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Ageing and Cognitive Function: A Mini-Review

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Abstract

The global population is ageing and it is vulnerable to cognitive changes. Age-associated cognitive changes are not identical between one individual and another and may differ through the affected cognitive domain. It is therefore essential to be alert to cognitive function in the elderly to recognise age-related cognitive changes, which may finally lead to severe cognitive changes or dementia with associated functional disabilities. This concept is particularly important for neurologists, neuropsychiatrists and forensic psychiatrists who assess cognitive abilities of their older patients, as well as having to deal with their legal competencies. At a population level, it is crucial to keep this population active and capable of maintaining their connections with the community. This paper discusses different domains of cognitive function and summarizes the current evidence regarding the impact of ageing on cognitive function.

Keywords: *Cognition; Dementia; Aging; Memory; Attention; Executive Function*

Introduction

In the seventeenth century, B.C. Pythagoras, a Greek physician and philosopher proposed the age milestones as 7, 21, 49, 63 and 81 years. He put the last two under the term "senium" (old age) meaning the time when "the scene of mortal existence close" [1] with a significant decline in the human body and mental abilities. Later, Aristotle [384-322 B.C.] stated that old citizens do not deserve high administrative positions, because ageing often leads to mental failure. Nevertheless, about three centuries later, Cicero [106 - 143 B.C.], a Roman philosopher, mentioned that cognitive decline might happen in those with a "weak will." He proposed that "old men can retain their mental abilities if they preserve their interests." In other words, this statement implies the "use it or lose it" motto/hypothesis [2].

Nowadays, in contrast to the Pythagoras era, the number of people aged 65 or older outweighs children under age five. The World Health Organization reported that in 2010, the numbers of individuals older than 65 years worldwide was about 524 million and is projected to grow to 1.5 billion by 2050 [3]. Therefore, as the world population ages, the consequences, including age-related diseases and dementia, should be foreseeable [4].

In contrast to the Aristotle's perspective, and despite the frequency of age-related cognitive changes in the elderly, the consequences of ageing are not inevitable. In addition, cognitive decline is not unitary, and thus the rate and speed of diminishing abilities may vary between individuals [5]. The majority of the aged population can live independently with no remarkable cognitive impairment. This is partly because cognitive changes are influenced by interindividual and intraindividual variability. Accordingly, cognitive changes should be differentiated from clinical dementia. This article provides a brief overview of age-related cognitive changes within both basic (i.e. attention, perception, processing speed, and memory) and high-level (i.e. decision-making and executive function) cognitive domains.

Ageing-associated cognitive changes

Cognitive domains may adversely be affected by ageing. There are plenty of tests available for screening of different domains of cognition (reviewed in [6,7]; (Table 1)). Changes in each domain are elucidated in the following.

