Cognitive Skills and the Aging Brain: What to Expect

By Diane B. Howieson, Ph.D.

Editor's Note: Whether it's a special episode on the PBS series, "The Secret Life of the Brain" or an entire issue dedicated to the topic in the journal Science, *a better understanding of the aging brain is viewed as a key to an improved quality of life in a world where people live longer. Despite dementia and other neurobiological disorders that are associated with aging, improved imaging has revealed that even into our seventies, our brains continue producing new neurons. Our author writes about how mental health functions react to the normal aging process, including why an aging brain may even form the basis for wisdom.*

Every day we perform hundreds of cognitive tasks but are mostly unaware of the effort involved. These tasks take different forms, such as noticing colors, remembering names, or calculating time on a watch. Measures of brain function using functional magnetic resonance imaging (fMRI) show that the most active areas of the brain vary according to the task being performed. The data confirm what researchers have known for many years: that our mental functions are comprised of many distinct types of cognitive abilities.

Mental abilities change throughout life, first as a result of brain maturation and later with aging of brain cells and their billions of complex interconnections. As people age, their movements and reflexes slow and their hearing and vision weaken. Until the 1990s, most aging research examined cognitive abilities of adults younger than 80. More recent research includes the fast-growing 80s-and-older population, and has advanced our understanding of cognitive changes in the elderly. Scientists in a recent study asked, "When does cognitive functioning peak?" [1] and found evidence for considerable variability in the age at which cognitive abilities peak and decline throughout life.

Cognitive Changes with Aging

Certain cognitive abilities show at least a small decline with advanced age in many, but not all, healthy individuals. Although differences between the young and elderly can be shown in some cognitive areas described below, declining ability does not translate into impairment of daily activities. These changes are subtle. The most consistent change is cognitive slowing. For example, on a writing task in which people were asked to substitute as quickly as possible symbols for numbers, 20-year-olds performed the task almost 75 percent faster on average than 75-year olds. Age-related slowing is also evident on certain attentional tasks, such as trying to grasp a telephone

number when someone rattles it off quickly. Overall, cognitive slowing is thought to be a contributing factor in elderly people's higher rate of automobile accidents per miles driven.[2]

Age hinders attention, particularly when it is necessary to multitask. When switching from one task to another, the elderly have more difficulty paying attention to multiple lanes of traffic, for example, or noticing if someone is about to step off a curb at a busy intersection. Processing information rapidly and dividing attention effectively are cognitive skills that peak in young adulthood. How fortunate it is that college and vocational students are typically at an age when the brain is working with optimum efficiency.

Similarly, the ability to keep multiple pieces of information in mind at the same time is another skill that peaks around ages 18 to 20, and becomes more difficult thereafter. Every time you mentally calculate a tip in a restaurant, you use an information processing skill called "working memory." In the clinic, we often test working memory by asking people to recite backward a string of numbers that we have just read to them. This task requires working memory because the numbers need to be held in mind long enough to rearrange them.

While memory declines for many people over time, the exact nature of the decline depends on the particular type of memory. To be able to recall an event or new information, the brain must register the information, store it, and then retrieve it when needed. The ability to recall new information, such as reading material, peaks early and gradually becomes more challenging after age 40, particularly for visual material. Studies show that by age 70 the amount of information recalled 30 minutes after hearing a story once is about 75 percent of the amount remembered by an 18-year

old.[3] Recognizing information from the story is easier than remembering it without any cues, and this ability is usually well retained throughout life. In other words, older adults are less likely than young adults to freely recall most of the information from a recently read news article, but they may be just as good at recognizing the content if someone talks about it.

Language skills develop rapidly throughout childhood and are well retained throughout adulthood, with one exception: Recalling a familiar person's name or a particular word during conversation commonly becomes harder for adults after age 70. Although this type of word-finding involves memory, the problem lies in accessing the word, even though it exists in the person's knowledge or vocabulary. Sometimes this problem manifests as a "tip of the tongue" experience—you feel close to recalling the word and may even know that it begins with a given letter. If someone else says the name or word, you easily recognize it. This problem is particularly frustrating because mustering effort to force recollection of the word is likely not to help. The word is apt to pop into mind later when you are going about another activity.

Visual perceptual abilities, principally the ability to understand spatial relationships, also show decline with age, especially after age 80. This weakness causes another driving-related problem, such as not knowing how far away a curb is or how much to turn to parallel-park a car. Visual scanning ability also can diminish so that, for example, it becomes more difficult to see a misplaced object among other items.

