Healthy Cognitive Aging

Caitlin R. Bowman and Kana Kimura

Department of Psychology, University of Wisconsin-Milwaukee

Author note

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Correspondence concerning this article should be addressed to Caitlin R. Bowman, University of Wisconsin-Milwaukee, 2441 E Hartford Ave, Milwaukee, WI 53211, United States. Email: bowman2@uwm.edu

Abstract

While some older individuals develop an age-related dementia like Alzheimer's Disease, many people live to a very advanced age without developing any disease affecting their cognitive abilities. Here, we review what cognitive changes happen in healthy aging and how they differ from pathological cognitive aging.

What is healthy cognitive aging?

Healthy cognitive aging is a term for the normal pattern of cognitive changes that typically starts around age 60-65. It is important for us to understand the types of cognitive changes that are normal so that we notice when someone surpasses those normal changes and may have an age-related dementia like Alzheimer's Disease. It is also important because healthy cognitive aging is the most common form of cognitive aging. In this article, we first define healthy cognitive aging in contrast to two types of pathological aging: Alzheimer's Disease and Mild Cognitive Impairment. We then describe some of the tools that researchers and clinicians use to determine whether someone may be experiencing pathological aging. Lastly, we describe tools for assessing normal cognitive change and what those tools have shown us about how older age affects cognition.

Distinguishing between healthy and pathological cognitive aging

Some cognitive abilities may decline in healthy aging (Blazer et al., 2015, Harada et al. 2013), but the decline is not universal across all abilities, and the degree of decline is not severe enough to require medical intervention. Healthy cognitive aging contrasts with Alzheimer's Disease and Related Dementias (ADRD) and with Mild Cognitive Impairment (MCI) (Gu et al., 2014; Insel et al., 2016). ADRD is the most common form of dementia, and it is caused by brain changes that include accumulation of abnormal proteins and degeneration of neurons (Braak, 2011; Jack et al., 2009; Villemagne et al., 2013). It is characterized by progressive and severe decline in cognitive function that eventually leaves individuals unable to complete daily tasks and care for themselves (Laver et al., 2016). MCI is the stage between healthy aging and dementia, characterized by greater loss of memory function than is typical but otherwise normal cognitive function and activities of daily life (Petersen et al., 1999). Compared to those with MCI and ADRD, those experiencing healthy cognitive aging report higher overall quality of life (Bárrios et al., 2013; Neumann et al., 1999) and can often maintain an independent lifestyle.

How do we know who is experiencing healthy cognitive aging and who may have MCI or ADRD? Because some amount of age-related cognitive decline is normal, it can sometimes be difficult to tell when a friend or family member is showing signs of pathological aging. Further, treatments tend to be more fruitful at early stages of a disease, so it can help to detect a potential ADRD when the symptoms are still relatively subtle. Neuropsychological measures have been developed to distinguish healthy from pathological aging.

The Mini-Mental State Examination (MMSE) is commonly used to test for cognitive impairment and to detect signs of dementia (Table 1; Folstein et al., 1975). It is also used to evaluate the cognitive status of patients with traumatic brain injury (de Guise et al., 2013). The MMSE contains eleven questions assessing several cognitive domains. For example, the orientation section of the exam tests if an examinee knows the date and season and where they are at the time of administration. The recall section tests the ability to recall three words immediately and after a short delay. Advantages of MMSE include its short duration and easy set-up: administration typically takes less than ten minutes and does not require expensive equipment or specialized training. The clinical criterion for cognitive impairment is scoring less than 25 out of 30 possible points, but a low score does not necessarily mean that an individual has dementia. Specialists also need to consider other factors such as physical disabilities, education, language, and cultural differences when interpreting an MMSE score and making follow-up recommendations (Brucki et al., 2011; Kochhann et al., 2009).

