In Review

Aging and Memory: A Cognitive Approach

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This article describes changes in memory during the normal aging process from the standpoint of cognitive psychology. There is now a great deal of evidence to show that memory is not one single function but may be described in terms of different memory systems that show differential effects of aging. For example, memory for procedures, and some perceptual memory functions, show few age-related changes, whereas working memory, episodic memory, and prospective memory decline substantially in the course of normal aging. Memory for facts and knowledge (semantic memory) holds up well in older individuals provided that the information is used frequently, although the ability to retrieve highly specific information (such as names) typically declines. The article discusses current theoretical accounts of the effects of aging; different theorists have attributed the changes in memory and cognition to mental slowing, declining attentional resources, an inability to inhibit unwanted information, and a decline in cognitive control. Other suggestions include the notion that memory performance in older adults is particularly vulnerable when the need for self-initiated processing is greatest; conversely, performance is greatly helped by the provision of environmental support. The practical implications of these research findings and ideas include the point that clinical memory assessments should incorporate tests designed to measure the different aspects of memory functioning.

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Highlights

- Current research in cognitive aging has shown that age-related changes in memory vary greatly depending on the particular memory system tested.
- The types of memory that decline most with age (for example, working memory and episodic memory) require substantial amounts of self-initiated processing.
- The article concludes by discussing appropriate ways of assessing memory impairments and the possibility of remediation.

Key Words: *aging, memory, cognitive functions, attentional resources, inhibition, executive functions, encoding and retrieval, memory for context, false memory, prospective memory, memory assessment*

Current work on age-related changes in memory rests on evidence from previous research that strongly suggests that memory is not a single entity that either works well or does not. Rather, aging and some other conditions appear to have a more detrimental effect on some types of memory than on others. One way to organize different types of memory is the systems view advanced by Tulving and his colleagues.[1] Comprising 5 major memory systems with different characteristics and dealing with different types of information that are mediated by different regions in the brain and are differentially vulnerable to aging, these systems are procedural memory, the perceptual representational systems, working memory, semantic memory, and episodic memory. Procedural memory is the system or systems that mediate the acquisition and later performance of cognitive and motor skills. The perceptual representational systems encode and retain sensory information, and are believed to mediate perceptual priming effects, measured as increased perceptual processing speed for a previously encountered item. These 2 types of memory are implicit, require no effortful remembering, cannot be verbalized, and generally hold up quite well with age. The working memory system is responsible for holding small amounts of information in the span of conscious awareness. A further distinction can be made between primary memory—simply holding information in mind for a short period of time—and true working memory—holding and manipulating information in mind. The ability to simply hold and repeat back a string of digits (digit span) declines very little with age. However, if the participants must manipulate the information held in mind, for example, reorganize a short list of words into alphabetical order, age-related decrements typically occur. Semantic memory refers to general knowledge about the world and holds up well with age, although memory for names is typically impaired by aging. Finally, episodic memory is responsible for remembering events and experiences that have happened to us personally, and shows the greatest age-related difference.

A typical episodic memory task involves presenting participants with some materials to memorize, and later testing their ability to remember them. However, age differences are not consistent across tasks within the domain of episodic memory. Depending on the type of information and the processes involved, some types of tasks are disproportionately impaired as a function of aging. Tasks that show substantial age-related declines include free recall tests, in which participants are asked to recall the materials they studied without any extra cues or guidance; associative learning, in which participants must create and retrieve associative links between units without prior relations; source memory tasks, in which participants are asked to remember the original source of the information (for example, where a fact was learned) as opposed to the content of the information (that is, the fact itself); and prospective memory tasks, in which participants need to hold an intention in mind and execute it at a future time without explicit cues or reminders. Some of these tasks will be discussed further in later sections. Fuller reviews on the differential effects of aging on memory are provided by Balota et al[2] and Zacks et al.[3]

Abbreviations used in this article

AD Alzheimer disease

PM prospective memory

Theoretical Accounts

Older adults have greater difficulty with memory tasks that are more complex, effortful, and strategic, and it seems likely that these age-related declines in memory function result from impairments of basic cognitive functions. Researchers have proposed several mechanisms to account for the patterns of age-related changes; these include general slowing, reduced processing resources, loss of inhibitory functions, and lack of cognitive control.

