Principles and Practice of Behavioral Neurology and Neuropsychology

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CHAPTER

36

Aging and the Brain

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Cognitive aging
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Mobility

INTRODUCTION

A number of changes occur in the aging brain. While some of these changes may be noticeable to the affected individual, others are detectable only through fine observations or highly controlled experiments. If intricate studies are necessary to discover changes in cognitive abilities, one may ask whether such changes are important. Applied research on normal age-related loss teaches us that even minor changes in areas such as attention or short-term memory can affect a person's ability to function independently, which in turn can affect quality of life (QOL). For example, combined losses in attention and the ability to quickly detect and act upon information may be enough to keep some older adults from driving safely. As the population continues to live longer, more people will be living with functional impairments that can threaten independence, and society may face even greater demands for costly services such as assisted living facilities and nursing home care.

Recent research has indicated that reversing or slowing age-related cognitive declines and augmenting cognitive abilities may improve everyday functioning in older adults. This possibility is linked to the notion that the neural architecture of the aging brain, in the absence of pathology, remains plastic (Kolb & Whishaw, 1998). Neuronal production, migration, and differentiation have been observed in older adults. Processes of neurogenesis in older adults imply that improved functioning is possible (Scharff, 2000). Neural plasticity throughout the lifespan strongly suggests that well-designed cognitive interventions may be able to capitalize on the cognitive underpinnings of certain functional tasks.

This chapter provides an overview of the cognitive/neuropsychological functions that decline with normal aging, how these functions are identified, and the effects of cognitive impairments on everyday functioning (e.g., falling, driving, taking medications, and other instrumental activities of daily living [IADLs]). Theories of age-related cognitive decline, assessment issues, cognitive interventions, and future research directions will also be discussed.

IMPAIRMENTS IN COGNITIVE FUNCTION WITH AGE

Maintenance of cognitive function is important for health, longevity, and QOL. There is a great deal of variability with regard to the cognitive changes that occur with age. Some older adults experience only slight changes in cognitive abilities, while others experience significant declines. Overall, research supports the contention that there are some universal age-related cognitive losses. Generally, changes that occur with age can be organized into areas such as intelligence, executive function (EF), memory and learning, and information processing.

Intelligence

Again, it is important to note that many older adults evidence stable intellectual and cognitive abilities with age, and others may show improvements with age (Schaie, 1996). For the average older adult, declines in intelligence are minimal until a person reaches the eighth decade of life (Schaie, 1996). In some cases, rapid decline in intellectual abilities within the few years before death is observed; this phenomenon is termed terminal drop (Johansson et al., 1992). Severe cognitive decline, however, as occurs with dementia, is not an aspect of ordinary aging. Moderate to severe dementia affects 5.5% to 7% of adults over the age of 65 years (Di Carlo et al., 2000). Although the incidence of dementia does increase with age, it is not an inevitable outcome of aging even into the tenth decade of life (Anderson-Ranberg et al., 2001).

When declines in intellectual functioning are observed with age, they tend to be specific to the domain of fluid intelligence (Bickley et al., 1995). Fluid intelligence primarily includes active reasoning, logical thought, and solving novel problems (Horn, 1982). Examples of fluid tasks would include selecting unfamiliar rotated figures that match a stimulus figure or inferring a rule to complete a letter series. In contrast, crystallized intelligence involves applying knowledge and rules that are acquired through experience. This type of intelligence relies heavily upon memory, education, and cultural background (Baltes et al., 1995b). Examples of crystallized tasks include checking a simple addition problem or finding a synonym for a stimulus word (Table 36-1). Based on the Seattle Longitudinal Study of Adult Intelligence, Schaie (1994) has reported that fluid abilities may start declining in young adulthood, whereas crystallized abilities increase or remain stable into middle age. Crystallized intelligence declines may occur later in life, but are not dramatic in the course of normal aging.

Several factors, experiences, and strategies are related to maintenance of intelligence. Higher education and continued intellectual activity appear to have protective effects upon intelligence with age (Compton et al., 1997). Extensive experience or expertise in an area also mitigates age-related declines. Hoyer and Rybash (1994) have found that although fluid abilities generally decline with age, these abilities are preserved in areas of expertise. People who have a great deal of experience in a particular area have a strong knowledge base that facilitates their performance. Apparently, information processing and fluid thinking become dedicated to specific knowledge systems and thereby become as resistant to age-related declines as crystallized abilities. Clearly, continued use of one's abilities has the potential to prevent cognitive losses.