The Montreal Cognitive Assessment (MoCA) is another cognitive assessment used to differentiate healthy cognitive aging from MCI (Table 1; Nasreddine et al., 2005). The MoCA contains 30 questions asking an examinee to, for example, draw patterns, follow instructions, and remember a set of words over a brief delay (Nasreddine et al., 2005). While some of the MoCA questions are similar to those on the MMSE, the MoCA is considered more sensitive to detecting the transitional phase between healthy and pathological cognitive aging (Ciesielska et al., 2016; Tsoi et al., 2015). A score of 25 points or less out of 30 points indicates that the examinee may have some degree of cognitive impairment (Nasreddine et al., 2005). The main drawback to the MoCA is that it takes a longer to administer than MMSE. Like the MMSE, a low score on the MoCA is not sufficient to diagnose MCI or dementia and is typically combined with other follow-up measures (Cohen & Klunk, 2014; Hanseeuw et al., 2019; Luo et al., 2022).

Neuropsychological measures to assess normal cognitive function

Even among cognitively healthy people, cognitive abilities can differ substantially. One person may perform exceptionally well on some cognitive tasks while others may perform close to average. How do we know how an individual's cognitive abilities compare to others in the general population?

The Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV; Wechsler, 2008a; Wechsler, 2008b) is an assessment of wide-ranging cognitive abilities. The WAIS-IV is a comprehensive assessment, testing cognitive domains not measured in short assessments like MMSE or MoCA. However, it is also a longer assessment and requires more training to administer. The WAIS-IV provides composite scores in four cognitive areas: **verbal comprehension**, **perceptual reasoning**, **working memory**, and **processing speed**. Each of these abilities is measured through 2-3 subtests (detailed below). Each test starts at a relatively 'easy' level in which most people can answer correctly. Each test gets progressively more difficult, and the examiner stops when the participant no longer answers correctly or when the end of the test is reached. Each score can be standardized to quantify how typical an individual's score is for their age group. The four WAIS-IV components can also be added to derive an overall IQ score (Table 1). Research has shown declines in overall IQ with advanced age (Wechsler, 1944; 1958). However, WAIS-IV scores have also revealed that older age has a larger impact on some areas of cognition than others, which we review below.

Table 1

Neuropsychological assessments of cognitive aging

	What it measures	Important cut-off scores
MMSE	Detects dementia	<25/30
MoCA	Detects MCI	<25/30
WAIS-IV	IQ compared to general population	Mean = 100; Standard Deviation -= 15

Note. Mini-Mental State Examination (MMSE); Montreal Cognitive Assessment (MoCA); Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV); Mild Cognitive Impairment (MCI)

Processing speed and cognitive aging

Processing speed is the time it takes for an individual to perform a cognitive task - the speed in which an individual comprehends and reacts to information they receive. There are two WAIS-IV subtests of processing speed: Symbol Search and Digit-Symbol Coding (Figure 1). For both processing speed tests, participants perform under a time limit and are asked to do the task as quickly as they can without making mistakes. Their scores are based on how many items they complete in the allotted time, accounting for any errors they make.

One of the most robust findings in healthy cognitive aging is that older adults tend to respond more slowly than young adults, even on tasks where they are performing equally well in terms of accuracy (Ghisletta et al., 2012; Park et al., 2002; Ryan et al., 2000; Salthouse, 1998). Declines in processing speed may underlie many other cognitive deficits because slowing disrupts the synchrony among cognitive processes. Imagine a factory where one machine is running slower than the rest - component parts cannot be delivered at the right time, having downstream effects in the overall ability to make a product efficiently. That may be similar to how cognitive slowing can lead to poorer cognitive performance in older adults. Consistent with that idea, age-related slowing becomes stronger as the complexity of cognitive tasks increases (Salthouse & Ferrer-Caja, 2003). Declining processing speed also has real-world impacts: decline in processing speed is a major risk factor for accidents and death associated with driving in older adults (Edwards et al., 2010).

