging. Although she usually wears bilateral hearing aids, she also manages her bottom-up sensory deficiencies (i.e., hearing loss) through excellent cognitive (top-down) skills, including her knowledge of language, conversational rules, vocabulary, and her ability to “fill-in-the-blanks” based on the context in which a conversation occurs. Conversely, if we apply this exact same audiogram to an 82-year-old retired steelworker experiencing early signs and symptoms of Alzheimer’s disease, negative synergy will render a much more difficult and potentially devastating problem for the

retiree. For example, his ability to recall and implement traditional rules-of-language and his ability to develop an accurate conversational percept in real-time is poorer than that of the young attorney. His processing time is slower, he requires a better signal-to-noise ratio than younger listeners (Souza and Arehart, 2010), his “sense of knowing” is likely distorted or perhaps missing entirely (at times), and the combination of his hearing loss and cognitive decline often leads to incorrect auditory percepts and conclusions, as well as decreased emotional, physical, and social well being, and depression as well as a decreased quality of life (NAAAS, 1999).

Candidates for Negative Synergy

As one ages, the opportunity for multiple systems to fail or work less than optimally, increases, as does the opportunity for negative synergy. In fact, because the majority of our patients are elderly, it can be anticipated that many will have cognitive issues which impact their daily lives, and their auditory percepts and speech perception.

The average age of the new hearing aid wearer in the U.S. is 69 (Kochkin, 2009). People in their mid-80s have a 50-percent chance of having Alzheimer’s disease (CDC, 2010; Lunbinski, 2010). Mild Cognitive Impairment (MCI) is more subtle, yet is a measurable memory disorder characterized by memory impairment with normal cognitive functions and unimpaired activities of daily living without dementia (Kricos, 2009). MCI is often thought of as a “pre-Alzheimer’s disease” condition. Plassman, Langa, Fisher et al. (2008) estimated the national prevalence rate for MCI (in 2002) at approximately 22% for the population age 71 years and older and concluded MCI is more prevalent than dementia.

Key Factors in Cognition

There are many cognitive factors which directly (and indirectly) impact speech perception. Working memory, processing speed, and (selective) attention are key among them (Pichora-Fuller, 2009) and these cognitive factors (and more) significantly interact, sometimes compensating for cognitive and auditory deficiencies, and sometimes summing in a negative synergistic manner.

Working Memory

Working memory is a measure of the brain’s ability to hold and process information with respect to the events occurring at the moment. Lunner noted (2003) patients with the best working memory capacity were better able to discern processing effects from hearing aid amplification. Working memory has limits (Lunner, 2010; Craik, 2007) and it has been shown to decline with age (Rawool, 2007). When patients cannot recall the words from the beginning of a sentence upon conclusion of that sentence, the sentence will have little meaning and their ability to recall and recite the sentence will be greatly diminished. For patients with Alzheimer’s and other dementias, working memory capacity is

often diminished—sometimes in the presence of intact long-term memory. Although it may appear hearing is the primary issue, the issue is quite often listening. In many of these situations, working memory may be the source of the unresolved communication problem.

Processing Speed

Lunner (2003) assessed 72 hearing impaired subjects with respect to their cognitive ability as measured through working memory assessments and verbal information processing speed. Lunner found speech recognition in noise (with and without hearing aids) was significantly related to cognitive ability. Pichora-Fuller (2009) reported people who perform poorly on cognitive tests also perform more poorly on tests of speech recognition in noise, with or without hearing aids. Rawool (2007) stated among the most marked changes in older people is the general slowing of the rate at which information processing occurs and the fast pace of ongoing sensory input (visual, auditory, etc.) is difficult for older people to process. Lubinski (2010) notes “normal aging changes include reduced cognitive processing speed...” It is of tremendous pragmatic importance to speak slower, use shorter sentences, and use clear and redundant words and concepts while avoiding “elderspeak,” which may be perceived as condescending.