Executive Functioning

EF involves the capacity to regulate cognitive behavior, including the ability to plan and sequence actions in order to obtain a goal, to inhibit impulses, to switch attention, and to avoid futile repetitive responses (Malloy & Richardson, 1994; Rabbitt, 1997). Executive functioning is important for maintaining IADLs and functional independence (Grigsby et al., 1998; Cahn-Weiner et al., 2000). Many investigators have demonstrated decline in prefrontal and frontal lobe function, which is responsible for EF, with

TABLE 36-1. Examples of Crystallized and Fluid Intelligence Tests

Questions	*Answers*	*Cognitive ability*
	Crystallized Intelligence	
1. What is a synonym for the word "difficult"?	1. Hard Arduous Puzzling	Verbal meaning—Recognition and understanding of words
2a. What is 14 x 3? 2b. What is 26 + 46? 2c. What is 51 – 38?	2a. 42 2b. 72 2c. 13	Numerical principles—Applying known numerical principles and concepts
3. What is the opposite of "endure"?	3. Succumb Surrender	Verbal meaning—Recognition and understanding of words
	Fluid Intelligence	
1. Match the target figure to the exact copy. A. C. B. D.	1. D	Spatial orientation—Rotating objects mentally in two-dimensional space
2. Complete the following letter series. A B D E G H J K	2. M	Inductive reasoning—Identifying. regularities and inferring principles and rules
3. Police found a man had hung himself from a beam. The man was found hanging 8 feet in the air, there was no furniture in the room, only a puddle of water. How did he position himself to hang?	3. The puddle of water was a block of ice. He stood on the block of ice and as the ice melted, he strangled.	Deductive reasoning—Using facts and principles to determine what happened

normal aging (e.g., Glisky et al., 1995; Parkin & Java, 1999; Souchay et al., 2000; West & Alan, 2000).

Inhibition is one key frontal lobe function that declines with age. The ability to inhibit responses is as important as initiation. Inhibition allows one to access, delete, and restrain cognitive behaviors (Hasher et al., 1999), and fosters access to relevant information by hindering access to irrelevant information. Inhibition facilitates ongoing cognitive processes by deleting extraneous information that is no longer relevant. Restraint functions prevent salient but inappropriate responses from taking over, thereby permitting weaker but correct responses to be made. In essence, inhibition prevents "mental clutter," distraction, and interference and allows the allocation of fuller mental resources to the task at hand. The performance deficits of older adults on tasks that tap executive functioning have been compared to those of younger individuals who have frontal lobe lesions (Moscovitch & Winocur, 1992).

Memory and Learning

Changes in the aging brain also occur in the temporal cortex, hippocampus, and limbic system, all of which are associated with memory (Eustache et al., 1995). Older adults commonly complain about memory loss. Schofield and colleagues (1997) found that 31% of cognitively intact community-residing elders reported memory complaints. Given that there may be declines in metamemory as well (i.e., people forget that they forget), the prevalence of memory declines may be even greater than reported.

One view compartmentalizes memory into three distinct units: sensory memory, short-term memory, and long-term memory. Sensory memory refers to the 1 to 2 seconds in which information is transmitted, perceived, and available visually or audibly. From sensory memory, information is filtered, and relevant information is relayed into short-term memory, sometimes referred to as working memory. At this point, the information is either discarded or encoded and stored in long-term memory. Once in long-term memory, the information can be retrieved and used again. While short-term memory has limited storage capacity (holding only four to nine pieces of information), long-term memory is considered to have unlimited storage capacity (Lovelace, 1990).

It is believed that many age-related changes in memory are due to declines in short-term memory. The phrase "short-term memory" has been used to denote both the immediate recall of information and the function of working memory. Working memory can be described as the ability to both store and use information simultaneously. While the ability to immediately recall relatively simple information remains intact in normal aging, several researchers have noted that working memory declines with age (Foos & Wright, 1992; Salthouse, 1992a). For example, the ability to retain increasingly long strings of digits presented aurally, mentally manipulate those digits so that they are in reverse sequence, and recite them aloud is a classic working memory task (WAIS-III Digit Span) that declines with age. Although normal declines in working memory are expected with age, frank deficits in working memory may be suggestive of dementia and have been associated with early IADL impairments in Alzheimer disease (AD) (Earnst et al., 2001).

Long-term memory consists of two broad classes of memory—declarative (episodic and semantic) and nondeclarative—which are differentially affected by aging. The primary distinction between declarative and nondeclarative memory is that declarative (a.k.a. *explicit recall*) refers to conscious learning and nondeclarative (a.k.a. *procedural memory* or *implicit recall*) refers to unconscious learning. In other words, nondeclarative memory can be described as unintentional, automatic, or without awareness, and relies upon familiarity rather than deliberate study (Kausler, 1994; Smith, 1996). Use of nondeclarative memory occurs when one recalls the procedures needed to perform automatic skills such as twisting a doorknob or flipping a light switch (Poon, 1985; Light & Albertson, 1989). This type of memory includes skills, perceptual learning, motor learning, and classically conditioned responses. Nondeclarative memory remains intact in normal aging as well as in the early stages of Alzheimer disease (Kuzis et al., 1999).

