Chapter 8

Cognitive Aging

Neyda Ma Mendoza-Ruvalcaba,
Elva Dolores Arias-Merino,
María Elena Flores-Villavicencio,
Melina Rodríguez-Díaz and
Irma Fabiola Díaz-García

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Abstract

The study of cognitive function in gerontology is considered relevant because it is an important risk factor for other pathologies in the old age, such as physical disability and dependence, depression, and frailty, mainly because of early pathological changes in cognitive function which are considered a preclinical state that may progress to dementia. In this chapter, cognitive functioning and the dimensions that are included in it (attention, memory, meta-memory, processing speed, executive functions, visuospatial skills, and language) are conceptualized. Additionally, the current evidence is analyzed regarding age-associated changes that are experienced during cognitive aging. These changes, or cognitive decline, are distinguished from those that are part of cognitive pathologies, the most common mild cognitive impairment and dementia. Such pathologies are conceptualized based on the current diagnostic criteria, and controversies and challenges are discussed. Additionally, we analyze the risk factors for cognitive functioning in aging, both modifiable and nonmodifiable ones. A review of the main nonpharmacological intervention techniques used from the gerontology approach is made. It includes the cognitive training in the case of age-related decline or techniques of stimulation and cognitive rehabilitation in the case of mild cognitive impairment or dementia. Finally, we conclude with an analysis of the current state of this topic in the field of gerontology and its relevance in professional practice.

Keywords: cognitive aging, age-related decline, mild cognitive impairment, dementia, cognitive intervention

1. Introduction

Population aging is a global reality that is happening in a gradual and unavoidable manner, as a result of the low birth rate and mortality in the population, and at the same time, due to

the increase in life expectancy. However, aging is not only a population phenomenon but also an individual reality [1], which involves a series of changes in people at biological, psychological and social levels. In the psychological field, changes in the domains related to personality, affectivity, emotions, emotional control, and interpersonal relationships have been reported [2].

Regarding cognitive functioning, the changes that occur during aging are of increasing interest for gerontology because of the implications they could have in case they finally appear in their most pathological form: dementia.

Historically, the research of cognitive functions has its epistemological origin in the studies carried out by the philosopher Galenus, who argued that in the ventricles of the brain, the consciousness of the human being was found as a set of different capacities: perception, intellect, and memory. From the philosophy of Rene Descartes (1596–1650) arises the neurophysiological theory, which defined the relationship between body and spirit and tried to find the explanation of mental function in the ventricles as the basis of psychic functions, later setting the pineal gland as related to mental disorders.

Later, Flourens (1794–1867) argued that all neural tissues are involved in the different cognitive functions. But it was until Gall's studies (1758–1828) with his Frenology theory, that on one side, cognitive functions were associated with structures by examining the skull, and on the other side, the role of the cerebral cortex in relation to cognitive functions was presented. It was until the nineteenth century, with the establishment of the neuropsychology, when the correlation of anatomo-clinical structures with the alterations in cognitive functions was clearly set up [3, 4].

During the nineteenth century, the first stage of neuropsychology was established. Its study object is the relationship between the cerebral organization and the behavior in its broadest sense: actions, emotions, motivations, and social relations. The unit of analysis of neuropsychology is the individual, including his personal history, and his social and cultural environment. The founders of this approach are Luria, Vygotsky, and Leontiev, with the concern of locating psychological functions within circumscribed parts of the brain, defined higher mental human functions as complex reflex-like processes of social origin whose functioning is both conscious and voluntary and are possible due to their structure and functioning [5]. Later, in 1981, Luria proposed that cognitive functioning analysis should be done by looking for what is located outside the individual, the place where the origins of conscious activity are found. He also developed the idea that several macroanatomical areas and brain regions help each other to ensure control of the so-called human cognitive functions [6]. The cognitive psychology perspective studies the cognitive functioning as the way to know the world, through the construction of reality guided by experience. From there, the cognitive structure is formed and the concept of a cognitive scheme arises [7].

Piaget's theory can be found under this perspective, where the study of structures is left aside to focus on the development of cognitive functioning and its schemes, from a constructive approach of knowledge that at the same time disproves empiricists and innatists theories, based on a psychogenetic perspective [8].

Neuropsychology is a discipline with an integrative view, which today contributes decisively to our knowledge about how the brain and the alterations of its functioning work, focused on the cognitive development in relation to sociocultural factors.

The conceptualization of cognitive functioning functions had several meanings.

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Cognitive functioning has been defined as an evolutionary process in which individuals are immersed, which begins in fertilization and ends in death. In this process, both the organism in general and the nervous system in particular experience a series of changes that, in interaction with the environment, enable the development and maturation of both the nervous system itself and the behavior [9].

A more integrative view of mind-brain relationships defines the cognitive functions as functional interactions within and among cortical networks, which in turn are distributed throughout the cerebral cortex as memory, attention, perception, language, and intelligence; all sharing the same structure [4].

