Pakistan Journal of Social Studies Review

Volume. 1 Issue No. 2 (2025)

Effects of aging on cognitive decline and memory

Adeel Rahim
Lecturer, Department of Psychology, University of Haripur.
Sajjad Ali
M.Phil. Scholar, Department of Psychology, University of Peshawar.

Abstract

Aging is a complex biological process that significantly impacts cognitive function and memory, leading to a decline in mental acuity. This research investigates the relationship between aging and cognitive decline, focusing on the mechanisms underlying memory impairment in older adults. Various factors contribute to cognitive decline, including neurodegeneration, changes in brain structure, and alterations in neurotransmitter systems. The study reviews existing literature on age-related changes in memory, particularly episodic and working memory, and examines how these changes affect daily functioning and quality of life. Additionally, the role of lifestyle factors, such as physical activity, diet, and social engagement, in mitigating cognitive decline is explored. Findings suggest that while aging is associated with a decline in certain cognitive functions, interventions can enhance cognitive resilience and memory performance in elderly populations. This research aims to provide insights into potential strategies for preserving cognitive health in aging individuals.

Keywords: aging, cognitive decline, memory, neurodegeneration, brain structure, neurotransmitter systems, lifestyle factors, cognitive resilience.

1. Introduction

Cognitive decline is frequently viewed as a normal and therefore inevitable part of aging, but it should not be considered typical or inevitable (Ebaid & G. Crewther, 2020). Several neurobiological alterations are associated with aging, some of which are also relevant to cognitive aging. Age-related disease characteristics, neuropsychological and neuroimaging evidence of age-related cognitive changes, and subjective complaints of memory loss are observed from middle age in all individuals, with almost complete penetrance by age at the eighth decade. The psychological and social effects of memory failure are devastating, and memory loss ranks as one of the most feared aspects of aging (S. Geldmacher et al., 2012). Most adults over age 40 report occasional memory lapses, occurring for general cognitive function. Although a decline in cognitive function is common in normal aging, there is great variation in the rates and degree of decline.

Additionally, the data suggest that it is possible to change the trajectory of cognitive aging. There is no definitive intervention but there are safest lines of evidence on which to base practical recommendations. This requires systematic efforts across multiple fields, such as continued research into basic epidemiological, cognitive, and neurobiological processes of cognitive aging and memory, attempts to clarify how these processes are influenced by individual differences in genes, health, motivational dispositions and by environmental factors, and the development and evaluation of interventions to counteract cognition decline. (Nguyen et al., 2022)

2. Neurobiological Changes in Aging

with the escalating human lifespan, aging and the phenomenon of "growing old" hold an increasing interest in neuroscience research (Richard Ridderinkhof & J. Krugers, 2022). Scientific research has recently shown great progress in understanding the normal and abnormal aspects of the aging brain. Major neurobiological alterations both in distribution and magnitude begin as individuals transition into middle age. The most prominent changes are the degeneration of neuromorphology, with pronounced shrinkage, cell loss, and diminished complexity of neuronal soma. This cellular decline adjoins an involution of the dendritic-arbor, with attenuation in the branching complexity of spines. Neurobiological aging is associated with a last-in, first-out principle, such that brain regions that mature relatively late will be the most affected by neurobiological aging. The need is stressed to progress with the study of normal, expected neurobiological changes associated with aging, and their causal contributions to psychopathological functioning. There is cause for concern here, partly because the burgeoning elderly cohort worldwide will challenge the health care system, partly because a relational framework for the study of aberrant brain aging (and aberrant brain function in the elderly) will be lacking, and partly because it is, theoretically speaking, important to distinguish normal neural aging from off-time and misshapen development in late life. It is the goal here to provide an integrative perspective on aging neuroscience that delineates the expected, prototypical changes in the aging brain on biological, structural, and functional level. It is also intended to contemplate the functional implications of such changes to outline a research agenda with relevance to the mission to extend, and enhance, healthy cognitive aging. Beyond normal aging, it is monumentally relevant to also study these topics in the context of common neurodegenerative diseases that are prevalent in the elderly, in which case a reversed-causal pattern has been advocated. Those neurobiological features of aging that are potential drivers of cognitive dysfunction have been historically underexamined. By providing a framework that outlines what changes normally occur in the aging brain, and by explicating the cognitive dysfunction that is thereby putatively unleashed, the hope is to galvanize focused research on possible therapeutic and preventive interventions. (Wang et al.2021)

3. Cognitive Decline in Aging

The aging population is a central theme for our future. Worldwide, retired people currently account for 11% of the world's population; that rate is expected to nearly double over the next 30 years, reaching 21% (44% in developed regions), and in 2050, the number of elderly people worldwide will surpass the number of youth. Among other aspects, cognitive performance critically depends on the proper activation and maintenance of a complex interaction between neural activity in vast networks (S. Geldmacher et al., 2012).