Older adults more often have difficulty with declarative memory as they age, and age-related impairments can be seen in both types of declarative memory: episodic and semantic. Episodic memory involves the recall of temporal and spatial information associated with past personal experiences. Semantic memory involves language and world knowledge. Episodic memory generally becomes impaired with age before semantic memory. Thus, factual knowledge and language remain resistant to loss longer than episodic memory (Tulving, 1993).

Deficits in long-term memory depend in part upon the manner in which information is retrieved and the complexity of that information. Older adults are more likely to exhibit memory deficits when required to freely recall information, but perform better when they need only recognize information in the presence of cues (Craik & Jennings, 1992). In summary, memory declines with age are not generalized; rather, they are specific to the task at hand and the type of memory employed.

Information Processing

Information processing uses a computer metaphor for understanding how cognition occurs. Simply stated, information is transmitted via the sensory organs, processed in working memory, and stored or erased depending upon its relevance. All pertinent computations are handled by working memory, where most problem solving occurs (Klahr, 1992). Although the computer metaphor is a simplistic representation of very complex phenomena, it has proved helpful for understanding cognition.

With increasing age, adults experience difficulty in processing novel information, especially in the midst of distraction. However, age-related decrements in information processing vary depending upon task complexity (Allen et al., 1995; Fisher et al., 1995; Bashore et al., 1998). Overall, performance decrements with age become more evident as task complexity increases (Mayr & Kliegl, 1993).

In addition to complexity, the amount of distracting information involved in a task can detrimentally impact older adults' information processing performance. Generally, the more distractors that a task involves, the more difficulty older individuals have in comparison with young adults (Dywan & Murphy, 1996). However, older adults' abilities improve when they are provided cues, strategies, and practice (Plude & Hoyer, 1985). For example, Sekuler and Ball (1986) found that brief periods of practice yielded significant and long-lasting improvement in task performance. In sum, older adults have more difficulty processing information when the task is complex, when it involves a great deal of irrelevant information, and when it is unfamiliar; however, such difficulty can be mitigated with practice.

THEORIES OF AGE-RELATED COGNITIVE DECLINE

Several theories have been advanced to explain the age-related declines that are observed in cognition. No

TABLE 36-2. Causal Theories of Age-Related Cognitive Declines

Theory	*Definition*	*Characteristics*
Diminished processing speed	Mental processes slow with age, resulting in widespread cognitive declines.	* Slowing of information transmission * Robust across timed tasks
Limited capacity	Brain capacity to process information determines overall cognitive function. Capacity decreases with age.	* Resource allocation model * Cognitive capacity * Cognitive reserve
Frontal aging	Declines in the frontal lobes of the brain result in a loss of executive functioning, which in turn results in widespread cognitive disorganization. Lack of inhibition is most notable.	* Prefrontal areas are more vulnerable to aging. * Executive functioning is associated with frontal and prefrontal areas of the brain. * Metacognition deficits
Activity/disuse	Cognitive decline is a function of disuse and subsequent atrophy of neurons and neural pathways rather than purely age-related.	* Use it or lose it. * Neural plasticity * Training studies support this view.
	Cognitive-Perceptual Theories	
Common cause	Cognitive and perceptual declines denote extensive degradation in the central nervous system resulting in systemwide declines.	* Age leads to widespread neural degradation that independently affects both perceptual and cognitive systems.
Sensory deprivation	Sensory declines cause cognitive declines; specifically, prolonged sensory declines lead to neuronal death.	* Deprivation must be prolonged. * Sensory underload

single theory accounts for all age-related cognitive phenomena. Clearly, each explanation spills over into adjacent theories; this spillage hints at the interdependency of the various cognitive systems (Table 36-2). For the sake of brevity, only the most widely cited theories will be discussed in this chapter.

Diminished Speed of Processing

According to the diminished speed of processing theory, Birren, 1974; Salthouse, 1985), the speed with which older adults can mentally process information slows with age. This diminished speed of processing is due to generalized slowing that affects information transmission throughout the central nervous system (CNS). peed of processing declines can occur at all stages of rocessing, from the speed at which information is ncoded to the execution of a response (Cerella & Hale, 994). Researchers have found that age differences in erformance on various cognitive and neuropsycholog-al measures that are indicative of parietal, temporal, nd frontal lobe function all can be explained by older dividuals' reduced speed of processing (Lindenberger al., 1993; Schaie, 1994; Salthouse, 1995; Salthouse al., 1996; Bryan et al., 1997). Lindenberger and colleagues (1993) found that age-related decrements in fluency, reasoning, and memory were all mediated through differences in speed of processing.