From another perspective, cognitive functions come from the information processing activity in neural networks distributed along the cortex and represent past and future schemes of action. This perspective suggests that temporal organization affects perceptual processes, action, and cognition within a sequence designed to achieve a goal [10].

From a psychopedagogical framework, complex cognitive functions consist of the organizing and sequencing of plans, the ability to respond to various stimuli at the same time, cognitive flexibility, the ability to respond according to the context, resistance to distraction, and inhibition of inappropriate behaviors [11].

From Piaget's theoretical position, cognitive functions are considered as the mechanisms of information processing, which main function is to transform the internal and external stimuli into inputs for development and, in addition, to provide the individual with tools to face the positive entropy, and also the trend to exhibit states of thermodynamic equilibrium [12].

From the point of view of the structural cognitive modifiability theory, the cognitive functions are classified as perceptual thinking (basic functions), strategic (executive functions), analogical (educational functions), and reflexive (meta-cognitive functions) according to the last generation of the constructivism paradigm [13].

Finally, from the neuropsychology perspective, the different components of cognitive functions are defined as the abilities developed by brain structures that allow them to work with the information that is acquired from the environment. These cognitive abilities are divided into two groups: those known as basic cognitive functions such as sensation, perception, memory, attention and concentration; and higher cognitive functions such as thought, language, and intelligence, which are considered complex systems and also group different functions [14].

2. Age-associated changes

During the last decades, several scientific efforts have been focused on the study of normal cognitive aging. This has resulted in agreements, as well as numerous discrepancies around the topic, mostly regarding the use of different research methodologies, as well as the little control of other variables that are considered to be closely related to cognitive functioning.

In addition, finding differences between normal cognitive aging and a cognitive impairment involving pathology is clinically difficult, since the limits of diagnosis are not precise.

This task becomes even more complicated if these differences are also associated with other variables such as age, schooling, and other population differences [15].

The concept of cognitive functioning in normal aging has been defined as "the functioning of the cognitive system, either in adaptation or alteration, which can generate a regression or successful management of the functions of daily life in older adults" [16].

The study of the changes that occur in the cognitive domains has found a close relationship between the physiological and social aspects. On one hand, research focused on the study of the human brain through different techniques (brain mapping, electroencephalogram and cerebral magnetic resonance among others) has reported that the mechanism behind successful cognitive aging may be the preservation of the hippocampal function combined with a high responsiveness in the frontal area [17].

Likewise, studies developed with electroencephalogram and neuropsychological tests found a reduction in age-dependent cerebral electrical power in cortical areas such as the parietal, temporal, and occipital lobes, causing a decline in functions such as memory, attention, visuospatial skills, and processing speed, concluding that the physiological aging of the brain is characterized by a loss of synaptic contacts and neuronal apoptosis that causes a dependent decline in sensory aspects, processing, motor performance, and some cognitive functions.

On the other hand, Steffener et al. [18] conducted a study which reported that cognitive changes during normal aging are due to the slow decrease across different ages of cerebral blood flow and the gray matter volume, mainly in areas such as the prefrontal cortex and the temporal convolutions of the putamen and occipital regions. On the other hand, the social aspects that have been described in different longitudinal studies and were related to the changes of the cognitive functioning in older adults are the schooling, the good health, the social participation, the lifestyle, and the genetic factors [17, 18].

It should be pointed out that socioenvironmental variables can contribute to an individual's cerebral aging and therefore modify his cognitive and behavioral profile. This causes that while some of these factors can affect negatively, precipitating cognitive deterioration in normal aging, others can soften or even slow their effects.

To recognize which cognitive functions normally decline in older adults and when they occur is a complicated task, however, research has agreed that the domains generally involved in it are attention, verbal memory, visuospatial and visuoconstructive skills, processing speed and some of the executive functions such as inhibition, working memory and mental flexibility, while functions such as semantic memory and language are preserved, and even the latter can improve over the years [19–21].

Attention is a complex, dynamic, multimodal, and hierarchical functional system that makes easier the processing of information, selecting the relevant stimuli to perform a certain sensory, cognitive, or motor activity [21]. According to data, cognitive changes are particularly difficult for older adults, mainly in activities that involve orienting them between several elements or constantly changing between different successive testing options, due to the decrease in selective visual attention, which in part is due to the degradation of sensory processing.

It is important to emphasize that attention control is related to other cognitive functions such as processing speed, which suggests that older adults are less involved in tasks of anticipatory attentional resources due to the slower reaction time during aging [22].

Changes associated with age have been studied from the different domains of cognitive functioning.

Memory is a neurocognitive function that allows us to record, encode, consolidate, retain, store, retrieve, and evoke information [21]. This cognitive function has a sequence of three types of memory, from sensory to short-term (which is a transitory, fragile and sensitive storage to interfering agents) to long term memory (responsible for the more permanent storage of information and involves a process of consolidation); each have their own particular mode of operation but they all cooperate in the process of memorization and can be seen as three necessary steps in forming the lasting memory. There are also three main processes involved in the human memory: encoding, storage and recall (retrival) [23].