Executive functioning refers to higher-level skills, such as conceptualizing a problem, making appropriate decisions, and planning and carrying out effective actions. Older adults tend to be

slower in conceptualizing problems and less ready to change strategies when circumstances shift. In one well known study involving decision-making, approximately one third of older adults did poorly compared to younger adults.[4]

The task used to assess decision making in this study was the Iowa Gambling Task: Each participant is asked to choose cards one at a time from one of four decks. Some cards bring rewards in the form of play money, and others bring penalties. The goal is to win as much money as possible. Deck selection is based on hunches, and subjects are given immediate feedback. The catch is that the decks have different mixes of reward and penalty cards. In two decks, the reward cards bring relatively low rewards, but the penalty cards bring relatively low penalties, and choosing from these decks brings a net gain in the long-term. In the other two decks, the reward cards bring higher rewards, while the penalty cards bring higher penalties too, so that choosing from this deck brings a net loss long-term.

Over time, in the study, young participants tended to shift their performance so that they no longer selected cards from all decks—they selected only from the decks that gave them a net gain. However, a subset of older participants continued to select cards from all decks, resulting in a net loss. These same older participants also were more fooled by deceptive advertising in another experiment.

Findings from studies like these give a possible explanation of why some older adults are at greater risk of falling prey to fraud. Yet for many older adults, difficulty thinking through problems and mental flexibility may not be noticeable until the 80s or beyond.

Cognitive Optimism

Other important cognitive abilities decline little if any with age. Language and vocabulary are well retained throughout the lifespan. In fact, vocabulary continues to improve into middle age. Recall of general knowledge acquired at a young age, and well-practiced skills like arithmetic also peak in middle age and are resistant to age-related decline. In general, these age-resistant cognitive skills have been strengthened by experience, including situations that require reasoning and judgment. For example, if asked why many foods need to be cooked, most adults will have no trouble answering based on a lifetime of experience. In addition, older adults often have a better overview of a situation, or better appreciation involving the impact of a single event, than younger people do, because of their greater life experience.

The cognitive operations described above do not exist in isolation. Multiple cognitive skills such as attention, memory, and reasoning are involved in performing even simple daily tasks. Some activities require a complex combination of cognitive skills. Among these activities are the social behaviors of everyday life used while shopping, riding a bus or train, dealing with neighbors, or helping a friend. In fact, social skills strongly depend on the cognitive ability to form accurate impressions of others.

Although we have a good understanding of most of the cognitive changes that tend to occur with aging, we understand relatively little about age-related changes in the “social cognition” that we use during social interactions. Social behavior relies on a combination of cognitive and emotional factors, and the influence of aging on these factors is multifaceted. For example, a social

impression—an impression of a person one has just met—is built up from factors such as physical appearance, voice quality, facial expressions, and ways the person is behaving. Even though older adults have more limited information processing capacity, their automatic perceptions of people seem to be intact.

Most of us, particularly as we get older, have had the experience of meeting someone new and a minute later not being able to recall their name. Although usually assumed to be a memory failure, this is actually a failure to fully attend to the name because one is distracted by the broader social interaction, so that the name is not strongly registered in memory. (The trick here is to repeat the name aloud as soon as you hear it, as a confirmation, and then repeat it to yourself silently a couple of more times within a few minutes.)

In this situation, an age-related decline in information-processing speed tends to handicap the older adult. Similarly, age limitations interfere with performance when information acquired in an unfamiliar situation needs to be processed quickly or there are distractions that should be ignored. As a result, older adults on average consider fewer bits of information and use less effective decision-making strategies when they are in unfamiliar situations, compared to younger adults.

One view supported in studies of social cognition is that older adults' limitations in the amount of information that can be processed quickly and accurately are often counterbalanced by increased social expertise from accumulated experience and knowledge.[5] Thus in familiar situations, middle age and older adults, compared to younger adults, tend to make more accurate interpretations of the behaviors of others when prior experience and knowledge helps to focus attention and make it

more efficient. A lifetime's worth of experiences in social situations can facilitate decision making—and that is sometimes referred to as having wisdom.

Individual Differences in Aging

For most people cognitive or social decline with aging is minor and influenced by multiple factors. One factor is called "cognitive reserve."[6] People who are more intelligent at a young age or have better cognitive maintenance through education, occupation, or stimulating activities retain cognitive skills with aging better than those who are less accomplished in these respects. A recent study involving a large number of people in Scotland who had intelligence tests at age 11 and again 50 years later found that the biggest predictor of cognitive ability at the older age was cognitive ability at age 11.[7] It is possible that being blessed with the right genes accounted for much of this benefit, although little is known about what genes might be involved.

Having friends and enjoying activities with others also appears to be beneficial. Numerous studies have shown that the level of social engagement, such as the size of a person's social network or frequency of contacts, promotes cognitive health or reduces risk of dementia.[8] Having a purpose in life has been shown to be associated with reduced risk of Alzheimer's Disease. Together these factors help explain the variability we see in how well cognitive function is retained with advanced age.

