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Review

An overview of the hallmarks of cognitive aging

Vanessa M. Loaiza

Abstract

Although the notion of cognitive aging is commonly associated with decline in popular culture, a wealth of scientific literature shows that cognitive aging is more aptly characterized as multidirectional, such that trajectories of cognitive changes include areas of stability and growth (e.g., general knowledge) in addition to decline (e.g., episodic long-term memory). This article overviews these multidirectional trajectories, the heterogeneous factors that moderate the rate of change across individual trajectories, and the extensive literature that has investigated the most important factors, such as working memory, that constrain cognition across the adult lifespan. In light of the multidirectional nature of cognitive change, increasing research has considered methods to leverage the often-overlooked benefits of getting older to ameliorate cognitive deficits.

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Introduction

For many, the idea of cognitive aging often inspires a mix of fear and resignation toward what is assumed as inevitable: A gradual decline of basic abilities, such as memory and reasoning, that results in limitations to autonomy and wellbeing. This bleak view is not only at odds with the lived experience of many healthy older adults who report modest cognitive constraints in everyday life [1], but also a more nuanced view informed by the cognitive aging literature.

The purpose of the current article is to overview the fundamental principles and empirical findings characterizing the field of cognitive aging over the last 50 years, which often challenge lay assumptions of the cognitive changes that accompany older age. These hallmarks include the multidirectional nature of cognitive aging trajectories, the heterogeneity of these trajectories depending on individual circumstances, and the importance of constructs such as working memory (WM) to explain and predict the trajectories of cognitive aging. Fruitful avenues of future research will continue the momentum of work leveraging the interaction between these multidirectional trajectories, such that age-related cognitive deficits may be best ameliorated by incorporating methods derived from the often-overlooked benefits of getting older.

Multidirectional trajectories of cognitive aging

A key hallmark of the lifespan development literature is the notion of multidirectionality: Whereas some factors show declines with advancing age, others show stability or even growth [2]. In cognitive aging more specifically, one of the most well-known instances of multidirectionality is the well-replicated finding that fluid abilities, such as reasoning and processing speed, tend to show declines in healthy older age, whereas crystalized abilities such as general knowledge and vocabulary tend to increase and remain stable [3–6]. Multidirectional patterns are also evident in sub-domains of cognitive aging, such as memory: Age-related deficits are evident in WM, i.e., the immediate memory system that keeps a limited amount of information active for ongoing cognitive processing [7], as well as episodic long-term memory (LTM), but particularly in recollecting specific details of previously experienced events, whereas familiarity in the absence of those details is relatively less impaired [8,9]. Similarly, memory for associative [10] and contextual [11] details are often more deficient in older age compared to memory for item-specific content. These multidirectional patterns in behavioral performance often mirrors those of the corresponding neuroscientific literature, such that regions of the brain associated with WM (i.e., the prefrontal cortex) and recollection (i.e., the hippocampus) have shown structural declines with advancing age, whereas brain regions associated with familiarity (i.e., the entorhinal cortex) exhibit less change [12,13].

A great deal of research often focuses on the rate of change between and within individuals in these domains with the aim to understand the causes and consequences of cognitive aging. It is first important to note that longitudinal studies tracking within-person changes over time typically show more modest cognitive decline in fluid abilities that begins in late middle age compared to the more linear decline from early adulthood exhibited in cross-sectional studies that make comparisons between age groups at a single point in time [3,6]. The source of this discrepancy between longitudinal and cross-sectional designs may owe to a combination of practice effects and attrition that minimize age differences in longitudinal studies as well as cohort differences (e.g., in access to technology) that may exacerbate age differences in cross-sectional studies. In a recent quasi-longitudinal study that avoided these issues by comparing participants who were tested only once but from the same cohort (e.g., 50 and 60 year olds respectively tested in 2000 and 2010), Salthouse [6] showed that the trajectories of speed, reasoning, and episodic LTM showed declines that were comparable to cross-sectional estimations. These findings indicate that cohort differences are unlikely to play a major role in cross-sectional studies of cognitive aging, which seem to best represent the rate of age-related change in several major fluid abilities.

Another well-known feature regarding the nature of cognitive aging trajectories, whether cross-sectional or longitudinal, is that decline in fluid abilities is more pronounced after the age of 65 [6] and significantly accelerates in the last few years of life [14,15]. The latter finding is often referred to as “terminal decline” or “terminal drop,” depending on how steep the change appears to be [15], and it is often observed in multiple domains including cognitive abilities [14]. Individual variability in rates of terminal decline has been shown to be rather modest [15] despite the fact that the causes and nature of the decline can vary, such as normal function preceding sudden unpredicted death versus gradual decline for those with longstanding health issues [14]. Such work coheres with a great deal of research investigating factors that predict mortality, which include basic sensory impairments like olfaction even after controlling for other risk factors [16,17]. These findings have been interpreted to suggest that overall brain health can be captured by basic cognitive and sensory abilities that are increasingly correlated with advancing age [18], especially in the last years of life [19].

Individual differences in the trajectories of cognitive aging

A second hallmark of cognitive aging is that multidirectionality can vary greatly on an individual basis, with some older adults exhibiting stable cognitive ability compared to others who show declines that are similar or worse than those typically shown in aggregate [20,21]. A number of individual circumstances are known to moderate individual trajectories, including but not limited to one’s socioeconomic background [22], physical and sensory disability [18,23], racial/ethnic disparities in access to education [24], whether a person is living with dementia [25], and even an intersectional combination of these factors [26,27]. These studies collectively show that the rate of cognitive decline is often slower for those who are most privileged in these different regards.