Memory is one of the most studied cognitive domains because it is a frequent complaint that older adults make during normal aging. Kral's research since 1962 has led to evidence of the existence of a slowly progressing memory loss characterized by the inability to remember, sometimes relatively unimportant parts of the experiences of the past. The affectation of this domain in its processes of acquisition, consolidation, and spontaneous evocation is related to the cerebral biological functioning that will depend on variables such as quality of life.

Regarding the different types of memory, aging has a significant effect, on one hand, on the decline of immediate and episodic memory rather than on semantics and, on the other hand, on evocation rather than consolidation. Aging also affects the codification of new information, especially when strategic processing is needed [24].

Perception is the mental capacity that allows us to integrate and recognize through our senses. It allows us to recognize those objects to which we pay attention and to create our own knowledge patterns. In that sense, there must be an encounter between the sensorial information and the memory files that leads to the perception or interpretation of reality.

It is often difficult to dissociate spatial skills from constructional ones, being the latter defined as the ability to integrate elements into an organized whole (examples of these skill are copying geometric figures and the construction with cubes), since it requires the handling of space. According to the Pan-American Health Organization, changes in these cognitive functions in aging are due to the decline of visual acuity and processing, which causes problems of sensitivity to illumination and vision difficulties in poorly lit places, problems to distinguish colors, to focus at different distances and deficits related to spatial perception in general.

The executive functions (or meta-cognitive processes) would be those processes involved in the planning and supervision of cognitive processing. The term "executive" encompasses a series of cognitive processes, including updating and tracking information and inhibiting responses [24].

This kind of functions could be understood as a set of high-level operations that sequence and control the basic operations and, at the same time, make decisions in the moments of choosing among alternatives. Because they are linked with other cognitive functions, it is difficult to evaluate them in a specific way. At the same time, it is more complicated to find tasks that refer only to the performance of each one of them.

Some of the tasks that have been considered as executive functions are the working memory, the majority of everyday cognitive tasks that require the establishment of goals, the implementation and follow-up of the operations to reach those goals, and both the checkup of each one of these operations and of the fulfillment of the final purpose; their relevance could be used as evidence of the importance of executive functions in the lives of people [25]. In normal aging, it has been found that changes in executive functions are mainly observed in: working memory, when keeping information available for a short period of time; in inhibition, because over the years, more problems to concentrate on relevant information are experienced and inhibit attention to irrelevant aspects, in addition inhibitory processes are less efficient to allow the initial entry of information into the operational memory and in mental flexibility [26].

Processing speed has been defined as the reaction time that produces a global effect on cognition [27]. It is one of the functions in which a decline has been found as part of normal aging, and it has even been associated with the cause of cognitive changes in other domains such as care and executive functioning.

Moreover, as a cognitive task becomes more complex, older adults may not have the necessary resources of mental operations to carry out the later phases of it because cognitive functioning is slower and sometimes does not allow them to complete some mental operations that are needed for a correct final task performance [28]. Other studies compared two groups, one of young adults and other of older adults, and applied neuropsychological tasks to measure executive functioning and found a lower performance in inhibitory control, abstraction, and working memory but not the rest of this kind of functions [29].

The subjective perception of adults about their cognitive functioning (also called meta-memory) is another factor that significantly influences the activities of daily living (ADL) during aging, a recent study showed that a third of the evaluated population reported memory problems, thinking skills, and their ability to reason, all of them associated with their overall health [30].

Finally, it is important to note that the cognitive changes that occur in normal aging are presented as a slight decline and do not interfere with the level of independence during aging; if these changes appear in the opposite way, it is possible to suspect deterioration or cognitive change related to a pathology.

3. Mild cognitive impairment and dementia

In cognitive aging, there is a decline which is considered normal. Some cognitive functions remain stable while others decline as part of normal aging. These cognitive changes associated with age occur to people who do not have pathologies that affect memory or cognitive abilities, and these changes do not interfere with the ability to participate in everyday activities. However, cognitive changes in aging can have a wide range, from those that are normal to those that are pathological, and between these there may be a series of intermediate changes. This transition state is known as Mild Cognitive Impairment (MCI) [31].

The construct of Mild Cognitive Impairment (MCI) has been extensively used worldwide, both in clinical and in research settings, to define the gray area between intact cognitive

functioning and clinical. The MCI intends to identify this intermediate stage of cognitive impairment that is often, but not always, a transitional phase from cognitive changes in normal aging to those typically found in dementia [32]; in this sense, MCI is considered a predemential syndrome [33].

In 2013, the American Psychiatric Association (APA) proposed new criteria for dementia in the fifth edition of the Diagnostic and Statistical Manual for Mental Disorders (DSM-5) and recognizes the predementia stage of cognitive impairment [34]. The condition, which has many of the features of MCI, is known as mild neurocognitive disorder (NCD). Mild NCD recognizes subtle features of cognitive impairment that are different from aging but do not represent dementia. Furthermore, mild NCD focuses on the initial phases of cognitive disorders and precedes major NCD that is analogous to the previous diagnosis of dementia.