Slowing

According to the general slowing account, aging is accompanied by a general reduction in processing speed that in turn leads to declines in a broad range of cognitive functions, including memory performance. Based on path analyses of large-scale psychometric data, Salthouse[4] argued that the independent contribution of age to memory measures is relatively weak after controlling for the speed factor, and that age is only indirectly related to memory performance. Processing speed clearly plays a role in many cognitive functions, and it is plausible that complex tasks involving multiple types of processing should suffer more from slowing, showing greater age-related declines. However, supporting evidence for this view comes mainly from path analysis data; it remains unclear how the hypothesis accounts for some experimental data. For example, age-related declines are found in tasks such as free recall that do not obviously have a speed component. Second, allowing unlimited processing time (for example, self-paced study) does not reduce memory problems for older adults, but instead improves performance in younger adults more. Third, aging is associated with differential effects on tasks that do not apparently involve different amounts of processing (for example, greater effects on source recognition than on item recognition). It seems likely that other factors besides slowing are also involved.

Reduced Processing Resources

The processing resources framework proposes that the amount of attentional resources available for cognitive processing declines with age. Attentional resources are seen as a type of so-called mental energy, with difficult cognitive tasks requiring more resources than simpler tasks. As a result of reduced processing resources, older adults are less likely to carry out the effortful and strategic memory processes associated with good performance.[5,6] This framework accounts well for many differential aging effects observed within each memory system; thus, older adults have greater difficulties with working memory tasks than with simple span tasks, with remembering specific names than with general facts, and with free recall than with recognition tasks. However, this view has been criticized as too vague about its core construct: attentional resources. What exactly are these resources and what are their neural correlates? If it is the case that a reduction in attentional resources underlies age-related memory problems, it should be possible to mimic the effects of aging by reducing attentional resources in young adults by having them perform a second task during encoding and retrieval.[5] The results of such studies have generally provided good support for the processing resources framework. Overall, they suggest that reduced resources can account for much of the age-related decrement in memory functions; however, aging seems to be associated with some additional factor, possibly a specific impairment in forming associations between unrelated pieces of information.[7]

Inhibition

Hasher and Zacks[8] proposed that older adults show working memory deficits caused by less efficient inhibitory mechanisms. According to their view, inhibition serves 2 primary functions that are of relevance to memory performance: preventing irrelevant information from entering working memory, and deleting no-longer-relevant information from working memory. The inhibition view is appealing in that it fits well with the fact that older adults often have great trouble dealing with interference and distractions, and that aging is associated with an increased rate of false recognitions and memory intrusions. However, it does not directly account for the simultaneous decrease in hit rates in recall and recognition, nor does it obviously explain the difficulties older adults have with prospective memory tasks, where their problem seems to reside in initiating rather than inhibiting the execution of planned intentions.

Control

This notion relies heavily on the distinction between automatic and consciously controlled processing in memory tasks.[9] Jacoby[10] differentiates recollection, a controlled form of memory use, from familiarity, an automatic type of memory process. Aging is accompanied by declines in controlled processing, while automatic processing is largely spared. Thus older adults have few problems in finding information familiar; however, they have substantial difficulty in recollecting details of the original experience. Jacoby has developed ingenious methods to provide independent estimates of recollection and familiarity; these studies demonstrate that familiarity holds up with age, whereas recollection does not.[11]

The notion of control combines the explanatory power of both the processing resources framework and the inhibition view to account for the differential effects associated with aging in memory. However, it also suffers from the vagueness of its central construct: What exactly is control? Presumably cognitive control is linked to executive functioning, which again is a concept that remains to be specified.