Attention: Where You Attend is How You Will Do

Selective attention is made more difficult secondary to cognitive and auditory decline. Craik (2007) reviewed Treisman’s work from the 1960s in which selective attention was offered as a framework within which bottom-up and top-down processes were considered. Treisman noted “attention acts throughout a series of levels of analysis...” from sensory to cognitive, with successive levels of tests and analysis. Thus, loud and meaningful messages will arrive at conscious awareness—although for different reasons. Craik noted when listeners were presented with dichotic presentations, they often failed to perceive or note the unattended message. Pichora-Fuller (2009) noted competing speech is often hard to dismiss because it is meaningful and the listener must divide his/her attention between the primary signal and the competing speech. Selective attention to the loudest signals and most meaningful signals will help assure they are processed with due respect from bottom-up and top-down systems.

The Role of Amplification

The role of amplification is to present the highest quality bottom-up signal (including maximal audibility and a maximal signal-to-noise ratio) to the brain, so as to facilitate efficient and effective top-down processing and to ease the cognitive burden (Beck, 2009; Beck and Clark, 2009; Beck, 2010). Component factors of high quality bottom-up signals include extended bandwidths, adaptive directional-

ity, bilateral/bimodal fittings, advanced noise reduction, maintenance and delivery of spatial cues, automatics that engage if and only if they improve the signal-to-noise ratio and amplification which facilitates easy-to-use (plug’n’play) connectivity to the patient’s most important sound sources, including one-on-one conversations and the ability to seamlessly listen to their televisions and telephones. *THP*

References and Recommendations

- Alzheimer’s Association (2010): *Special Report: Race, Ethnicity and Alzheimer’s Disease*. Pages 50–51.
- Beck, DL (2009): Cognition Friendly Amplification. *British Society of Audiology Newsletter*, Volume 57, August. http://www.oticonusa.com/eprise/main/SiteGen/Uploads/Public/Downloads_Oticon/British_Society_Audiology/British_Soc_Audiology_Newsletter_Vol_57_Aug_2009.pdf
- Beck, DL (2010): Defining Quality in Hearing Aid Fittings. *ENT & Audiology News*, Vol 19, No 3, July/August 2010. Pages 82–83.
- Beck, DL and Clark, JL (2009): Audition Matters More as Cognition Declines and Cognition Matters More as Audition Declines. *Audiology Today*. March/April, 2009, Pages 48–59.
- CDC (Centers for Disease Control and Prevention): Aging—Healthy Brain Initiative. Alzheimer’s Disease. Section title “Who Has Alzheimer’s?” Retrieved online July 28, 2010, www.cdc.gov/aing/healthybrain/alzheimers.htm
- Craik, FIM (2007): The Role of Cognition an Age-Related Hearing Loss. *Journal of the American Academy of Audiology*. Volume 18, Number 7, Pages 539–547.
- Cruikshanks, KJ (2010): Age-Related Hearing Loss—Demographics and Risk Factors. *Audiology Today*, July/August 2010, Pages 61–63.
- Kochkin, S (2009): MarkeTrak VIII: 25-Year Trends in the Hearing Health Market. *Hearing Review*, October. Page 22.
- Kricos, P (2009): Providing Hearing Rehabilitation to People With Dementia Presents Unique Challenges. *Hearing Journal*. Volume 62, Number 11, Pages 39–43.
- Lubinski, R (2010): Communicating Effectively With Elders and Their Families. *The ASHA Leader*. March 16.
- Lunner, T (2003): Cognitive Function in Relation to Hearing Aid Use. *International Journal of Audiology*. Volume 42. Pages S49–S58.
- Lunner, T (2010): Cognition, Hearing Loss and Listening Effort. *Oticon Clinical Update*, May. Pages 6–9. http://www.oticonusa.com/SiteGen/Uploads/Public/Downloads_Oticon/Oticon_Clinical_Updates/OCU2010.pdf
- NAAAS (National Academy on An Aging Society, 1999): Hearing Loss—A Growing Problem That Affects Quality of Life. <http://ihcrp.georgetown.edu/agingsociety/pdfs/hearing.pdf>
- Pichora-Fuller, MK (2009): How Cognition Might Influence Hearing Aid Design, Fittings and Outcomes. *The Hearing Journal*. Volume 62, Number 11, Pages 32–35.
- Plassman, BL, Langa, KM, Fisher, GG, Heeringa, SG, Weit, DR, Ofstedal, MB, Burke, JR, Hurd, MD, Potter, GG, Rodgers, WL, Steffens, DC, McArdle, JJ, Willis, RJ, Wallace, RB (2008): Expand+Prevalence of Cognitive Impairment without Dementia in the United States. *Ann Intern Med* March 18, 2008 vol. 148 no. 6 427–434
- Rawool, VW. (2007): The Aging Auditory System, Part 3: Slower Processing, Cognition, and Speech Recognition. *Hearing Review*, September.
- Schum, DJ And Beck, DL (2008): Negative Synergy: Hearing Loss and Aging http://www.audiologyonline.com/articles/article_detail.asp?article_id=2045
- Souza, P and Arehart, K (2010): Aging, Auditory Perception and Hearing Aids. *Audiology Today*, July/August 2010, Pages 64–65.