There are several subtypes of MCI, which differ according to the type and number of impaired cognitive abilities, the most common is the amnesic which mainly involves memory problems, while in the nonamnesic, memory operation is not compromised. Likewise, when only one dimension of cognitive functioning is affected, it is called DCL of a domain or multidomain if more than one cognitive ability (e.g., memory, reasoning, executive functions, etc.) is affected [32]. These MCI subtypes are usually related to different pathological processes, for example, it has been found that people with amnestic DCL are more likely to progress to Alzheimer's disease (AD) [35, 36], while people with nonamnestic MCI are more likely to develop Lewy Body Dementia [36].

According to this definition, MCI is operationalized based on clinical data of changes in cognitive abilities (see **Table 1**). The subjective cognitive complaint needs to be confirmed by objective cognitive measures, such as neuropsychological test batteries. Objective cognitive impairment is defined as a poor performance in one or more cognitive measures, which suggests deficits in one or more cognitive areas or domains. There is no gold standard to specify which neuropsychological test battery to use, but it is important that all the main cognitive areas are examined. Typically, executive functions, attention, language, memory, and visuospatial skills are taken into account. Functional abilities are investigated by means of a thorough interview with the person and with the next of kin and registered in terms of activities of daily living (ADL) and instrumental activities of daily living (IADL) scales [32].

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It has been shown that a significant proportion of people with MCI progresses to dementia in periods of 1–2 years and approximately 50% progresses toward dementia over a 5-year period [37].

	Normal aging [31]	Mild cognitive impairment [32]	Dementia DSM-IV [41]	Major neurocognitive disorder DSM-5 [34]
Memory	Absence or presence or memory complaints Normal objective memory according to age. Memory problems are gradual, do not worsen suddenly	Subjective cognitive complaint, raised by the patient or an informant, or observations made by the clinician	A1. Memory impairment	A. Evidence of significant cognitive decline from a previous level of performance in one or more cognitive domains: • Learning and memory • Language • Executive function • Complex attention • Perceptual-motor • Social cognition
Other cognitive functions	Normal cognitive functioning according to age	Objective cognitive impairment in one or more cognitive domains preferably relative to appropriate normative data for that individual	The course of deterioration is characterized by a gradual onset and a continuous cognitive impairment. A2. At least one of the following: • Aphasia • Apraxia • Agnosia • Disturbance in executive functioning	Evidence of decline is based on: Concern of the individual, a knowledgeable informant, or the clinician that there has been a significant decline in cognitive function; and a substantial impairment in cognitive performance, preferably documented by standardized neuropsychological testing or, in its absence, another quantified clinical assessment.
Activities of daily living (ADL)	Preservation of functional independence	Preservation of functional independence	B. The cognitive deficits in A1 and A2 each cause significant impairment in social or occupational functioning and represent a significant decline from a previous level of functioning	B. The cognitive deficits interfere with independence in everyday activities. At a minimum, assistance should be required with complex instrumental activities of daily living
Associated pathologies	No dementia	No dementia	C. The cognitive deficits do not occur exclusively during the course of delirium	C. The cognitive deficits do not occur exclusively in the context of a delirium D. The cognitive deficits are not better explained by another mental disorder

Table 1. Comparison of the different diagnostic criteria in normal aging, mild cognitive impairment and dementia (according to DSM-IV and DSM-5).

Dementia is a NCD that usually begins gradually and has a progressive course. It can be variable, and there is often a long period of time between the occurrence of the first signs of cognitive impairment and the moment they meet the criteria for the dementia diagnosis [38].

The American Psychiatric Association (APA) introduced in 2013 the term "Major neurocognitive disorder" replacing the term "dementia," defined as a decline in mental ability severe

enough to interfere with independence and daily life [34]. However, not all the care professionals and organizations are likely to use the new term. Currently, the Alzheimer's Association, for example, uses the term *dementia* instead of *neurocognitive disorder*. See criteria in **Table 1**.

Globally, around 47 million people have dementia, with nearly 60% living in low- and middle-income countries, and there are 9.9 million new cases every year; Alzheimer's disease is the most common cause of dementia and may contribute to 60–70% of cases. The estimated proportion of the general population aged 60 years and over with dementia at a given time is between 5 and 8 per 100 people. The total number of people with dementia is projected to near 75 million in 2030 and almost triple by 2050 to 132 million. Much of this increase is attributable to the rising numbers of people with dementia living in low- and middle-income countries [39]. The most common forms of dementia are Alzheimer's disease and vascular dementia (VD) [40]. **Table 1** shows a comparison of diagnostic criteria in normal aging, mild cognitive impairment, and dementia.

4. Risk factors for mild cognitive impairment and dementia

Science has gradually shown which risk factors (RF) for MCI and dementia can be currently considered. The knowledge of RF for these pathological processes plays an important role in its prevention. Ideally, prevention strategies should target people who are not even symptomatic [42]. Prevention of dementia is a public health priority [43].