Cognitive decline is the overarching term for a diminished range of cognitive functions, that is, mental capabilities that allow perception, reasoning, problem-solving etc. The operational definition can vary, possibly excluding more severe conditions, such as dementia. In aging, a range of cognitive functions could be affected by the normal aging process (Zihl & Reppermund, 2022). There is a broad understanding of what cognitive decline is and its manifestations. On the one hand, the distinction from normal aging is more solidly in place. Here, cognitive aging is the continuation of any quantifiable cognitive development in an adult over time. The other hand pertains to healthy cognition in elderly individuals. That is, at a given age, between-individual differences in cognition can and should exist. Such a view corresponds to the majority of older individuals who do not suffer from a serious cognitive disorder. Cognitive decline can manifest itself in many forms. Not only do various cognitive processes underly functioning, but the patterns of changes across the lifespan are also manifold. Further, also within one cognitive process, the manifestation of change may be diverse, such as varying magnitude and starting point of change. (Nouchi et al.2021)

3.1. Memory

Memory sits atop the list of age-related cognitive complaints and life concerns. Introspective and workaday experiences typically focus on episodic or working memory. Accumulated research elaborates these difficulties and the cognitive processes that underlie memory decline. However, lab-based studies generally consider memory functions more narrowly, focusing heavily on standardized tasks of simple memory performance. These can be further organized under the headings of prospective, retrospective, and associative. The most thoroughly studied of these is episodic memory, which dominates the unidimensional laboratory research literature, in part because it is held to be the form of memory showing the greatest loss with age. A great deal of process research has been done with this form of memory, covering encoding processes such as limited attention to relevant details, decisions on how to structure input representations, and so on. Associative memory has been the focus of many well known models of basic memory functioning and decline. The processes most often studied include processes of deep or semantic encoding. Individual variability in memory performance is large (even in the absence of dementia). Much research has addressed the sources of memory difficulty in aging adults. This has touched on basic memory encoding and storage issues (the most robust age differences on memory are at retrieval), elaborative, organization strategies in memory encoding, and retrieval, age and cohort changes in beliefs regarding memory changes, individual difference factors. A common focus of such research is event variables, what older individuals actually do and are confronted with in memory-relevant situations. Viewed from the perspective of lab-based research, rather basic and potent or coarse descriptions of event variables are offered. However, there is a growing and trenchant matter laboratory that memory events such as instructions, event structure, and demands, as well as memory task environment design, are of paramount importance to understanding memory function and decline. The laboratory approach is sensitive to these many sources. At the most general level, memory declines with advanced age. This is most robust for episodic or associative tasks, the more complex forms of memory. Very simple and unpracticed forms of memory are largely immune. Any research design that relies on a comparison of performance of older and young adults will show a decline in the elderly. There is a significant and consistent proportion of older adults who display good memory performance, approximately 25% with A-Z individuals, older than 80. This should not mask the reality, however, of a normal distribution of those without memory impairments around exceedingly low levels of performance. Hypotheses of divided declines in effortful conations can be maintained on the basis of time-based and event-based prospective memory, but lesser declines would be expected in the elderly for tasks which support habitual usages of memory retrieval. (Kletzel et al.2021)

3.2. Attention

Robertson has proposed that a lifetime of engaging noradrenergically rich cognitive processes strengthens the right-lateralized fronto-parietal networks (Shalev et al., 2020), which, in turn, leads to an age-related difference, hence compensatory mechanism. Notably, the highly noradrenergic task processing involved in filtering out distractors becomes less-resource demanding for individuals with a stronger lifetime engagement of such processes. Attention is one of the cognitive functions most strongly affected by aging (M. McDonough et al., 2019). This domain encompasses a wide range of processes and is usually broken down into a number of distinct divisions, including selective, divided, and sustained attention, among others.