It is important to note, however, that age-related slowing is not necessarily a ubiquitous process. There is a great deal of individual variability in the rate of slowing. Furthermore, speed of processing declines may be specific to a particular aspect of processing such as stimulus encoding rather than generalized slowing. Bashore and colleagues (1998) found that when reaction time alone is measured there is support for the diminished speed of processing theory. However, when both reaction time and event-related brain potentials are examined, there is more evidence for task- and process-specific patterns of cognitive slowing. Decrements in processing speed alone cannot account for all age-related declines in cognitive performance.

Limited Capacity

Another theory proposed to explain age-related cognitive declines is the limited capacity theory. According to this theory, attentional resources peak in young adulthood and decline gradually with age due to reduced or limited processing capacity (Hoyer & Plude, 1982). In other words, there is a surplus of cognitive capacity in young adulthood but as the brain ages and suffers gradual age-related insults (e.g., free radical damage, cerebrovascular or systemic difficulties, chronic hypoxia), the cognitive reservoir slowly diminishes. Researchers have suggested that subtle decrements in processing capacity may result in information processing difficulties in general and working memory declines in particular (Salthouse, 1992b; Kail & Salthouse, 1994).

Frontal Aging

Declines in executive functioning due to deterioration in the neurologic integrity of the frontal lobes, including prefrontal cortical areas, have been proposed to account for age-related declines in several areas including memory (Troyer et al., 1994; Shimamura, 1995) and functional abilities (Grigsby et al., 1998). Support for the frontal lobe theory comes from studies demonstrating that cognitive processes dependent on the prefrontal cortex exhibit age-related declines both earlier and to a greater extent than cognitive processes dependent on nonfrontal regions.

Activity/Disuse

The activity/disuse theory states that cognitive decline is a function of disuse, resulting in neuronal atrophy. Conversely, this theory posits that neurons remain viable when an organism is stimulated and encouraged to use existing abilities. This theory is consistent with research indicating that mental functioning is improved in the presence of stimulating novel events. Research investigating cognitive interventions supports this view. For example, Vance and Porter (2000) found that global cognition was either maintained or improved in adults with AD in adult day care after they were exposed for 3 months to several novel treatment materials. Although the findings were not robust, the presence of an effect even among dementia patients supports the strength of activity/disuse theory. It could be argued that every treatment designed to improve cognitive functioning is predicated upon this theory, implicitly or explicitly, in that treatments are based upon the understanding that cognitive functioning can be augmented through some type of stimulation.

Common Cause

The common cause theory states that age-related cognitive changes are caused by an overall decline in the physiologic integrity of the brain and nervous system. According to this theory, widespread physiologic decline in the nervous system contributes to age-related impairment in motor, sensory, and cognitive functions (Lindenberger & Baltes, 1994). This theory is based on evidence indicating that declines in mental functioning are related to declines in sensory and motor functioning. For example, researchers have found that after statistically accounting for several confounding variables (e.g. education, health, mood), lower limb strength remained closely associated with age-related variance in reasoning (Anstey et al., 1997). The strength of this association supports the notion that the physiologic integrity of the nervous system affects all neurodependent functions regardless of their seeming dissimilarity.

No single cause of physiologic decline in the nervous system has been identified, but several have been suggested. Possible causes range from speed of processing declines, and frontal lobe declines, to poor nutrition (Gonzalez-Gross et al., 2001) or declines in proteins regulating postsynaptic neuronal plasticity (Hatanpaa et al., 1999).

In conclusion, all of these theories propose mechanisms for observed cognitive changes with age. An examination of the unique and overlapping contributions of these hypotheses can lead to a fuller understanding of cognition and aging.

IMPACT OF COGNITIVE IMPAIRMENTS ON MOBILITY AND EVERYDAY FUNCTIONING

There is substantial evidence that cognitive abilities are important predictors of individual differences in the ability to function in everyday life. The relationship of cognition to mobility is the primary focus of the discussion that follows.

Mobility

Mobility is a functional ability that is important for maintaining QOL and independence with age. Mobility can be defined as a person's intentional movement throughout his or her environment (Owsley et al., 1999) and can be conceptualized on a continuum ranging from bedbound to unrestricted (Stalvey et al., 1999). Mobility also encompasses the ability to move throughout one's environment in order to complete a task or achieve a goal (Owsley et al., 2000).

With increasing age, mobility limitations increase in prevalence and are associated with impairments in sensory, cognitive, and physical functioning (Barberger & Fabrigoule, 1997). In nearly 20% of the 65+ population, mobility restrictions adversely affect QOL by increasing the need for care and decreasing personal independence (Guralnik et al., 1996). Mobility problems have been associated with acute medical conditions (Branch & Meyers, 1987) and depression (Seeman, 1996), and mobility problems also signal the likelihood of further deterioration in functional independence (Manton, 1988).