In the health sciences field, a RF is the probability of suffering a certain disease, having a complication or dying [44]. In this paper, we will present some of the most recognized RF, classifying them according to their origin in social, biological, and psychological and by their nature in modifiable and nonmodifiable (see **Table 2**).

4.1. Biological factors

4.1.1. Vascular disorders

Regarding blood pressure (BP), both high and low BP have been linked to cognitive impairment and dementia [45]. The role of cerebral blood vessels in the wide spectrum of pathologies underlying cognitive impairment highlights the importance of vascular structure and function in brain health [46]. The pathophysiology of the relationship between BP and cognition

Risk factors	Modifiable	Nonmodifiables
(A) Biological	Vascular disorders	Genetic
	Metabolic disorders: diabetes mellitus	Brain injuries
(B) Psychological	Depression	—
(C) Social	Education	Age
	Intellectual commitment	Sex

Table 2. Risk factors for MCI and dementia.

is unclear, but hypoperfusion and neurodegeneration have emerged as potential underlying mechanisms [45, 47]. Results from a longitudinal study as part of the Kungsholmen Project [48] showed that low diastolic pressure predicted the risk of dementia among very old people. In the study, blood pressure showed a substantial decrease for approximately 3 years before the dementia syndrome became clinically evident [45].

In contrast, cohort studies have found that elevated blood pressure levels in the middle age may increase the risk of dementia in advanced age. As a result, the exposure to four risk factors related to BP: smoking, hypertension, high cholesterol, and diabetes in the middle age increased the risk of dementia in old age compared to only having one of the risk factors [49]. This relationship between blood pressure and the risk of dementia may depend on the age of patients when blood pressure is measured, as well as the time interval between blood pressure and dementia assessments [50, 51].

4.1.2. Metabolic disorders: diabetes mellitus

Diabetes mellitus (DM) is associated with a dementia risk of 1.5–2.5 times higher among old adults in the community. DM is a significant risk factor not only for vascular dementia but also for Alzheimer's Disease. The mechanisms that support this association are unclear but may be multifactorial in nature, such as cardiovascular risk factors, glucose toxicity, changes in insulin metabolism, and inflammation [52].

Both hyperglycemia and hyperinsulinemia, as part of the metabolic process leading to DM type 2 (DM2), are associated with cognitive dysfunction and dementia due to stroke. This is often accompanied by other mental function disorders, such as depression or anxiety [53]. An epidemiological study showed that the incidence rates of hospitalization for VD in adult aged 70 years and over were twice as high in patients with DM2 as in those who did not presented it [54].

4.1.3. Genetic factors

Genetics clearly plays a role in AD, both in early and late onset. Early-onset AD or beginning before age 65 years can be caused by one of the more than 200 sequence variants in the genes of the beta amyloid precursor protein, presenilin 1 (PSEN1), or presenilin 2 (PSEN2) [55, 56]. Despite the consistent genetic basis for AD, significant variability in onset age has been observed, suggesting an important role of environmental factors or genetic modifiers in determining the onset age [56]. Late-onset AD is also heavily influenced by genetics, although the Mendelian pattern of inheritance is often unclear. There are several factors that could explain this, even if causal mutations exist [57]. Late-onset AD is complex, and apolipoprotein E is the only genetic risk factor unanimously accepted for its development. Several genes involved in AD have been identified using advanced genetic technologies; however, there are many additional genes that have not been identified [58].

Related to this, a long research that analyzed the Genealogical Index of Familiarity up to 14 generations showed that the pairs of people with family ties who died of AD were significantly related. The relative risk for AD death among the relatives of individuals who died of AD increased significantly for close and distant relatives [57].

4.1.4. Previous brain injuries

A new area of interest involves understanding the effect that head trauma has on the behavior and cognitive abilities of brain aging. This issue becomes even more important as the geriatric population grows [59].

Traumatic brain injury (TBI) is an injury in which effects could be devastating often resulting in lifetime cognitive deficits [60]. More than 70% of people with TBI report memory deficits [61]. Contact sports are a source of recurrent TBI. Athletes whose last concussion was in early adulthood (more than 30 years before examination) were reported to have poorer episodic memory and poorer response inhibition, as well as significantly reduced movement speeds in neuropsychological tests, when compared with same-age athletes without a history of concussion [62]. Regarding the cognitive aging process, the evidence showed that cognition problems exhibited by young adults after severe TBI are similar to many cognitive weaknesses in attention deficit and poor working memory of an elderly population with no neurological history. There is evidence that TBI can result in decreased cognitive reserve that can accelerate the cognitive decline normal process, leading to premature aging, potentially increasing the risk of dementia [63].

4.2. Psychological factors

4.2.1. Depression

Depression can affect cognitive functions and may emulate cognitive impairment. It can be considered comorbidity, a prodromal factor or a consequence of vascular cognitive impairment, more than a factor that specifically alters vascular physiology or neural health, leading to cognitive impairment [64]. Some studies have concluded that depressive symptoms are associated with cognitive impairment; however, the mechanisms underlying the association between these two common conditions need further exploration. It is unclear whether cognitive impairment over time can be explained by depression or it is just a sign of an incipient dementia [65].