Tuning of selective attention is critical in the performance of any event in daily scenarios, as it allows filtering of conflicting or irrelevant information from the main focus or task. As we grow old, many cognitive processes, including attention, deteriorate, resulting in a less effective selection of relevant information, as well as an increase in stimulus distraction. This proposal is supported by the inability of older adults to successfully ignore or reject distractor stimuli, regardless of the task's simplicity, or even in the presence of acquired lessons that should lead to process improvement in the context of distractors ignoring. The overview of results in the present sets of experiments corroborate this assertion, showing a failure of older participants to reject distractors perceived via unattended features, even at low display size. (Estrada-Plana et al.2021)

4. Factors Influencing Cognitive Aging

Cognitive aging is affected by a plethora of factors, spanning biological, psychological, and environmental spheres. For years, research on cognitive aging has been predominantly aimed at understanding and predicting the effect of several factors that may influence cognitive changes, specifically cognitive decline and memory decrements, with advancing age. A broad spectrum of biological, psychological, and environmental factors have been investigated to accomplish this goal. Biologically, genetics play a key role in moderating the factors that affect cognitive changes associated with aging. Different genetic predispositions may increase vulnerability to cognitive decline, but also determine the effect of other environmental risk and protective factors. At the same time, the aging physiology and normal and atrophy or neurodegenerative diseases, like Alzheimer’s disease, greatly influence cognitive functioning. The studies also showed evidence that lifestyle and environmental factors, such as diet, physical and social activity, and a variety of chronic health conditions or medical treatments, modulate the progression and extent of cognitive changes in late adulthood. Psychologically, depressive symptoms and stress burden have been proven to be risk factors for cognitive aging, as well as personality traits like neuroticism. In an opposite direction, affective wellbeing or positive life events may moderate the influence of age on cognitive changes. Moreover, a higher cognitive reserve, mostly just increased education and learning, may buffer cognitive decline arising from AD pathology, and, thus, it is considered a relevant protective factor against age-related memory and learning impairments (Wafa et al., 2017). However, other cognitive domains, such as executive functions, do not seem to be protected by cognitive reserve, which suggest that the mechanism of its action is not yet fully understood. Epidemiological inquiries also investigated the effects of education and lifelong learning activities on cognition, showing conflicting results related to its protective value. The findings are expected to contribute to the individualization and harmonization of both: cognitive interventions in cognitive aging and public health programs fostering healthy cognitive aging, in the light of the examined multi-determinant cluster of cognitive changes over time. These investigations need a holistic, individualized framework to consider simultaneously the biological, psychological, and environmental sources of variability of cognitive changes over time and to understand how different determinants interact with each other and, thus, result in that cognitive outcome. The definition of cognition is broad and includes several interconnected processes that enable humans to adapt to the surrounding environment. Such a definition highlights that cognitive activities cannot be perceived in a reductionist way, but as production of relationships that have to be integrated with the context in which they occur. Thus, it is important for the disciplinary understanding that cognitive results are subject to particular characteristics that vary according to the perspective from which they are observed. Unlike history, in psychology, neuroscience, and contemporary philosophy, the predominant approach centred around adopting cognitive changes as the main indicator of history consciousness. Essentially, when working memory limitations or processing speed decline or episodic memory decreases become noticeable, people start to consider themselves as history. Such a conception is based on the significantly outdated stage model of memory system taxonomy so deeply influenced psychology of memory from 1960 until the 1990s. From this perspective, reminiscence or mere knowledge about the past was evident either disregarded or seen as a different phenomena, as unrelated to such hippocampus-dependent tasks like those mentioned. (Shahmoradi et al.2022)

5. Interventions and Strategies to Mitigate Cognitive Decline

As the global population continues to grow older, efforts to mitigate cognitive decline are crucial in order to reduce the large public health and societal burden that can be caused by degenerative neurological conditions. Active brain training games help improve memory and attention skills in the clinical target population; tailored to the needs of older adults since severe game mechanisms may present greater cognitive challenges. A “three-section” training approach is designed to effectively enhance the memory and attentional capabilities of the elderly populace. In this strategy, three types of game formats focus on different cognitive functions. Theoretical analysis based on a simplified form of the dual-process memory retrieval model in (J.