Mobility can be assessed in many different ways. An individual's ability to perform activities of daily living (ADLs) (e.g., dressing, bathing, and toileting) or instrumental activities of daily living (IADLs) (e.g., handling money, using the phone, and driving) can be examined. Performance of specific maneuvers such as walking or climbing stairs and balance can be observed. The extent to which one travels throughout his or her environment can be quantified. Additionally, adverse mobility outcomes such as automobile crashes or falls may be considered as well. Each of these has been linked to declines in cognitive function.

Activities of Daily Living/Instrumental Activities of Daily Living

There is substantial evidence that cognitive variables are important predictors of individual differences in the ability to perform tasks required in daily living. With age, decline is often noted in the performance of daily activities that rely on cognitive function, referred to as IADLs. Lawton and Brody (1969) described distinct categories of IADLs that are essential to maintaining an independent lifestyle. These categories include abilities such as managing finances, self-administering medications, using the telephone, preparing meals, and housekeeping (Fillenbaum, 1987). Additionally, the inability to independently perform self-care ADLs, such as dressing, feeding oneself, and toileting, has also been linked to cognitive decline and to negative outcomes such as poor nutrition and fatigue (Diehl et al., 1995; Visentin et al., 1998).

It is important to note that the cognitive abilities underlying everyday function are complex (Willis, 1996). The performance of "real-life" tasks relies upon multiple cognitive abilities (Allaire and Marsiske, 1999) as well as an individual's overall health, social skills, and social networks. Even so, the identification of specific cognitive skills that are related to specific functional declines could lead to effective interventions.

In general, everyday performance is more strongly related to fluid intelligence than to crystallized intelligence (Diehl et al., 1995). Specifically, fluid abilities such as memory span and speed of processing appear to affect older adults' performance of IADLs (Willis, 1991). Diehl and colleagues (1995) found that speed of processing best predicted fluid intelligence, which in turn was the strongest predictor of older adults' performance on everyday activities. Limits in the performance of daily activities may also be in part caused by deficits in executive functioning. Royall and colleagues (2000) found that executive function is predictive of IADL impairment and the need for care, even among noninstitutionalized retirees. Even elderly persons without dementia may be at risk with regard to the complex cognitive skills that underlie everyday competence (Ganguli et al., 1991). Furthermore, older adults who have had lifelong sociocultural disadvantages may be especially at-risk (Willis, 1996).

Falls

Falls are a potentially serious and possibly life-threatening event for older adults. Approximately 20% to 30% of persons over the age of 65 fall at least once each year (Stalenhoef et al., 1999; Bergland et al., 2000). The result can be catastrophic; mobility may be severely limited as a result of a broken hip, and in some cases a fall results in death (Tinetti et al., 1988; Cummings et al., 1995). Falls diminish quality of life by limiting one's ability to ambulate, interfering with the performance of daily activities such as bathing or going to the store, and reducing social activity (Stalenhoef et al., 1999; Tinetti et al., 2000; Sicard-Rosenbaum et al., 2002).

Although some falls have a single obvious cause, many can be linked to cognitive factors (Fuller, 2000). For example, Tinetti and colleagues (1988) found that cognitive decline, excluding dementia, was associated with increased risk for falling. Declines in executive functioning (Nevitt et al., 1991) and attention (Shumway-Cook et al., 1997) have also been associated with increased risk of falls.

Driving

Cognitive losses have been associated with other adverse mobility outcomes such as decreased driving exposure, increased driving avoidance, and crash involvement. Deficiencies in EF, mental status, and memory have been associated with decreased driving exposure, increased avoidance, and increased incidence of crashes among older adults (Foley et al., 1995; Johansson et al., 1996; Ball et al., 1998; Stutts, 1998). Diminished speed of processing (as measured by the Useful Field of View) has also been associated with the avoidance of several types of driving situations (Ball et al., 1998) and has been found to be an excellent predictor of state-recorded motor vehicle crashes in studies using both retrospective and prospective designs (Ball et al., 1990, 1993; Owsley et al., 1998).

Cognitive function is imperative for maintaining mobility and avoiding impairments in ADLs, IADLs, or other adverse events such as falls and crash involvement. Maintaining mobility appears to be vital for sustaining one's quality of life.

ASSESSING AGE-RELATED COGNITIVE DECLINE

Many changes in cognitive abilities occur with age, and several theories to account for these changes have been reviewed. Because impairments in cognitive function are predictive of functional difficulties such as mobility impairments, loss of independence, and decreased QOL, and because the potential exists for reversing or slowing the progression of cognitive declines, it is important to identify those older adults who are at risk by reliably assessing their cognitive abilities.