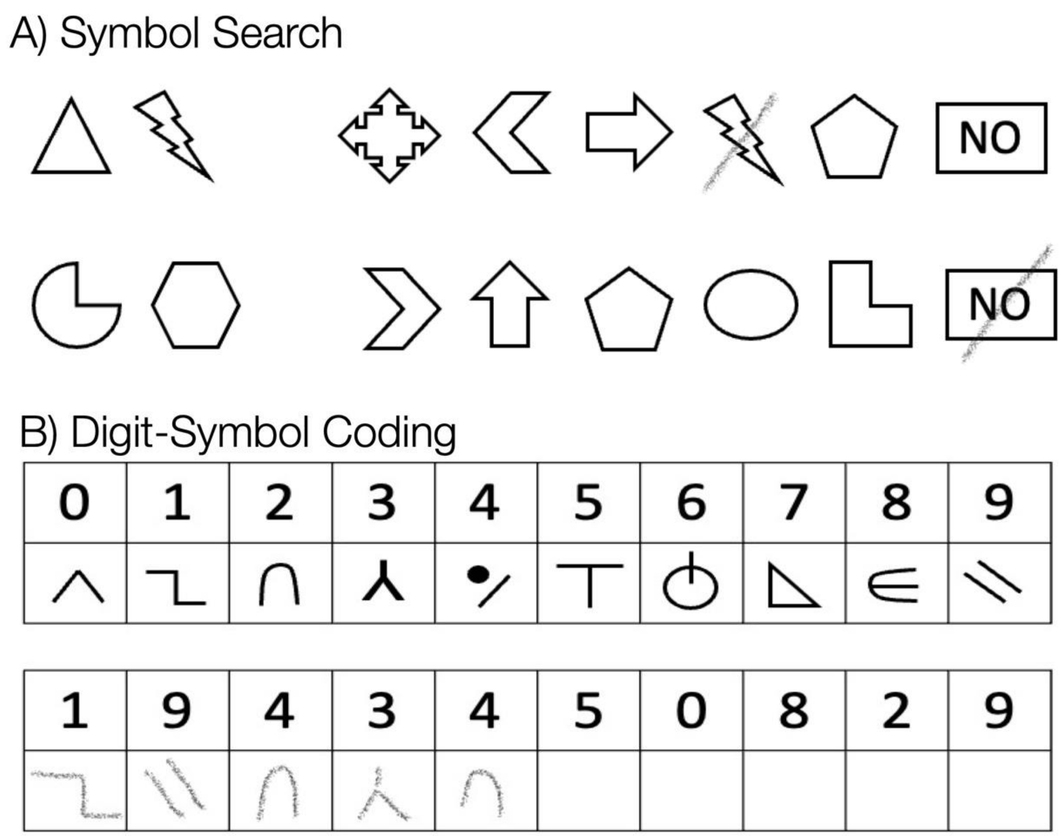

Figure 1. WAIS-IV subtests for assessing processing speed. **A.** In the Symbol Search test, items are presented sequentially in a row. In each row, two target symbols are presented to the left, and a set of five symbols and a “NO” box are presented to the right. Examinees are asked to search for the matched item to the target symbol. If there is a matched item, they draw a line on it. If there is no matched item, they mark on “NO” box. **B.** In the Digit-Symbol Coding test, examinees match symbols to numbers according to a key. They are instructed to copy the symbol into boxes below a row of numbers varying from 0-9. For both tests, examinees complete as many items as they can in 2 minutes.

Working memory and cognitive aging

Working memory is the ability to remember information over short periods of time, typically on the order of seconds or tens of seconds (Angelopoulou & Drigas, 2021; Bhandari & Badre, 2016; Oberauer, 2019). For example, we need working memory to keep a set of numbers in mind while we perform mental math or keep a grocery list in mind while we shop. There are two WAIS-IV subtests: Digit Span and Arithmetic (Figure 2). There are three versions of the

Digit Span test. All versions start with the examiner reading a series of digits aloud. Depending on the version, the examinee either repeats the digits back in the exact same order, in reverse order, or rearranges them to be in order from the lowest number to highest number. For Arithmetic, participants are asked to solve arithmetic word problems without the use of a pen and paper.

Research shows that working memory abilities decline in healthy aging (Bopp & Verhaeghen, 2005; Salthouse et al., 1989; Schneider-Garces et al., 2010). For example, in the aforementioned Digit Span tasks, older adults tend to perform about as well as young adults on the Digit Span forward that involves simply repeating back digits in the same order. However, age-related deficits in performance arise for versions of the task that involve mentally re-ordering the digits (Brown, 2016; Wiegersma & Meertse, 1990). This is explained by older adults' tendency to perform worse when the complexity of tasks increases, such as when there are more pieces of information to remember or when the information needs to be manipulated in some way. These findings have led to the conclusion that older adults have a lower working memory capacity than young adults (Iordan et al., 2020; Salthouse et al., 1989; Schneider-Garces et al., 2010).