The theoretical accounts reviewed above are all in their general stages, and each accounts for some empirical data better than others. To better evaluate these theoretical views, some questions remain to be answered:

- Is a single-factor account sufficient to explain all age-related changes in memory? As described in the next section, memory aging is a complex phenomenon and there are many manipulations that can modulate or moderate the size of age differences in memory performance. Perhaps all of the above-described factors play some role, or even interact in some way.
- Are there links among these factors? Although the theoretical accounts take quite different perspectives, they do not necessarily generate contradictory predictions; sometimes they fit with each other quite well. For example, deficits in controlled processing can cause information to be encoded in a generic, unelaborated way; similarly, carrying out controlled processes requires substantial amounts of attentional resource.
- What are the underlying biological changes that mediate these cognitive changes? Presumably declines in cognitive functions are closely linked to the biological changes associated with aging. Studies to specify the biological foundation of these accounts are still in their early stages, although work using neuroimaging and other techniques is yielding encouraging results.

Empirical Findings

Encoding and Retrieval

Remembering can be viewed as a set of mental operations or processes, including acquisition (or encoding) and later retrieval of the encoded information. Age-related deficits in memory can therefore be regarded as inefficiencies in the relevant processes that lead to better remembering. For example, effective encoding processes involve elaborating on the information, creating associations, organizing the items, and integrating them with one's existing knowledge structure; while effective retrieval processes involve searching for relevant cues, elaborating on the cues, and monitoring the memory output. These strategic processes are typically effortful and resource-demanding, and thus unlikely to be carried out by the older brain according to the reduced processing resources theory.[5]

Have older adults simply lost the capacity to carry out the relevant memory processes? The most likely answer is no. Many studies have shown that, with the provision of effective encoding techniques and adequate retrieval support, memory performance in older adults can be improved.[3,12] For example, Craik[13] proposed that older people are less likely to spontaneously initiate relevant retrieval processes, although they are able to execute these processes when guided explicitly by the environment or the task. This view is supported by the changes in age-related differences in memory performance across different retrieval tasks. In a metaanalysis reported by La Voie and Light[14] the effect sizes of age differences for free recall, recognition, item priming, and associative priming tasks are 1.05, 0.69, 0.34, and 0.33, respectively. In a free recall task, participants are given a long list of items and then asked to recall them without any hints or cues. The support or constraint provided by the task is thus minimal and the demand for self-initiated processes maximal. This type of task typically shows the largest age differences. In a recognition task, participants are presented again with the studied items in their original form along with distracter items and asked to differentiate them; age differences in this type of task are smaller, owing to increased environmental support and decreased need for self-initiated processing. Finally, the size of age differences is minimal in priming tasks, in which participants simply name studied and unstudied items as fast as possible. Priming effects refer to the improvements in naming speed for studied items over unstudied items. In this kind of task, no explicit remembering is required and performance is largely spared in older adults.

Similarly, one could assume that the efficiency of encoding processes declines with age for the same reason and can also be repaired with appropriate support in the task. This assumption is supported by mixed results. For example, older adults can often perform at the same level as that of younger adults if the encoding materials are pictures instead of words,[5] presumably because pictures compensate for the age-related deficits in imagery processing at encoding. Conversely, when visual words are presented with related sound effects (for example, seeing the word dog and hearing the dog barking), older adults have greater difficulty integrating visual words with their related sound effects and do not show the same benefits as young adults.[15] Apparently older people do not benefit from any form of support; instead, the encoding support needs to be appropriate to the encoding characteristics of the older brain. These results suggest that older adults do suffer from inefficiencies in both encoding and retrieval processes; however, with appropriate support in the task, these inefficiencies can be compensated for. Indeed, some studies have shown equivalent levels of memory performance by providing mnemonic support, both at encoding and at retrieval.[16]

Memory for Source and Context

Numerous studies have reported that memory for the source of a remembered fact declines disproportionately with age. In a metaanalysis, Spencer and Raz[17] found that the size of age differences in context memory is reliably greater than that in content memory. Remembering of contextual information relies heavily on successful integration of the content of an event with its context. Therefore, Chalfonte and Johnson[18] proposed that older adults have greater difficulty in binding contextual features into a coherent memory representation, leading to the age-related deficit in memory for context. Similarly, Naveh-Benjamin[7] suggested that older adults have greater difficulty creating and retrieving associative links between multiple units.

What might be the underlying mechanism for such binding or associative deficits in older adults? One candidate is their reduced processing resources. Specifically, Craik[6] suggests that older adults tend to process incoming information in a shallower fashion, owing to the reduction in available processing resources. Such shallower processing can be regarded as poorer integration of the event with existing knowledge, resulting in an age-related binding or associative deficit.