4.3. Social factors

4.3.1. Age and sex

Through studies results, the age and sex of the individuals have been considered as risk factors of mild cognitive impairment and dementia. Some studies have reported that the prevalence of dementia increases exponentially with age [66] and doubles every 5 years after the age of 65 years. Several studies showed an increasing prevalence among the older age groups [67, 68]. In higher income countries, prevalence is 5–10% among those over 65 years [68]. Regarding sex, there are results in which dementia is higher in women than in men [68, 69]. One possible explanation for this is that women live longer than men [68]. However, recently, another cohort study reported that both the prevalence and the incidence were higher in men [69, 70].

4.3.2. Education and intellectual commitment

Dr. James A. Mortimer was one of the first to propose a relationship between years of formal education and risk of dementia. He suggested that education can be a protective factor against

dementia, raising the level of "intellectual reserve." Regarding this, a systematic review of the literature on the relationship between education and dementia in the last 25 years concluded that lower education was associated with an increased risk of dementia in many but not all studies.

Education associated with the risk of dementia showed different results according to the population, and the years of education did not uniformly reduce the risk of dementia. It seems that a more consistent relationship with dementia occurred when the years of education reflected cognitive ability, suggesting that the effect of education on the risk of dementia can be better assessed in the context of a life development model [71].

In addition to this, occupations performed during lifetime that did not require complex cognitive processes or stimulants seem to be associated with an increased risk of dementia. For example, when studying a group of nuns (average 54 years of age), a strong association was found between low educational and occupational levels with dementia. The risk of dementia increased in those participants with poor education, without professional training and who had never been in charge of a leadership position. These findings support the hypothesis of the benefits of having a cognitive reserve capacity against the consequences of brain diseases [72]. In this sense, it was reported that university preparation represented a lower risk of dementia among five categories, where illiterates showed the highest proportion of individuals with dementia, while the lowest proportion was found in university students [73].

5. Intervention in cognitive aging

Broadly speaking, research on cognitive aging shows a gradual decline scenario, which may or may not be normative, and is associated with age and previously identified risk factors. The progression from normality to pathology is a concern in the health sciences field due to the negative implications that mild cognitive impairment and dementia have on people's lives.

This is why gerontology has focused on the study of nonpharmacological intervention techniques that promote the improvement or maintenance of cognitive functioning at a level that allows people to lead a functional and disability-free life associated with cognitive pathologies. The main conceptual basis for nonpharmacological intervention on cognitive functioning in aging focuses mainly on the concepts of brain plasticity, brain reserve, and cognitive reserve.

Under the concept of brain plasticity [74], in the last 25 years, evidence has been presented to support the idea that the brain is far more flexible in structure and function than it was previously believed. Brain plasticity refers to the extraordinary ability of the brain to modify its own structure and function following changes within the body or in the external environment. Although it is stronger during childhood, it remains the fundamental and significant lifelong property of the brain during aging. Brain plasticity is implicated in learning abilities and plays a fundamental role in degenerative brain disorders. Recent research suggests that the pathology of the Alzheimer's disease, for example, is associated with the loss of plasticity.

The brain reserve is related to neurobiological aspects and it has a more passive approach, since it refers to the size and number of neurons that a person has after a brain injury.

Finally, the cognitive reserve has been defined as the adaptation of the brain to an injury situation using pre-existing cognitive processing resources or compensation resources through the activation of neural networks [75]. The cognitive reserve allows better tolerance of the effects of the disease associated with dementia, supporting a greater amount of neuropathologies before reaching the symptoms of the disease. The cognitive reserve influences the manifestation of the symptoms of cognitive impairment and, at least partially, in its development toward dementia [76]. People with MCI and low reserves show a steeper decline early in the process of deterioration, compared to the high level of reserve this marked deterioration would have at the end of the process, due to the protective role of this reserve [77].

The intervention for the optimization of cognitive functions is based on these concepts to implement nonpharmacological treatments, in order to overcome the challenges of cognitive changes associated with aging, prevent pathologies such as MCI and dementia, and, finally, if it is necessary, alleviate their effects.

According to the British Psychological Society [78], there are a variety of nonpharmacological treatments and interventions which can help people to maintain good mental health, especially after diagnosis of MCI or dementia. Psychosocial interventions can help the diagnosis of dementia, reducing stress and improving mood (such as anxiety or depression), improving and maintaining cognitive functioning, and promoting quality of life in general. Specifically, treatments for improving and maintaining cognitive functioning in aging are Cognitive Training, Cognitive Stimulation Therapy, and Cognitive Rehabilitation that have significant differences in terms of their purpose, target population, duration, and management.