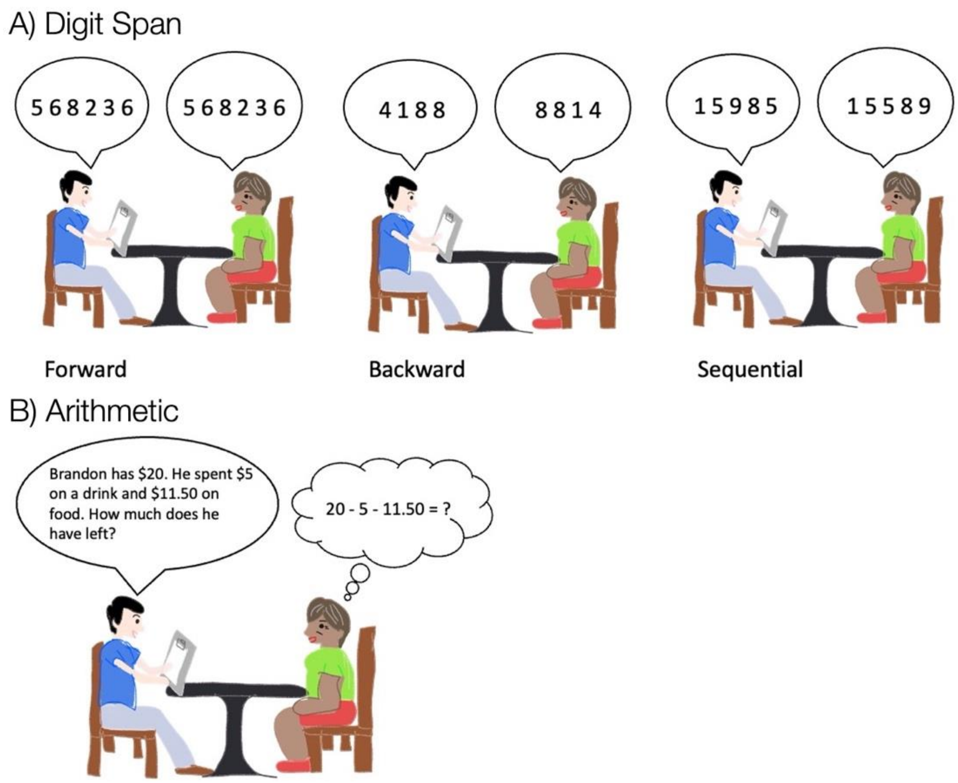

Figure 2. WAIS-IV subtests for assessing working memory. **A.** Across three phases of the Digit Span test, the examiner reads digits aloud and the examinee repeats them back in forward order, in backward order, or rearranges the numbers to be in sequential order. **B.** In the Arithmetic test, the examiner reads math problems aloud and the examinee answers them using mental math.

Perceptual reasoning and cognitive aging

Perceptual reasoning is the ability to take in information and accurately interpret, organize, and find patterns in the received information. There are three WAIS-IV subtests that measure perceptual reasoning: Block Design, Matrix Reasoning, and Visual Puzzles (Figure 3). In Block Design, examinees are presented with blocks having different colored patterns and asked to use them to recreate patterns provided by the examiner. In Matrix Reasoning, examinees are given a partial pattern made up of colored shapes and are asked to indicate which of a set of pieces completes the visual pattern. For Visual Puzzles, the examiner provides a test figure, and examinees pick three pieces that could be combined to recreate the test figure.