It is worth noting that there are exceptions in the literature where older adults show the same level of performance in source memory tasks as younger adults. For example, Rahhal et al[19] presented trivia statements to younger and older adults. The statements were read by either a male or a female speaker. In addition, participants were told that one speaker always tells the truth and the other speaker always lies. In a later test, participants were either asked which speaker read each re-presented statement, or asked whether the statement was true or false. Older adults showed poorer performance remembering the voice information, but not the truth information, suggesting spared ability to remember conceptual source information. In another source memory study, Ferguson et al[20] manipulated the distinctiveness of the 2 sources. Words were read to the participants by 2 experimenters. In one condition, the 2 experimenters were a man and a woman, chosen to have as many different characteristics as possible (such as physical appearance, voice tone, and clothing colour). In the other condition, the 2 experimenters were both women and chosen to be perceptually similar (such as voice, accent, hairstyle, and dressing). Older adults showed comparable performance to their younger counterparts in distinguishing the 2 distinctive sources, but had greater difficulty in distinguishing the 2 similar sources.

These pieces of evidence suggest that older adults show smaller deficits when the sources or contexts are salient, distinctive, and conceptual, and larger deficits when they are similar and perceptual. To organize these findings about age-related differences in memory for context, Craik[6] suggested a hierarchical framework. According to this view, knowledge representations are organized hierarchically on a continuum, from general to specific information. Representations of context-free knowledge reflect the general end of the continuum, whereas contextual details of an experienced event are considered to be at the specific end of the continuum. Older adults experience greater difficulty both in encoding and in retrieving information at the specific ends; for example, episodic contextual details and specific names of people. Contextual information of an event can also be considered to vary in degrees of specificity. Participants will have to recollect highly specific contextual details to differentiate between similar sources or contexts. Older adults have more difficulties retrieving such information, thus showing greater deficits.

False Memory

Age-related changes are also characterized by increased susceptibility to memory slips and errors. One demonstration of such errors is the false memory paradigm in which participants are presented with word lists in which all items are semantically related to a common associate that is not actually presented (such as bed, rest, awake, blanket—all related to the concept of sleep).[21,22] In the later test, participants are very likely to falsely recall or recognize the common associate (sleep, in the example above). Further, older adults are more likely to report such critical lures than are younger adults.[23]

Explanations proposed to account for the age-related increase in susceptibility to false memories often take a dual-process approach. For example, Schacter and colleagues[24] suggest that impaired recollection of item-specific information in combination with intact memory for general similarity or gist information leads to the greater susceptibility to false memories. According to the activation-monitoring framework proposed by McDermott and her colleagues,[25] false memories are induced by activation spreading among common associates, in conjunction with less effective monitoring processes[26] required to discriminate among studied items and highly activated distracters.

In his dual-process model, Jacoby[27] proposed that performance in memory tests is driven by the combined influence of controlled processes, or recollection, and automatic processes, or familiarity. Aging was found to selectively impair recollection, while leaving familiarity spared. Age-related memory errors often occur when they are driven by a high level of familiarity, in combination with the lack of recollection to counteract them. This case was illustrated by Jacoby[27] to demonstrate an everyday memory problem commonly experienced by older people: repeating a story without realizing that they have told it before. In the first phase of this experiment, older and younger participants were instructed to read a list of words. The words in this visual list were presented once, twice, or thrice. After the visual list, participants heard a second list of words and were instructed to remember them for a memory test. In the later recognition test, participants were instructed to respond "yes" to the auditory (heard) items only and to reject items from the visual list. Repetition in the visual list helped younger adults to reject the items. However, older adults were more likely to falsely recognize a repeated visual item as an auditory item. That is, the familiarity of an item increased with repetition, which, in combination with their diminishing ability to recollect the initial presentation, resulted in an increased false recognition rate in older adults. Similarly, having told a story increases its familiarity, making older adults more likely to repeat it when they fail to recollect the specific occasion of prior telling.