Cognitive function	Definition	Common tests for evaluation [7]	Brain area	Ageing-related changes
Selective attention	Ability to selectively choose a desired piece of information, while ignoring the rest	MoCA, Stroop test, Ruff 2 and 7 selective attention test, TEA, TMT forms A and B, DSST	Lateral prefrontal and parietal cortex, as well as superior colliculus [8]	May decline
Divided attention	Ability to divide attention to accomplish several tasks efficiently and concurrently	TMT forms A and B, DSST	Medial and lateral frontal regions [9]	May decline
Sustained attention	Ability to maintain concentration on a task over an extended period of time	SART, CPT, IVA, TOVA	Frontal and parietal cortical areas (mostly in the right hemisphere) [10]	Not impaired
Processing speed	Ability to speedily process information to efficiently execute cognitive tasks in a limited period	TMT forms A and B, DSST, Stroop test	White matter integrity (mainly left frontal, parietal and temporal regions) [11]	May decline
Decision-making	Ability to choose a preferred option or a course of actions among several alternative possibilities	TMT forms A and B, DSST, IGT	Dorsolateral prefrontal cortex [12]	May remain stable
Executive control	The mechanisms of integration, regulation, and controlling of cognitive processes	MoCA, TMT forms A and B, DSST, D-KEFS (verbal fluency task), WCST	Prefrontal cortex and frontal basal ganglia-thalamocortical circuits [13]	May decline
Short-term memory	Ability to maintain a limited amount of currently relevant information in a readily available state for a short period	MMSE, MoCA, DSST, digit-span task, WMS, ROCF, CVLT, RAVLT	Prefrontal cortex [14]	May decline in high demanding tasks; or be slightly affected by slowness of information processing
Working Memory	Ability to maintain and manipulate a critical and limited amount of information with several options and consequences	MoCA, DSST, digit-span task, n-back, LNS	Frontal and posterior cortical areas, and subcortical structures [15]	May decline in high demanding tasks; or slightly affected due to slowness of information processing
Episodic memory	Ability to consciously remember, recognize, and recollect experiences	MoCA, ROCF, RAVLT, autobiographical memory task	Medial temporal area, including parahippocampal cortical areas and the hippocampus [16]	May decline
Semantic memory	Explicit storage of knowledge/categorical information and word meanings	Word comprehension test, category fluency test	A variety of regions in posterior neocortex, including temporal, inferior parietal lobes, dorsomedial and inferior prefrontal cortices [17]	Not affected; the elderly may even perform better than younger adults
Procedural memory	Part of memory that participates in recalling motor and executive skills that are necessary to unconsciously perform a routine task	Serial reaction time task, pursuit rotor task	Basal ganglia, cerebellum and limbic system [18]	Controversial; may often remain intact
Priming	Ability to easily identify a stimulus after a previous exposure to a relevant stimulus	Word-stem completion task	Anterior neocortical regions, including prefrontal cortex [19]	May remain stable
Prospective memory (PM)	Ability to plan, retain and retrieve a planned intention	Cambridge Prospective Memory Test (CAMPROMT)	Medial temporal lobe (focal PM) and lateral parietal and prefrontal regions (non-focal PM) [20]	May decline, particularly in tasks with higher levels of controlled strategic demand

Table 1: *Cognitive domains, classifications, definitions, and age-related changes.*

Abbreviations: *CPT: The Continuous Performance Test; CVLT: The California Verbal Learning Test; D-KEFS: The Delis-Kaplan Executive Function System; DSST: The Digit Symbol Substitution Test; IGT: The Iowa Gambling Task; IVA: The Integrated Visual and Auditory; LNS: The Letter-Number Sequencing Task; MMSE: The Mini-Mental State Examination; MoCA: The Montreal Cognitive Assessment; RAVLT: The Rey Auditory Verbal Learning Test; ROCF: Rey-Osterrieth Complex Figure; SART: The Sustained Attention To Response Task; TEA: The Test of Everyday Attention; TMT: The Trail-Making Test; TOVA: The Test of Variables of Attention; WCST: The Wisconsin Card Sorting Test; WMS: Wechsler Memory Scale.*

Attention

Attention is a cognitive process through which one can selectively concentrate on one specific subject and ignore the others. Attention is one of the most commonly affected cognitive abilities by ageing. In selective attention tests, older adults usually show slower responses compared with younger ones. This is explained by a general slowing of information processing in the elderly rather than a defect in selective attention [21]. However, the performance of subjects in other tests evaluating divided attention or tasks requiring either a higher level of attention or attention switching have shown an inverse association with age. This cannot be attributed to merely slower information processes at advanced ages.

Perception

Cognitive abilities and perception are tightly correlated [22]. For the elderly, perceptual supports, such as glasses and hearing aids are often needed. Perception is a cognitive ability in connection with sensory capacities, and thus perceptual abilities may decline with ageing [23].

Decision-making

Decision-making is a cognitive process to identify a selective choice among several alternatives, made upon clear demands with several processing resources [24]. Interestingly, decision-making often remains intact in older adults. They may even make better decisions compared with younger adults [25] of a meta-analysis of 29 studies (with 4,093 young and old adults) showed that differences in decision-making among old and young adults might be associated with learning [26]. Therefore, these differences are related to changes in working memory, episodic memory and attention.

Processing speed

Ageing may lead to a significant decline in the mental speed processing of information. Salthouse., et al. [27] showed that a large part of age-related variation in cognitive tasks, such as working and long-term memory might be related to slowing in information processing. However, it seems that high-level cognitive abilities, such as working memory, may largely remain independent to speed processing [28]. Moreover, mental speed might improve via target-oriented training [29].

Memory

Age-related memory problems are a common complaint among the elderly. However, the impact of ageing on memory system may significantly vary between individuals. Different classification systems have been introduced for memory with regard to clinical symptoms, neuropsychological examinations and neuroimaging findings. Therefore, it is advisable to study the impact of ageing on memory within its subclasses.