Age-related cognitive declines can be difficult to determine for several reasons. Individual characteristics such as health, education, and mood state can influence cognitive performance. Lack of baseline cognitive data for a given individual makes it very hard to differentiate between performance that represents, *for that individual*, normal cognition versus cognitive decline. On the other hand, frank cognitive impairment is relatively easy to identify. Issues surrounding the administration of measures and lack of specificity among measures also can cloud interpretation of cognitive assessment.

One test administration issue that has been long debated is the use of self-report versus objective ratings. Self-report assessments can be problematic in that older adults may have trouble accurately estimating their performance (Myers et al., 1993; Diehl et al., 1995). For example, it has been suggested that older adults tend to overestimate their level of everyday competence in comparison with actual performance (Ford et al., 1988). Due to problems such as these, performance-based tests generally are preferred over self-ratings.

Yet another issue to consider is that the time of day that tests are administered may significantly affect performance. Circadian cycles influence arousal patterns, and arousal can influence cognitive performance. Some individuals experience greater arousal in the evenings and others in the mornings. May and Hasher (1998) found that performance of EF tasks was mediated by circadian variations. Older adults performed better during times in which they were more in synchrony with their arousal state.

It is also important to consider the ecological validity of any given assessment measure. Even the most widely used measures of mental status are simply a sampling of one's cognitive ability under artificial circumstances. Although a given instrument may be keen in detecting small variations in certain intellectual abilities, it may be unrelated to everyday function. Furthermore, laboratory assessments of older adults' intellectual functioning often underestimate their ability to function in more familiar everyday situations (Salthouse, 1990).

Additional factors that can create variability in the cognitive assessment of older adults include the influence of prescription medications and interactions among medications. Undesirable medication effects such as psychomotor slowing can result in the appearance of age-related declines. Observed cognitive difficulties are sometimes simply the result of polypharmacy rather than age or early-stage dementia.

Education has repeatedly been shown to complicate the determination of age-related cognitive declines. Education has been found to be an independent predictor of performance among the elderly on measures of language, learning and memory, praxis, and executive functioning (Collie et al., 1999). This link between education and cognitive function can make cognitive performance difficult to interpret.

Mood abnormalities, especially depression, have been widely cited for exerting detrimental effects on cognitive functioning. Severe depression can create a pseudo-dementia that mimics AD. For this reason, clinicians must account for the impact of mood disorders before making a dementia diagnosis (Bassuk et al., 1998). Benedict and colleagues (1999) found that geriatric psychiatry inpatients whose mood improved also exhibited improved cognitive functioning, especially on tests of spatial processing and learning. Considering that depression is a pervasive problem, with about 10% of older adults exhibiting at least some depressive symptoms (Jefferson & Greist, 1993), it must be considered as a potential confound in the assessment process.

Cognitive measures themselves are often subject to cultural and historical biases. Park and colleagues (1999) found that people raised in different cultures process information differently. Historical biases include cohort-specific advantages. For instance, younger adults are more experienced with testing situations, characteristics, and strategies. They have greater sophistication in the areas of computer testing, timed testing, multiple-choice responses, process-of-elimination strategies, and multiprocedure problems. Cognitive tests that use these characteristics may inadvertently place older adults at a disadvantage, artificially lowering their test scores relative to those of younger adults.

Cognitive Assessment Measures

Despite these caveats, current cognitive assessments do provide standardized evaluation of mental functioning and may be helpful for identifying individuals who could benefit from interventions. Below is a list of some of the most widely used cognitive assessments. Such measures are important for research and treatment because they provide global and specific information on one's ability to process information.

Comprehensive assessment is essential for answering questions about the cognitive domains underlying functional performance. Selection of a cognitive battery is guided by the research question at hand; an example of such a battery can be seen in Table 36-3. Consideration also must be given to the amount of time and expertise required for test administration, the availability of individuals qualified to interpret the data (generally neuropsychologists or clinical psychologists with additional training in neuropsychology), and the availability of age-appropriate normative data for each test. A comprehensive battery uses multiple measures of each posited cognitive domain or cognitive construct in order to avoid idiosyncratic, test-specific performance and to more fully represent the construct. As any researcher who has attempted to factor analyze a group's performance on a cognitive battery will fully appreciate, no specific test represents a pure measure of a single domain. Performance on a single test is a minute sample of behavior that at best can only partially represent a given domain. Furthermore, virtually all tests tap more than one domain. The cognitive constructs are interrelated, and many of the measures themselves are also highly related. These complexities necessitate the use of caution in drawing sweeping clinical or research conclusions based upon limited data and imperfect measurement models, whether conceptually or empirically derived.