Several attempts have been made to help older adults overcome their susceptibility to false memories. However, some manipulations that reduce false memories in younger adults are not so effective with older adults. For example, McCabe and Smith[28] found that a prior warning about the deceptive nature of the false recognition paradigm significantly reduced false memories in younger adults, but less so in older adults. A more successful attempt was reported by Dodson and Schacter.[29] When studied items were presented with distinctive details (for example, pictures), older adults were able to reject critical lures based on the strategy that studied items should be accompanied by recollection of such details. They argue that such strategy, referred to as the distinctiveness heuristic, is a global strategy reflecting both a shift in response criterion (an increased demand for evidence) and a fuller item-by-item analysis for source-specifying information.

Instead of trying to guide a global strategy, Jennings and Jacoby[30] showed improvement in older adults by training recollection processes per se. In their experiment, participants first studied a list of words and later performed a continuous recognition test in which studied items were mixed with new items that were repeated after a few intervening items (lag). Participants were instructed to reject new items and their repetitions. These repeated items were expected to give rise to many false recognition responses if older adults failed to recollect their sources of presentation. Over a 7-day training session, the experimental group received feedback regarding the accuracy of their responses, and the lags were gradually increased after each correct trial. This group showed significant improvement over the control group, who received the same amount of practice with the task, but with lags varying randomly.

Prospective Memory

PM refers to the ability to remember to perform an action in the future, in contrast to retrospective memory, which refers to the ability to remember an event that happened in the past. PM is important in our daily life, and its decline is often one of the major complaints in older adults (such as forgetting an appointment and taking medication). Thus the topic has received increasing interest in the past decade. Laboratory studies make the distinction between time- and event-based

PM tasks. In an event-based PM task, participants are asked to perform an action in response to an environmental cue, mimicking the real-life situation of, for example, remembering to pick up the laundry when I pass the plaza; whereas in a time-based PM task, participants are required to perform an action at a certain time in the absence of any external reminders, mimicking the situation of, for example, remembering to call my nephew at 9 o'clock. Early studies reported significant age differences in time-based PM tasks, but not in event-based tasks,[31] and suggested that this result is attributable to the lack of external reminders in time-based PM tasks, thereby requiring more self-initiated processing to execute the intention. However, recent studies have reported age-related deficits in both event- and time-based PM, but more consistently in time-based PM. In a metaanalysis reported by Henry et al,[32] age-related declines were found in both event- and time-based PM tasks in laboratory settings (the effect sizes were –0.34 and –0.39, respectively). Older adults seemed to be more impaired in time-based PM tasks than in event-based tasks; however, the difference was not significant.

McDaniel and Einstein[33] suggested that the size of age differences in event-based PM tasks depends on the extent that older adults can rely on automatic processes that allow the intention to pop into mind in response to the environmental cue. Some factors modulating the demands for controlled processes include:

- distinctiveness of the cue;
- the association between the cue and the intention; and
- the attentional demand of the background task performed by the participant (for example, driving alone, compared with engaged in an interesting discussion).

These suggestions are in line with the notions of reduced processing resources and reduced cognitive control. That is, age-related deficits in PM tasks are presumably due to declines in the efficiency of control mechanisms that switch attention away from the ongoing task to monitor environmental cues, along with reduced processing resources that normally enable self-initiated processing in the absence of any cue.

Interestingly, although PM tasks in laboratory settings consistently show age-related deficits, PM studies in real-life settings typically show an advantage for older adults, in line with the common observation that older adults are usually more reliable than younger adults at keeping appointments. Admittedly, laboratory PM tasks are very different from daily PM activities. Older adults may perceive laboratory tasks as less important and interesting, and in real life they may also benefit from the use of memory aids and more structured daily lives. To approach this question, Rendell and Craik[34] devised a laboratory board game called Virtual Week to simulate real-life activities. However, the results still showed that older adults performed less well than younger adults in the laboratory task, while again outperforming younger adults in a real-life version of the task. The effect is unlikely due to the use of memory aids as the participants were explicitly instructed not to use them. Thus the age-related superiority favouring older adults in real life must be attributable to factors such as greater motivation and (or) compliance.