Normal Brain Aging

Years ago it was widely assumed that the death of neurons, cells that transmit signals throughout the brain, is a common part of aging. We now know that there is little evidence of this. However,

the brain does tend to get smaller as people age and a number of changes appear to account for this decrease in size. Each neuron has a cell body and a number of processes called dendrites that extend in many directions toward other neurons for receiving signals. Think of a tree limb with many branches. During aging the size and complexity and efficiency of this "arborization" decreases, making communication between cells less effective. Each neuron also has an axon that transmits signals from one cell to another; these axons make up the "white matter" in the brain. Damage to white matter tracts with aging contributes to decreased brain size. These and other structural brain changes associated with aging correspond to age-related differences in performance across cognitive tasks. For example, white matter deterioration in the front of the brain has been associated with slower information processing speed and more difficulty recalling information.

A number of other structural and chemical changes in the brain that occur with aging are not fully understood. One condition is the buildup of a small neuronal protein fragment called amyloid beta, which accumulates to form aggregates of various sizes. Dense conglomerations or "plaques" of these aggregates are characteristic of the brains of Alzheimer patients and are seen to a lesser extent in elderly people with milder cognitive impairment. Alzheimer patients also develop an abnormal version of the neuronal protein tau within brain cells. Converging evidence from multiple types of studies suggests that amyloid plaques trigger the buildup of abnormal tau, which causes neuronal loss that is associated with dementia. Because some adults with dense amyloid beta plaques appear to have normal cognitive function, the relationship between the two is not fully understood. These adults may have an unknown protective factor. More information is needed from longitudinal studies to know whether the accumulation of amyloid beta aggregates in

cognitively intact adults will lead to declining cognitive ability and ultimately Alzheimer's disease, if a person lives long enough.

With aging come increased risks for vascular disease for many people. High blood pressure, high levels of the good cholesterol (HDL), high triglyceride levels (a type of fat found in the blood), obesity, and diabetes increase risk of stroke and white matter disease. Keeping the brain healthy through good nutrition and physical activity is important to reduce the risk of cognitive decline associated with vascular disease. A healthy diet includes limiting the intake of sugar and saturated fats, particularly trans fats. Scientists are learning the many ways in which physical exercise affects the brain, ranging from benefits shown in animal models at the cellular level, such as stimulation of brain-growth factors or reduction in oxidative stress, to a decrease in white matter damage in humans.

An exciting newer area of research, made possible by technical advances in imaging, is the study of age-related changes in brain activity. It is now possible, for example, to monitor brain activity by measuring how much oxygen (fMRI scanning) or sugar (PET scanning) individual brain regions consume. Even simple acts cause widespread activation of multiple brain regions and, by studying the pattern of active areas during a cognitive task, researchers can learn which networks or regions are task-specific. During normal aging, changes occur in the pattern of stimulation of neural networks, causing increased activation in some areas and decreased activation in others. Studies reveal that when an elderly person performs a cognitive task at the same level as a young adult, more areas of the former's frontal brain regions "light up," suggesting more brain activity is needed

to maintain cognitive performance. Many questions still need to be answered in order for science to understand the full impact of aging on brain network function.

Overestimating the Impact of Aging?

It is unclear how much cognitive decline is purely the result of aging of an otherwise healthy brain. Older adults in cognitive studies are more likely than young or middle aged adults to include people with undetected Alzheimer's dementia, cerebral vascular dementia, and other brain diseases that are more prevalent in people over 70. In one recent long-term study of older adults, brain diseases detected at autopsy accounted for a large amount of the cognitive decline measured during the study.[9] If individuals with undetected early stage brain diseases are included in studies of normal aging, the amount of measured cognitive decline that is purely age-related will be exaggerated.

Around the world researchers have made significant progress in understanding factors that influence cognitive health and the related risk of developing dementia. This research has been given high priority because of the devastating personal, family, and societal costs of illnesses such as Alzheimer's disease. Advances have led to an understanding of some genetic and environmental factors but much is still unknown. Currently, an intensive quest is under way to find new treatments to stop, slow, or even prevent Alzheimer's and related disorders that cause dementia. Providing researchers with the funds necessary to make progress in this search will hopefully lead to the discovery of better ways to reduce late-life cognitive decline.

Bio

Diane B. Howieson, Ph.D., is a neuropsychologist and associate professor emerita of neurology at the Oregon Health & Science University. She was head of the neuropsychology division of the Portland VA Health Care System for 12 years before joining the C. Rex & Ruth H. Layton Aging & Alzheimer Disease Center at the Oregon Health & Science University. She has published more than 40 scientific articles, primarily in the areas of aging and dementia. She is co-author of the widely used professional book: *Lezak, Howieson, Bigler, & Tranel, Neuropsychological Assessment,* 5th edition, Oxford University Press, 2012.

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