The Cognitive Training, also called Brain Training, involves specific aspects of memory and other cognitive skills. Since it is not personally tailored, regular pastimes such as crosswords, Sudoku, games, or exercises on a computer would also count as cognitive training. Cognitive training is for anyone who wants to keep his brain active and enjoys brain training games and puzzles, including people living with dementia. Exercises are designed to train specific functions, such as memory of words, logic and reasoning, attention, problem solving, and mathematics. Training could be a regular activity done continuously and can be self-administered [78].

Cognitive Stimulation Therapy (CST) is a group therapy that is used to help strengthen personal communications skills, thinking, and memory. CST groups run for a limited number of sessions (usually 12–14, one or two per week). As a complement, the maintenance cognitive stimulation therapy (MCST) groups continue indefinitely and aim to maintain the benefits that CST groups provide. CST and MCST are suitable for people with diagnosis of mild cognitive impairment or dementia in mild-to-moderate stages. A typical CST session lasts for 1 hour and may involve games, singing, applying reminiscence therapies, sharing stories, discussing current events, practicing arts, and making crafts. CST has shown to be beneficial for cognition and quality of life, and it is also cost-effective. Additionally, if CST is followed by MCST, it offers a significant improvement in cognitive function providing long-term benefits [79].

On the other side, cognitive rehabilitation is an approach to manage the impact that dementia-related difficulties, such as problems with thinking and memory, can have on everyday life. It is recommended for people who have early-onset dementia. Cognitive rehabilitation is not about curing or reducing dementia-related difficulties with thinking and memory, instead it

is about learning ways of compensating these difficulties or managing them better. Many cognitive rehabilitation programs could involve families and careers. Usually, it is implemented by gerontologists, occupational therapists, clinical psychologists or clinical neuropsychologists [78]. Cognitive rehabilitation mainly focuses on identifying and addressing individual needs and goals, which may require strategies for taking in new information or compensatory methods such as memory aids, and has provided preliminary indications of its potential benefits in improving activities of daily living in people with mild Alzheimer's disease [80].

Any kind of cognitive intervention should be based on a previous diagnosis, including two types of assessment. The first should be a screening (usually with the Mini-Mental State Examination), and the second is an in-depth evaluation (with standardized tests in the sociocultural context, according to age and schooling) of the performance of the individual in different cognitive tasks. From the diagnosis results if the person shows a "normal" or intact performance, meaning that he preserves his cognitive functions as expected to his age and schooling in their context; or it presents a significantly inferior performance that can be classified as slight cognitive impairment and in case of suspected dementia. This previous evaluation is needed to take the decision of whether an intervention is necessary and what kind is required, what aspects should be developed on and what capacities should be promoted [81].

The objectives of intervention programs based on training and/or cognitive stimulation are generally set out in terms of "improving, maintaining, strengthening, and restoring." While in programs based on cognitive rehabilitation, the objectives are defined in terms of "compensate."

Once the type and purpose of the treatment have been selected, during the planning of the cognitive intervention, basic methodological aspects must be considered, in order to systematize the steps involved in the process. These guidelines include [82]: (1) Systematic organization of the session and its activities, (2) progression, starting with easy and continue with difficult activities, (3) intensity, with a suitable and adapted rhythm, (4) logic and sense, with meaning and actual sequence, (5) the activities should be interesting, (6) motivation, curiosity, and desire to learn, (7) the activities should be gratifying, (8) personal and emotional involvement, the elements of the process should have a pleasant and emotional sense, (9) the elements of the process should promote the interpersonal relationships of people with their environment.

As a basic guideline during the intervention work, it is recommended to maintain a routine through a structured session, in this sense, as part of the training and/or cognitive stimulation a session scheme is proposed. It includes the following elements, not necessarily in this order:

1. Orientation to reality (personal, spatial and temporal) [81].
2. Attention/concentration technique.
3. Relaxation technique.
4. Psycho-educational technique, knowledge and theoretical information promote the improvement of the perception of memory.
5. Practical training in the use of mnemonic strategies adapted to the needs of the person (see **Table 3**).
6. Feedback and closure. Always ask: How does this help me in everyday life?

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Strategies	Technique	Definition and examples
Internal	Organization/categorization	It consists of establishing categories of data or information grouping it based on their common characteristics. (e.g., grocery lists according to the type of food, color, location in the kitchen)
	Visualization	Based on the ability to recreate visual mental images. (Ex: visually imagine a photo or movie where all the elements that want to be remembered are found)
	Mental associations	Relate items that want to be remembered (e.g., associate the name of a person with a physical characteristic)
	Mental hooks	Associate elements linked to the imagination and location, which can mentally link data that can be easily located in the mind
	Story technique	Organize a story with data from a list of items or events that want to be remembered (e.g., to create a story that includes the planned activities during the day)
	Itinerary method	It is about making mental associations of an image in a specific place. To achieve this, a mental journey or an itinerary should be made, setting in certain places the elements to remember (e.g., in the different rooms of the house)
	Mental maps	It involves creating a panoramic view of a situation in order to remember both general and specific data
External	Memory aids	These are aids located in the context or near the person's environment. In this situation a person or object promotes the memory (e.g., change the ring from one finger to another, carrying a schedule, diary, calendar, etc. Ask a person to remind me of an activity)

Table 3. Mnemonic strategies and techniques that can be used as part of training and cognitive stimulation programs.