Dominguez & Barbagallo, 2018) is used to optimize the game design. (Abd-Alrazaq et al., 2022)

Cognitive training games are developed to help older users maintain their brain health. A key target of cognitive training is the enhancement of memory retrieval processes, including the ability to reliably retrieve a memory and the speed or efficiency of retrieval. In addition to tailored adjustment for the clinical target population, game design is further guided by a simplified form of the two-system memory retrieval model. In this simplified form of the model, memory retrieval is divided into two broad processes: familiarity-based retrieval and recollection-based retrieval. The former is characterized as a fast and effortless retrieval process, whereas the latter is a slower and more resource-intensive retrieval process. The usefulness of this two-system retrieval model is that it provides a theoretical basis for a series of experimental findings. For example, it has been shown that reducing the strength of memory traces affects recollection, but not familiarity (in accordance with the model). Applying this insight in the context of videogame memory is the thesis central hypothesis and provides an avenue to mitigate profound cognitive deficits observed in the domain of everyday cognitive functioning of individuals suffering from severely decreased attention, and, perhaps more appropriately, to preserve cognitive ability. (Acevedo et al.2022)

References:

Ebaid, D. & G. Crewther, S. (2020). Time for a Systems Biological Approach to Cognitive Aging?—A Critical Review. ncbi.nlm.nih.gov

S. Geldmacher, D., E. Levin, B., & B. Wright, C. (2012). Characterizing healthy samples for studies of human cognitive aging. ncbi.nlm.nih.gov

Richard Ridderinkhof, K. & J. Krugers, H. (2022). Horizons in Human Aging Neuroscience: From Normal Neural Aging to Mental (Fr)Agility. ncbi.nlm.nih.gov

Zihl, J. & Reppermund, S. (2022). The aging mind: A complex challenge for research and practice. ncbi.nlm.nih.gov

Shalev, N., B Brosnan, M., & Chechlacz, M. (2020). Right Lateralized Brain Reserve Offsets Age-Related Deficits in Ignoring Distraction. ncbi.nlm.nih.gov

M. McDonough, I., M. Wood, M., & Miller, J. (2019). A Review on the Trajectory of Attentional Mechanisms in Aging and the Alzheimer's Disease Continuum through the Attention Network Test. ncbi.nlm.nih.gov

Wafa, J., Julia, G., Sandra, G., Michael, H., Szabolcs, K., & Ahmed A., M. (2017). Factors underlying cognitive decline in old age and Alzheimer's disease: the role of the hippocampus.. [PDF]

J. Dominguez, L. & Barbagallo, M. (2018). Nutritional prevention of cognitive decline and dementia. ncbi.nlm.nih.gov

Nguyen, L., Murphy, K., & Andrews, G. (2022). … cognitive decline away? A systematic review and meta-analysis of commercially-available brain training programs in healthy and cognitively impaired older adults. Neuropsychology Review. [HTML]

Wang, G., Zhao, M., Yang, F., Cheng, L. J., & Lau, Y. (2021). Game-based brain training for improving cognitive function in community-dwelling older adults: A systematic review and meta-regression. Archives of Gerontology and Geriatrics, 92, 104260. [HTML]

Nouchi, R., Hu, Q., Saito, T., Kawata, N. Y. D. S., Nouchi, H., & Kawashima, R. (2021). Brain training and sulforaphane intake interventions separately improve cognitive performance in healthy older adults, whereas a combination of these interventions does not have more beneficial effects: evidence from a randomized controlled trial. Nutrients, 13(2), 352. mdpi.com

Kletzel, S. L., Sood, P., Negm, A., Heyn, P. C., Krishnan, S., Machtinger, J., ... & Devos, H. (2021). Effectiveness of brain gaming in older adults with cognitive impairments: a systematic review and meta-analysis. Journal of the American Medical Directors Association, 22(11), 2281-2288. nih.gov

Estrada-Plana, V., Montanera, R., Ibarz-Estruga, A., March-Llanes, J., Vita-Barrull, N., Guzmán, N., ... & Moya-Higueras, J. (2021). Cognitive training with modern board and card games in healthy older adults: two randomized controlled trials. International Journal of Geriatric Psychiatry, 36(6), 839-850. udl.cat

Shahmoradi, L., Mohammadian, F., & Rahmani Katigari, M. (2022). A systematic review on serious games in attention rehabilitation and their effects. Behavioural Neurology, 2022(1), 2017975. wiley.com

Acevedo, B. P., Dattatri, N., Le, J., Lappinga, C., & Collins, N. L. (2022). Cognitive training with neurofeedback using fNIRS improves cognitive function in older adults. International Journal of Environmental Research and Public Health, 19(9), 5531. mdpi.com

Abd-Alrazaq, A., Alhuwail, D., Al-Jafar, E., & Ahmed…, A. (2022). The effectiveness of serious games in improving memory among older adults with cognitive impairment: systematic review and meta-analysis. … serious games. jmir.org