Much of the cognitive research in memory aging deals with patterns of age-related declines in memory performance and their underlying cognitive processes. However, the real world involves more than cognition. Researchers have recently focused on the roles of social, emotional, personality, and health factors, and their interactions with cognitive factors. A noteworthy topic along this line is the effect of time of day on cognitive performance.[35] These researchers have shown that age differences in memory performance are modulated by time of day. Morning is typically the optimal time for older adults, whose performance in the morning can equal or even exceed performance levels of younger adults, whose optimal time is usually later in the day.

Practical Implications

Memory Assessment

Perhaps the most apparent and unequivocal theme in the past decades of cognitive research in memory and aging is the selective effect of healthy aging. That is, aging affects only some memory systems and (or) processes. Conversely, clinical memory testing usually adopts a more general view of memory: the ability to learn, retain, and recollect new information. For example, the commonly used Wechsler Memory Scale[36] measures aspects of memory according to the modality of the material (auditory or visual), the different test formats (free recall, cued recall, recognition), and the length of the retention period (immediate or delayed). Normal aging should have a greater effect on performance in subtests that rely heavily on self-initiated processing (for example, free recall tests) and those that involve associative information (for example, paired associate tests), but a smaller effect on performance in tests that rely on generic ideas (for example, recall of a story's gist) and those that involve a higher level of environmental support (for example, recognition tests).

To assess memory changes in healthy elderly adults, it is important to note that some clinical tests are more sensitive than others. In addition to the common distinctions made in clinical memory testing, a test should also be interpreted by the mental operation involved. For example, older adults' performance holds up quite well in the digit span test, often used clinically as a quick test for attentional and memory ability, or interpreted as working memory capacity. However, tasks that require manipulation of the items in addition to simply holding the items in mind—such as the Alpha Span task,[37] which involves mental reordering of a set of presented words into alphabetical order—are more sensitive to aging.

The selectiveness of memory aging also provides a good tool to differentiate normal from pathological aging. In particular, AD is characterized by memory deficits, especially in its early stage, where impairments in other cognitive domains are not yet evident. It is therefore important to distinguish patterns of memory loss associated with normal aging from those seen in early AD. In contrast to the differential decline in various aspects of memory task in healthy elderly adults, AD patients typically show a general deficit in memory. For example, they do not perform relatively better in recognition tasks than in recall tasks as do healthy older adults, nor do they show improvement from supportive task conditions such as semantic cueing. They also perform poorly on tests that measure semantic memory, such as the category fluency task.[38] Conversely, the differences between healthy older adults and AD patients in other age-sensitive measures may not be evidenced until later phases of AD.

Memory Improvement

The empirical studies reviewed above indicate that memory performance can be improved in healthy older adults by many means. These effective memory-enhancing methods take 2 major approaches: one is to create supportive conditions that minimize the demand for controlled processing (for example, provision of cues at test) or allow older adults to rely on their intact processes (for example, semantic processing); the other is to directly train their efficiency in strategic and controlled processes (for example, training recollection). The former approach can be used in practice to devise effective memory aids, whereas the latter approach has implications for designing rehabilitation programs for older adults.

The effect of a rehabilitation study on memory taking the latter approach was reported by Craik et al.[39] The memory training was designed specifically for elderly adults and focused on strategies and techniques that improve organizational and memory skills. The training had a beneficial effect on tests that rely heavily on strategic control (for example, recall of word lists and stories). Conversely, tests that are little affected by aging (for example, primary memory and recognition tests) showed little benefit. This result, along with other positive results in the literature,[40] suggests that training can improve memory functions in the elderly over an extended period. However, the extent that the beneficial effects are limited by the specific training task used remains to be identified. Further research must be done to test the generalizability of rehabilitation procedures.

In summary, older adults experience difficulties with memory functions; however, these difficulties are not consistent across all aspects of memory—some types of memory decline with age, other types show little or no change. Further, memory functions in healthy elderly adults can be improved or even repaired through training and support. Clinical researchers and professionals should be aware of the complex nature of memory aging when dealing with older people, and cognitive researchers should work toward further clarification of the findings to reveal the mechanisms underlying memory problems of older people.