Mnemonic strategies are used for improving memory processes and with it ensuring that important information is available when needed in our daily lives. Memory strategies can be distinguished according to their origin, whether they are external or internal. The first involves using aids that are outside our body to help us remember things, while internal strategies are mental activities that engage the person in remembering information [31] (**Table 3**). Both types of strategies are effective ways of learning and retaining information and are widely used as part of training and cognitive stimulation programs in the aging process.

On the other hand, interventions based on cognitive rehabilitation, designed for people with mild to severe dementia, should be highly personalized to fulfill the requirements regarding both to the potential and deterioration of the person, so it is difficult to design sessions with rigid schemes. However, this does not imply that the work should not be systematized. In a review of interventions targeting people with Alzheimer's disease or related dementia, a diversity in the types of interventions was found which consisted mainly of memory training, reminiscence therapy, validation therapy, and life review techniques [83].

6. Final remarks

Cognitive changes associated with aging can range from subtle to severe, those related to normal aging are generally mild and do not interfere with the ability to participate in normal daily activities. On the other hand, cognitive pathologies, such as dementia, affect a person's ability to live independently and are overwhelming for the families of affected people. Physical, emotional, and economic pressures can cause great stress to families, and support is required from the health, social, financial, and legal systems [39]. Mild cognitive impairment falls between these extremes. In MCI, cognitive changes are more substantial than those seen in normal aging but not severe enough to cause disability. Both MCI and dementia are pathological conditions, caused by underlying brain disorders or conditions that are not part of the normal aging process [31].

In the study of the age-associated changes, declines in memory, attention, perception, speed processing, and some executive functions have been reported; however, there is considerable inconsistency in the results. Limitations of the studies should be analyzed in order to identify bias associated with methodology, differences in the assessment tools, and diagnostic and performance criteria. The optimal approach to study the age-related cognitive decline involves the longitudinal examination of population-based aging cohorts [84]. Despite this, researching on cognitive decline in normal aging is very relevant in the gerontology field, due to the possibility that it may represent a less severe but similar process to that in dementia [85]. Moreover, as decline in cognitive functioning and the onset of dementia are associated with older age, the study of social, environmental, and individual risk factors is also needed.

Estimating the burden of the disease and its proportion due to the major risk factors of mild cognitive impairment and dementia allows effective preventive measures to be taken, especially against those risk factors that are modifiable and highly dependent on lifestyles. The cardiovascular and DM2 risk decrease with healthy eating, physical exercise, and therapeutic control. On the other hand, continuous learning that stimulates lifelong cognitive training and leisure activities that represent intellectual challenges can also reduce the risk of cognitive impairment; also, depression symptoms could be successfully treated.

Besides the study of cognitive change in aging, the progress toward the pathologies and risk factors, the field of study of the gerontology involves the challenge to develop effective intervention programs for promoting cognitive health in aging and old age. In this sense, it has largely shown that loss of function in cognitive domains is partly preventable and controllable, since it is susceptible to training through strategies of cognitive stimulation and rehabilitation. Despite the heterogeneity and variety in interventions and outcomes, that limit generalizability, the role of nonpharmacological interventions targeting MCI is promising, and must studies found a benefit with the intervention [86].

Finally, population aging coincides with other converging and interdependent global trends that are shaping our collective future, regarding the epidemiological transitions the past decades have witnessed a major transformation in the profile of diseases that are the principal causes of disability and mortality. Today, chronic, noncommunicable diseases are the

major cause of death and disability, and the rates are rising. The vast majority of older people have chronic conditions, and many have multiple conditions [87]. Mental diseases related to cognitive functioning are in the spotlight, specifically the dementia, considered as a public health priority [39]. The full impact of the pathologies in cognitive aging, mean mild cognitive impairment, or dementia is resonating throughout society. The economic costs of these pathologies impact families, health-care systems, businesses, and social structures. The emotional, psychological, and physical burdens of cognitive pathologies in aging impact individuals, his/her family, as well the formal support networks that provide assistance [83].

From Gerontology, the challenge entails rethinking the life course, to make aging a positive and disability-free individual experience. In this sense, the World Health Organization has proposed as a key element the active aging [88], also called "successful" [89] or "healthy" [90]. In any case, this type of ideal aging requires that the person can maintain an autonomous cognitive ability, which allows the functionality and control of his own life, for which it is necessary to preserve healthy cognitive functions.

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Author details

Neyda Ma Mendoza-Ruvalcaba[1]*, Elva Dolores Arias-Merino[2],
María Elena Flores-Villavicencio[2], Melina Rodríguez-Díaz[1] and Irma Fabiola Díaz-García[2]

*Address all correspondence to: nmendoza_ruvalcaba@yahoo.com.mx

1 University of Guadalajara CUTONALA, Tonalá, Jalisco, Mexico

2 University of Guadalajara CUCS, Mexico

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