Having acknowledged the many complexities involved in cognitive assessment, a sample cognitive assessment battery is provided (see Table 36-3) that includes multiple measures of hypothetical cognitive constructs or domains, with some measures appearing under more than one domain—an indication that these measures have been demonstrated to tap multiple constructs. This sample battery is not exhaustive but is one example of many possible assessment batteries. Nevertheless, it may provide the reader with an idea of measures that are generally accepted to represent cognitive domains of interest.

Activities of Daily Living/Instrumental Activities of Daily Living Assessment

In addition to the many measures available for cognitive assessment, there are also a variety of instruments for examining older adults' ability to perform prototypical everyday activities. Although cognitive assessment is often used as an indirect indicator of functional status, an examination of actual performance seems more ecologically valid. Some examples of such measures include the Observed Tasks of Daily Living (Diehl et al., 1995), the Everyday Problems Test (Willis, 1996), the Timed IADL task (Owsley et al., 2001), Barthel Self-Care Rating Scale (Sherwood et al., 1977), the Physical Self-Maintenance Scale (Lawton, 1971), and the Financial Capacity Instrument (Marson et al., 2000).

COGNITIVE INTERVENTIONS

A primary goal of cognitive aging research is to develop interventions that can enhance cognitive function. Cognitive training protocols have been developed for the improvement of memory, reasoning, and speed of processing, among other abilities (Baltes & Willis, 1982; Ball et al., 1988; Baltes et al., 1995a; Hayslip et al., 1995; Kramer et al., 1995; Neely & Bäckman, 1995; Caprio-Prevette & Fry, 1996; Oswald et al., 1996; Mohs et al., 1998; Edwards et al., 2002). These protocols have demonstrated improvement in a designated cognitive skill when training is employed.

Memory training studies have involved a variety of training protocols and often have used a multifactorial approach (Neely & Bäckman, 1995; Caprio-Prevette & Fry, 1996; Mohs et al., 1998). For example, Neely and Bäckman (1995) conducted a memory training study in which they found transfer of training to recall tasks that were similar but not identical to the training tasks. Similarly, Villa and Abeles (2000) used group sessions to help older adults develop prospective memory, using techniques such as memory strategies, internal rehearsal, relaxation techniques, and behavior modification. After seven sessions, participants showed a significant increase in their ability to remember tasks to be done in the future. Similar studies have shown that training can be used to improve memory for names (Schmidt et al., 1999), short-term memory (De Vreese et al., 1998), and facial recognition (Andrewes et al., 1996).

Several reasoning training studies have been conducted using the protocol from the Adult Development and Enrichment Project (ADEPT) (Baltes & Willis, 1982; Schaie & Willis, 1986; Willis et al., 1992; Willis & Schaie, 1994; Hayslip et al., 1995). The ADEPT training protocol consists of two types of training: figural relations training, which involves teaching strategies to facilitate mental rotation of figures; and reasoning training, which involves teaching different rules or strategies to solve letter series, letter sets, and number series problems. Training studies using the ADEPT protocol have generally found that training results in improvement on tasks similar to the training tasks (Willis et al., 1981). However, training effects do not appear to transfer to abilities that were not the focus of training (Willis & Schaie, 1994).

Roenker and colleagues conducted a study examining the effects of speed of processing training upon driving performance (described in Ball & Owsley, 2000; Roenker et al., in press). Individuals who received speed-of-processing training demonstrated significantly faster processing on the Useful Field of View (UFOV) test: a measure of the speed with which a spatial field can be scanned with a single glance; improved stopping time to road signs while in a driving simulator; and fewer dangerous maneuvers on an open road driving test (Ball & Owsley, 2000). A control group received an equivalent amount of training in a standard driver improvement class but did not demonstrate these gains. These findings indicated that speed-of-processing training transfers to similar measures of processing speed as well as to the functional outcome of reacting quickly to