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References

1. Tulving E. Concepts of memory. In: Tulving E, Craik FIM, editors. The Oxford handbook of memory. New York (NY): Oxford University Press; 2000. p 33–43.
2. Balota DA, Dolan PO, Ducheck JM. Memory changes in healthy older adults. In: Tulving E, Craik FIM, editors. The Oxford handbook of memory. New York (NY): Oxford University Press; 2000. p 395–409.
3. Zacks RT, Hasher L, Li KZH. Human memory. In: Craik FIM, Salthouse TA, editors. The handbook of aging and cognition. 2nd ed. Mahwah (NJ): Lawrence Erlbaum Associates Publishers; 2000. p 293–357.
4. Salthouse TA. The processing-speed theory of adult age differences in cognition. Psychol Rev. 1996;103:403–428.
5. Craik FIM, Byrd M. Aging and cognitive deficits: the role of attentional resources. In: Craik FIM, Trehub SE, editors. Aging and cognitive processes. New York (NY): Plenum Press; 1982. p 191–211.
6. Craik FIM. Age-related changes in human memory: practical consequences. In: Nilsson L, Ohta N, editors. Memory and society: psychological perspectives. New York (NY): Psychology Press; 2006. p 181–197.
7. Naveh-Benjamin M. Adult age differences in memory performance: test of an associative deficit hypothesis. J Exp Psychol Learn Mem Cogn. 2000;26:1170–1187.
8. Hasher L, Zacks RT. Working memory, comprehension, and aging: a review and a new view. In: Bower GH, editor. The psychology of learning and motivation: advances in research and theory. San Diego (CA): Academic Press; 1988. p 193–225.
9. Hasher L, Zacks RT. Automatic and effortful processes in memory. J Exp Psychol Gen. 1979;108:356–388.
10. Jacoby LL. A process dissociation framework: separating automatic from intentional uses of memory. J Mem Lang. 1991;30:513–541.
11. Jennings JM, Jacoby LL. Automatic versus intentional uses of memory: aging, attention, and control. Psychol Aging. 1993;8:283–293.
12. Craik FIM, Jennings JM. Human memory. In: Craik FIM, Salthouse TA, editors. The handbook of aging and cognition. Hillsdale (NJ): Lawrence Erlbaum Associates; 1992. p 51–110.
13. Craik FIM. On the transfer of information from temporary to permanent memory. Philos Trans R Soc Lond B Biol Sci. 1983;302:341–359.
14. La Voie D, Light LL. Adult age differences in repetition priming: a meta-analysis. Psychol Aging. 1994;9:539–553.
15. Luo L, Hendriks T, Craik FIM. Age differences in recollection: three patterns of enhanced encoding. Psychol Aging. 2007;2:269–280.
16. Troyer AK, Häfliger A, Cadieux MJ, et al. Name and face learning in older adults: effects of level of processing, self-generation, and intention to learn. J Gerontol B Psychol Sci Soc Sci. 2006;61:67–74.
17. Spencer WD, Raz N. Differential effects of aging on memory for content and context: a meta-analysis. Psychol Aging. 1995;10:527–539.
18. Chalfonte BL, Johnson MK. Feature memory and binding in young and older adults. Mem Cognit. 1996;24:403–416.
19. Rahhal TA, May CP, Hasher L. Truth and character: sources that older adults can remember. Psychol Sci. 2002;13:101–105.
20. Ferguson SA, Hashtroudi S, Johnson MK. Age differences in using source-relevant cues. Psychol Aging. 1992;7:443–452.
21. Deese J. On the prediction of occurrence of particular verbal intrusions in immediate recall. J Exp Psychol. 1959;58:17–22.
22. Roediger HL, McDermott KB. Creating false memories: remembering words not presented in lists. J Exp Psychol Learn Mem Cogn. 1995;21:803–814.