For example, research concerning early markers of Alzheimer’s Disease have shown that relatively intact abilities in healthy older age are more deficient in those with Alzheimer’s Disease [9,28]. Koen and Yonelinas’ [9] meta-analysis revealed that both recollection and familiarity are deficient in people living with Alzheimer’s Disease, whereas recollection is selectively impaired in healthy older age as explained previously. Similarly, Cecchini and colleagues’ [28] recent meta-analysis showed that feature binding, or integrating surface-level features like color and shape in WM, is deficient in people living with Alzheimer’s Disease, whereas healthy older adults exhibit minimal feature binding deficits. Such findings illustrate that multidirectionality further depends on individual characteristics such as dementia, and there is increasing acknowledgement of the importance of recruiting diverse samples of participants from a variety of backgrounds and cultures to fully capture such rich heterogeneity of cognitive aging [29].

The importance of working memory to explain and predict trajectories of cognitive aging

A substantial amount of research is focused on the underlying cognitive factors that contribute to the rate of change across individuals. Chief among them is WM capacity given that it accounts for a great deal of age-related variability in other constructs of higher-order cognition, such as episodic LTM [4,5]. That is, older adults with relatively lower WM capacity tend to disproportionately struggle on a range of other cognitive and everyday tasks, suggesting that WM constrains cognitive ability. Similar constructs have been considered as well, including executive functions such as task-switching and inhibition, but a growing body of work suggests that age deficits in these constructs are often overstated [30,31].

A key question of interest is what specifically underlies the aging deficit in WM that makes the construct so important to individual differences in cognitive aging. Consistent with the recurring theme of multidirectionality, there are different functions of WM, such as feature binding [28] or directing attention to information [32], that may be relatively spared in healthy older age compared to other functions, such as encoding associative bindings between arbitrary pieces of information [33]. Although it remains to be fully determined which aspects of WM are most important to individual differences in cognitive aging trajectories, many researchers agree that this is pivotal to clarifying the theoretical and practical importance of the construct [7].

The interaction of multidirectional trajectories of cognitive aging

Although it is encouraging that the picture of cognitive aging is not simply one of ubiquitous decline, the question of how best to ameliorate cognitive deficits remains of longstanding interest to researchers and older people alike. Investigations of methods to improve memory ability are particularly popular, perhaps due to the previously discussed importance of factors like WM as well as the salience of everyday forgetfulness that can cause alarm in older people. A growing body of work has investigated the interaction between the previously discussed multidirectional trajectories, such that leveraging older adults' intact or even superior abilities may yield gains to other areas of impairment.

One intuitive approach to this end is to improve older adults' use of effective strategies to remember information. Indeed, it is well established that engaging in deep, elaborative encoding strategies (e.g., generating sentences, mental imagery, attending to the semantic meaning of the information) benefits retrieval from episodic LTM [34]. Although younger and older adults tend to report a similar rate of spontaneous elaborative strategies [35,36] that positively correlate with memory performance in both age groups [35], experimental work has shown that the benefit of *instructed* elaborative strategies to memory performance is less consistent in older compared to younger adults [37–40]. Bartsch and Oberauer [38] demonstrated that this was the case even when ensuring that any potential age difference in generating rich elaborative representations was controlled by providing faciliatory sentences to remember the presented words. Furthermore, Bailey and colleagues [41] showed that training participants to use elaborative strategies benefitted both younger and older adults' WM performance on the trained task, but the overall age difference in WM persisted, and applying the trained strategies in other related tasks did not yield gains in either age group. It is not immediately clear why encouraging elaborative strategies via instruction or training has not shown consistent or broader benefits to older adults' memory performance. As Bartsch and Oberauer [38] discuss, it may be the case that instructing elaborative strategies incurs additional demands that disproportionately impact older adults, thereby curtailing any benefit. Another possibility is that older adults may disproportionately fail to access the mediating strategy to cue successful retrieval of the target information, resulting in high reported elaborative strategies that do not necessarily link to improved memory performance [42]. Finally, the often-observed correlation between spontaneous elaborative strategies and memory performance could work in reverse, such that those with greater memory ability have greater capacity to engage in elaborative strategies.

Rather than strategies that may require intact memory ability to be successful, another approach is to encourage older participants to rely on other more stable factors, such as schematic support that draws on their extensive prior knowledge, to incorporate new information. For example, growing work has shown that age-related deficits in memory performance are selectively evident for information that lacks relevance to older adults' semantic knowledge, whereas they perform similarly to younger adults when information is familiar or meaningful [43–45]. Similarly, Loaiza and Srokova [46] demonstrated that older adults required a greater degree of meaningfulness to encode and retrieve associative bindings compared to younger adults. These results suggest an age-related increase in the interdependence between healthy older adults' considerable crystalized abilities, such as their densely interconnected semantic network, and their impaired fluid abilities, such as episodic LTM. This research inspires hope that older adults can capitalize on the hallmark of multidirectionality, but it is important to caution that older adults can suffer when rejecting incorrect information that coheres with their prior knowledge [44,47,48].

Future directions and conclusions

This overview has demonstrated how the hallmark of multidirectionality is pervasive in the cognitive aging literature, ranging from trajectories of cognitive change in the aggregate to the cognitive and non-cognitive factors that contribute to individual trajectories. To fully characterize the nature of cognitive aging and methods to mitigate deficits, more work recruiting diverse samples is necessary. Finally, harnessing the rewards that come with a lifetime of acquired experience may enhance the downsides of getting older.

Declaration of competing interest

The author declares no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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