TABLE 36-3. Sample Cognitive Battery

Cognitive domain	*Suggested measures*
Abstract reasoning (fluid intelligence)	• Mattis Dementia Rating Scale—Conceptualization • WAIS-III Similarities • WAIS Matrix Reasoning
Arithmetic capacity (crystallized intelligence; working memory)	• WRAT-III Arithmetic • WAIS-III Arithmetic
Attention/concentration	• Mattis Dementia Rating Scale—Attention • Trails A • WAIS Digit Symbol Substitution • WMS-III Digit Span • WMS-III Spatial Span • WMS-III Letter-Number Sequencing • Useful Field of View (UFOV®)
Dementia severity	• Mini Mental Status Exam • MOMSSE • Mattis Dementia Rating Scale
Depression	• Beck Depression Inventory • Brief Symptom Inventory—Depression • Geriatric Depression Scale • Hamilton Depression Rating Scale • Center for Epidemiological Studies Depression Scale
Executive function	• Mattis Dementia Rating Scale—Initiation/Perseveration • CLOX 1 (a clock drawing task) • Controlled Oral Word Association Test (COWA) (Letter and Category subtests) • Digit Symbol Substitution • EXIT25 • Trails B • Wisconsin Card Sorting Test
Fine motor function (neural integrity/common cause)	• Halstcad-Reitan Finger Tapping (screening for gross neurologic impairment and/or reduced psychomotor function)
Intellectual function	• WAIS-III VIQ, PIQ, and Full Scale IQ (or prorated IQ) • WAIS-III Processing Speed factor score • WASI Vocabulary and Matrix Reasoning (to form prorated Full Scale IQ)
Language (rule out advance dementia, stroke)	• WAB Auditory Verbal Comprehension • Boston Naming Test • COWA Test (Letter and Category fluency subtests) • WRAT-III Reading
Processing speed	• Useful Field of View (UFOV®) • Letter and Pattern Comparison • Finding As • WAIS Digit Symbol Substitution
Reasoning	• Figural Relations • Letter Series • Raven's Progressive Matrices

TABLE 36-3. Sample Cognitive Battery—cont'd

Cognitive domain	*Suggested measures*
Verbal memory	• Mattis Dementia Rating Scale—Memory (screening) • California Verbal Learning Test (list learning, recall, recognition, error types) • Hopkins Verbal Learning Test (list learning, recall, recognition, error types) • Rivermead (narrative memory) • WMS-III Logical Memory I (narrative memory) • WMS-III Logical Memory II (narrative memory)
Visual memory	• WMS-III Visual Reproduction I • WMS-III Visual Reproduction II
Visuospatial function (rule out stroke, subcortical dementia)	• Mattis Dementia Rating Scale—Construction • CLOX 2 (a clock drawing task) • WAIS-III Block Design

IQ, Intelligence Quotient; PIQ, Performance Intelligence Quotient; UFOV, Useful Field of View; VIQ, Verbal Intelligence Quotient; WAB, Western Aphasia Battery; WAIS, Wechsler Adult Intelligence Scale; WMS, Wechsler Memory Scale; WRAT, Wide Range Achievement Test.

hazardous situations while driving (Ball & Owsley, 2000). Further research using the speed of processing intervention has replicated the finding of improved UFOV performance and has demonstrated that this training also may transfer to improved performance of timed IADLs (Edwards et al., 2002).

It is now clear that specific cognitive functions can be augmented. However, further investigation is necessary in order to confirm whether interventions that target specific mental abilities transfer to concomitant real-world tasks. To date, many cognitive training studies have indicated that improvements may be limited to performance of tasks similar to those used in training. Given these findings, future interventions must examine ways to improve generalization in order to effectively improve everyday functioning.

CONCLUSIONS

Despite the wide range of individual differences in cognitive changes with aging, in the aggregate there are several areas of cognition that decline with age. In particular, short-term memory, speed of information processing, and executive functioning exhibit robust decrements. No matter how cognitive declines are determined, only global measures and a few specific measures have been shown to directly predict concomitant declines in everyday functioning. This trend stresses two important areas for further study. First, cognitive measures used to predict real-world functioning must be carefully evaluated before determination of risk for certain functional losses can definitively be made. Second, a lack of connection between certain cognitive declines and everyday functioning is in itself a testament to the compensatory abilities that older adults develop. These compensatory cognitive skills represent a prime area for further investigation and for utilization in protocols designed to help at-risk elders remain autonomous.

Finally, given what is known about cognitive abilities and their impact on specific mobility functions such as driving, additional interventions targeting cognitive skills related to mobility must be developed and tested. Such interventions are the natural outgrowth of cognitive aging research and provide additional meaning to the careful basic research that continues to guide the field.

■ KEY POINTS

☐ Applied research on normal age-related cognitive loss teaches us that even minor changes in areas such as attention or short-term memory can affect a person's ability to function independently, which in turn can affect quality of life.

☐ Despite a great deal of individual variability with regard to the cognitive changes that occur with age, research supports the contention that there are universal age-related losses in executive function, memory, and information processing speed.

☐ With increasing age, mobility limitations increase in prevalence and are associated with impairments in sensory, cognitive, and physical functioning.

☐ Comprehensive cognitive assessment is essential for answering questions about the cognitive domains underlying functional performance. Selection of a cognitive battery is guided by the research question at hand, the amount of time and expertise required for test administration and interpretation, and the availability of age-appropriate normative data for each test. A comprehensive battery uses multiple measures of each posited cognitive domain or cognitive construct in order to more fully represent the construct and to avoid idiosyncratic, test-specific results.

☐ It is now clear that specific cognitive functions can be augmented. However, further investigation is necessary in order to confirm whether interventions that target specific mental abilities transfer to concomitant real-world tasks.

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