23. Normal KA, Schacter DL. False recognition in younger and older adults: exploring the characteristics of illusory memories. Mem Cognit. 1997;25:838–848.
24. Schacter DL, Koutstaal W, Norman KA. False memories and aging. Trends Cogn Sci. 1997;1:229–236.
25. McDermott KB, Watson JM. The rise and fall of false recall: the impact of presentation duration. J Mem Lang. 2001;45:160–176.
26. Johnson MK, Hashtroudi S, Lindsay DS. Source monitoring. Psychol Bull. 1993;114:3–28.
27. Jacoby LL. Ironic effects of repetition: measuring age-related differences in memory. J Exp Psychol Learn Mem Cogn. 1999;25:3–22.
28. McCabe DP, Smith AD. The effect of warnings on false memories in young and older adults. Mem Cognit. 2002;30:1065–1077.
29. Dodson CS, Schacter DL. Aging and strategic retrieval processes: reducing false memories with a distinctiveness heuristic. Psychol Aging. 2002;17:405–415.
30. Jennings JM, Jacoby LL. Improving memory in older adults: training recollection. Neuropsychol Rehabil. 2003;13:417–440.
31. Einstein GO, McDaniel MA, Richardson SL, et al. Aging and prospective memory: examining the influences of self-initiated retrieval processes. J Exp Psychol Learn Mem Cogn. 1995;21:996–1007.
32. Henry JD, MacLeod MS, Phillips LH, et al. A meta-analytic review of prospective memory and aging. Psychol Aging. 2004;19:27–39.
33. McDaniel MA, Einstein GO. Strategic and automatic processes in prospective memory retrieval: a multiprocess framework. Appl Cogn Psychol. 2000;14:127–144.
34. Rendell PG, Craik FIM. Virtual week and actual week: age-related differences in prospective memory. Appl Cogn Psychol. 2000;14:S43–S62.
35. Hasher L, Zacks RT, May CP. Inhibitory control, circadian arousal, and age. In: Gopher D, Koriat A, editors. Attention and performance XVII: cognitive regulation of performance: interaction of theory and application. Cambridge (MA): The MIT Press; 1999. p 653–675.
36. Wechsler DA. Wechsler Memory Scale–III. New York (NY): Psychological Corporation; 1997.
37. Craik FIM. A functional account of age differences in memory. In: Flix F, Hagendorf H, editors. Human memory and cognitive capabilities, mechanisms, and performance. Amsterdam (NL): North Holland: Elsevier; 1986. p 409–422.
38. Butters N, Delis DC, Lucas JA. Clinical assessment of memory disorders in amnesia and dementia. Annu Rev Psychol. 1995;46:493–523.
39. Craik FIM, Winocur G, Palmer H, et al. Cognitive rehabilitation in the elderly: effects on memory. J Int Neuropsychol Soc. 2007;13:132–142.
40. Glisky EL, Glisky ML. Memory rehabilitation in the elderly. In: Stuss DT, Winocur G, Robertson IH, editors. Cognitive neurorehabilitation. New York (NY): Cambridge University Press; 1999. p 347–361.

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Résumé : Le vieillissement et la mémoire : une approche cognitive

Cet article décrit les changements de la mémoire qui se produisent durant le cours normal du vieillissement, du point de vue de la psychologie cognitive. Il y a désormais une grande quantité de données probantes qui indiquent que la mémoire n'est pas une seule fonction, mais qu'elle peut être décrite en termes de différents systèmes de mémoire révélant des effets différentiels du vieillissement. Par exemple, la mémoire des procédures, et certaines fonctions de la mémoire perceptuelle, montrent peu de changements liés à l'âge, alors que la mémoire de travail, la mémoire épisodique et la mémoire prospective déclinent substantiellement durant le cours normal du vieillissement. La mémoire des faits et connaissances (mémoire sémantique) se maintient bien chez les personnes âgées, pourvu que l'information soit utilisée fréquemment, bien que la capacité de récupérer des renseignements très spécifiques (comme des noms) décline habituellement. L'article discute des exposés théoriques actuels sur les effets du vieillissement; différents théoriciens attribuent les changements de la mémoire et de la cognition à un ralentissement mental, au déclin des ressources attentionnelles, à l'incapacité de bloquer l'information superflue, et au déclin du contrôle cognitif. Il est également suggéré entre autres que le rendement de la mémoire chez les adultes âgés est particulièrement vulnérable quand le besoin de traitement autonome est le plus grand; réciproquement, le rendement est aidé efficacement par l'apport d'un soutien environnemental. Les implications pratiques des résultats et des idées de cette recherche incluent la notion que les évaluations cliniques de la mémoire devraient incorporer des tests destinés à mesurer les différents aspects du fonctionnement de la mémoire.