Perceptual reasoning abilities tend to decline with age (Mapstone et al., 2003; Rattanavichit et al., 2022). A study investigating age-related differences in WAIS subtests found that scores on Matrix Reasoning reach their highest level at the age of 16 to 17 and start declining at midlife (Ryan et al., 2000). Together with processing speed and working memory, perceptual reasoning is part of what is known as ‘Fluid Intelligence’: the ability to comprehend and learn new information and apply effortful reasoning processes (Tucker-Drob et al., 2022). Fluid abilities tend to decrease with age (Baltes et al., 1999; Lindenberger, 2001), which some have attributed to impaired vision and hearing in older adults (Peelle & Wingfield, 2016; Uchida et al., 2019) that reduces the quality of sensory information that older adults can use to support fluid reasoning (Roberts & Allen, 2016). Others suggest that Fluid Intelligence declines in older age because older adults are more susceptible to being distracted by information that is not relevant for the task at hand (Hasher & Zacks, 1988). Though there are some controversies in the underlying mechanisms of this cognitive change, fluid abilities are often reported to decrease as people age.

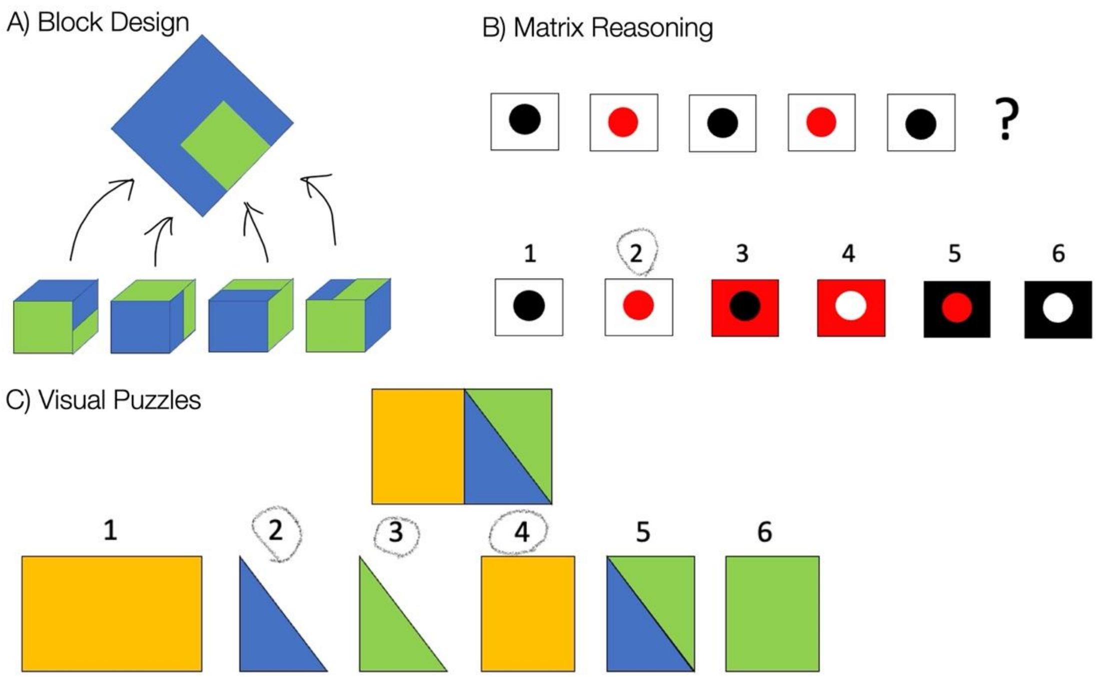

Figure 3. WAIS-IV subtests for assessing perceptual reasoning. **A.** In Block Design, the examinee uses colored blocks to recreate a pattern shown by the examiner. **B.** In Matrix Reasoning, the examinee picks which of six options would continue or complete a pattern. **C.** In Visual Puzzles, the examinee picks three of six shapes that could be combined to look like a pattern shown by the examiner.

Verbal comprehension and cognitive aging

Verbal comprehension is a measure of semantic memory, which is an individual's level of general world knowledge and language abilities. It is measured by three WAIS-IV subtests: Similarities, Vocabulary, and Information (Figure 4). In Similarities, the participant is asked to find a similarity between two words. For example, a similarity between Jamaica and Japan is that they are both island countries, and both winter and summer describe seasons. Vocabulary tests a participant's ability to define words by asking them what words like "orange" and "modify" mean. Lastly, Information consists of general knowledge questions asking about facts from domains such as geography, science, and history. The examiner asks questions like "Who was the first woman to win a Nobel Prize?" and "On what continent is Spain?" Together, these subtests provide information about an individual’s level of factual and conceptual knowledge, which is sometimes termed ‘Crystallized Intelligence’ as a counterpoint to Fluid Intelligence.