Short-term memory and working memory

Both short-term and working memory may decline with ageing. Rehearsal may maintain the capacity of counting. However, counting backwards may uncover impaired working memory. The growing slowness of information processing, distractions with irrelevant information, and insufficiency of inhibitory control in the elderly partially explain these alterations [30].

Declarative and nondeclarative memories

Declarative (explicit) memory is a subgroup of long-term memory, which includes two major components; i.e. semantic memory and episodic memory. Nondeclarative (implicit) memory includes three major components; i.e. classically conditioned memories, priming, and procedural knowledge. While declarative memory remains largely intact in the aged population [31], a notable decline in nondeclarative memory can be observed in this population [31]. Moreover, memory tasks requiring high levels of attention and controlled processing are often difficult for the elderly.

In declarative memory, different aspects of episodic memory, including storage, encoding, and retrieval may be affected by ageing [32]. Autobiographical memory is a cognitive function linked to a combination of personal experiences (episodic memory) and general knowledge (semantic memory). In the elderly, autobiographical memory may remain intact. Younger adults may produce more episodic details, and thus more events, locations, perceptions and thoughts, while older adults may produce more semantic details not connected to a particular time and place [33]. In nondeclarative memory, priming often remains intact and is not affected by age [31]. Despite a decline in the explicit recognition memory for figures, repetition priming does not differ in older adults [34].

A different pattern was observed in semantic memory; for instance, vocabulary scores are age-insensitive; thus, seniors often perform better than younger adults [35]. Ageing may not affect vocabulary and knowledge of language. Therefore, access to semantic or other no-episodic information might be preserved or even facilitated. Memory for a procedural task in the elderly is usually either intact [36] or is partially affected [34]. However, others reported contradictory results [37], which can be explained, to some extent, through either using different assessment tools or the lacking of a pure neurocognitive examination of the procedural memories. Furthermore, the tasks that require sensory-motor functions may have to be performed more slowly in those with comorbid conditions, such as musculoskeletal disorders.

Prospective memory

Prospective memory refers to an ability to plan, retain and retrieve a preplanned intention [38,39]. There are varying results regarding the effect of ageing on prospective memory. Nevertheless, the results of two meta-analyses have suggested a global decline in prospective memory with ageing [40,41]. This deterioration was more prominently found in tasks with a higher level of controlled strategic demands [40].

Executive functions

Executive function may also change with ageing. Age-associated declines in executive function may be attributed to white-matter changes, atrophy, and certain forms of frontal lobe neurotransmitter depletion [42]. However, this is not an inevitable outcome of ageing [43]. Age-related decline in many cognitive domains may stem from the changes in executive control. Intervention methods could maintain or enhance executive functions, and consequently cognitive abilities [44].

Human diversity

Interindividual variability is an interesting subject in almost all branches of medicine. Many factors from genetic background to socioeconomic and educational status may contribute to such variability. Recently, functional imaging studies have improved our understanding of different patterns of brain activity in healthy subjects. It has been shown that a cognitively intact adult may efficiently use brain networks and have a greater ability to recruit alternative networks compared with their counterparts [45].

Age-dependent intraindividual inconsistencies, such as reaction time, have been reported [46]. These differences may change with ageing. This intraindividual variability has a stable pattern, meaning that individuals with a greater level of inconsistency are also less predictable in other tasks and testing occasions [47]. It may also affect long-term cognitive outcomes. The intraindividual inconsistencies can be attributable to various genetic, environmental and neurotransmitter changes. The ageing process may be associated with a decrease in the stability of executive control over time, which in turn, may lead to interindividual variability [48]. Clinicians and researchers should acknowledge the intraindividual inconsistencies in the definition, classification and interpretation of neuropsychiatric tests.

Conclusions

Older adults are vulnerable to cognitive decline. However, the pattern, rate and domain of cognitive impairment may vary between individuals. Interindividual and intraindividual variability in cognition is undeniable and should always be considered in daily clinical practice and research. Available evidence suggests that the elderly may maintain most of their cognitive functions and may still remain functionally active in society.

Disclosures

All authors declare no conflicts of interest that could appear to have influenced the submitted work.

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