IHS Continuing Education Test: Cognition and Audition: Introductory Concepts

For continuing education credit, complete this test and send the answer section at the bottom of the page to: **International Hearing Society**

16880 Middlebelt Rd., Ste. 4, Livonia, MI 48154

- After your test has been graded, you will receive a copy of the correct answers and a certificate of completion.
- All questions regarding the examination must be in writing and directed to IHS.
- Credit: IHS designates this professional development activity for one (1) continuing education credit.
- Fees: \$29.00 IHS member \$59.00 non-member (Payment in U.S. funds only.)

1. Can hearing exist without cognition?

- a. yes
- b. no
- c. sometimes
- d. always

2. The “two sides of the coin” referred to are:

- a. cognition and language
- b. audition and language
- c. cognition and audition
- d. language and audition

3. Top-down processes include:

- a. language
- b. memory
- c. hearing
- d. language and hearing
- e. language and memory

4. Bottom-up processes include:

- a. hearing and vision
- b. hearing and language
- c. hearing and memory
- d. memory
- e. memory and cognition

5. Rate limiting elements of cognition include all but which:

- a. attitude
- b. genetic insults
- c. anatomic abnormalities
- d. physiologic abnormalities

6. If we consider all Americans over age 65, what percentage has Alzheimer’s?

- a. 5.5%
- b. 10.5%
- c. 15.5%
- d. 20.5%
- e. 25.5%

7. Which two things are discussed in the article with regard to negative synergy?

- a. aging with respect to vision and audition
- b. aging with respect to language and cognition
- c. aging with respect to vision and cognition
- d. aging with respect to audition and cognition

8. The average age of the new hearing aid wearer in the U.S. is:

- a. 49
- b. 59
- c. 69
- d. 79
- e. 84

9. People in their mid-80s have approximately what chance of having Alzheimer’s?

- a. 25%
- b. 40%
- c. 50%
- d. 65%
- e. 75%

10. Three key factors which impact cognitive abilities are:

- a. long-term memory, audition, and language
- b. working memory, audition, and language
- c. tinnitus, SNHL, and presbycusis
- d. working memory, processing speed, and selective attention

COGNITION AND AUDITION: INTRODUCTORY CONCEPTS

Name _____

Address _____

City _____ State/Province _____ Zip/Postal Code _____

Email _____

Office Telephone _____

Last Four Digits of SS/SI# _____

Professional and/or Academic Credentials: _____

(PHOTOCOPY THIS FORM AS NEEDED)

Please check one: \$29.00 (IHS member) \$59.00 (non-member)

ANSWER SECTION

(Circle the correct response from the test questions above.)

1. a b c d	6. a b c d e
2. a b c d	7. a b c d
3. a b c d e	8. a b c d e
4. a b c d e	9. a b c d e
5. a b c d	10. a b c d