Verbal comprehension shows less age-related decline compared to Fluid Intelligence measures and sometimes even shows improvement in older age (Cunningham et al., 1975; Horn & Cattell, 1967; Kaufman et al., 1989; Luo & Craik, 2008). Older adults’ lifetime of experience may help build up a great deal of knowledge, most of which is retained even as fluid abilities begin to decline. Even when age deficits in semantic memory are observed, they may be the result of differences in educational attainment between groups of younger and older people rather than due to the aging process itself, with older generations having less access to higher education that tends to promote general knowledge (Nyberg et al., 1996). Declines in processing speed and sensory acuity may sometimes pose a challenge for older adults’ abilities to understand and/or produce language, but older adults are often able to use context and their wide variety of background knowledge to overcome some of these challenges (Lash et al., 2013; Milburn et al., 2023; Payne & Silcox, 2019). These and related findings have led some to suggest that healthy older adults may be able to use Crystallized Intelligence to compensate for other cognitive deficits (Badham et al., 2016; Mohanty et al., 2016; Umanath & Marsh, 2014).

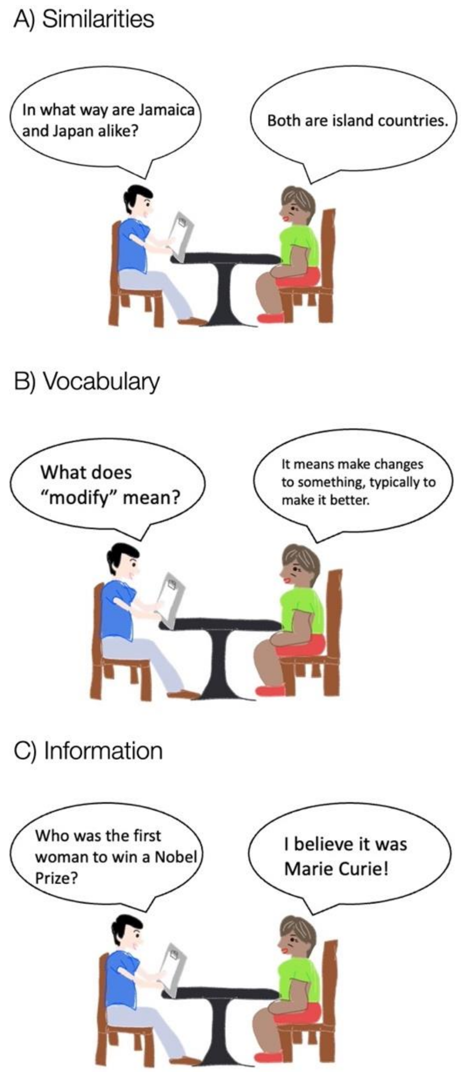

Figure 4. WAIS-IV subtests for assessing verbal comprehension. **A.** In the Similarities test, the examinee identifies a commonality between two items named by the examiner. **B.** In the Vocabulary test, the examinee defines words named by the examiner. **C.** In the Information test, the examinee answers general knowledge questions asked by the examiner.

Summary

Healthy cognitive aging is a form of aging that is distinguishable from pathological aging. Healthy aging preserves the ability to perform many mental processes like learning, decision-making, language comprehension and production, and remembering, albeit sometimes at lower levels of performance than healthy young adults. Some cognitive domains such as processing speed or Fluid Intelligence are more affected by age, while others such as Crystalized

Intelligence tend to be comparable to or better than those of young adults. Being on a healthy aging trajectory is a critical positive predictor of quality of life (Mol et al., 2007). It is very important to know which cognitive domains are most affected by age in order to improve interventions to slow cognitive aging and support older adults in living healthy, independent lives.

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