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Memory

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Despite a wealth of anecdotal evidence of age-related memory change, programmatic research on this topic is relatively recent, dating back no further than the 1970s. Most memory and aging research has relied on the laboratory methods of cognitive psychology and cognitive neuropsychology, often comparing convenience samples of healthy younger adults (18 to 30 years of age) with those of healthy older adults (age 60 years and older). Since the mid-1990s, the emergence of an interdisciplinary cognitive neuroscience of aging has caused a rapid increase in research examining the neural bases of age-related changes in memory. Findings reflect a complex mixture of age-related stability and decline across different memory functions and their neural correlates as well as a high degree of between-person variability.

Behavioral Findings

The results of experimental laboratory studies suggest that sensory memory, an initial repository for raw sensory information, remains stable with age. For example, younger and older adults' visual sensory memory stores are similar in capacity and duration. There also appears to be relatively little age-related change in short-term memory, which holds limited amounts of information in conscious awareness over brief periods of time. When younger and older adults are presented with random strings of digits or letters and asked to repeat them back in the same order after a short delay (3 to 30 seconds), older adults remember about as many items as do younger adults.

So-called “working memory” tasks, requiring the coordination of two simultaneous activities (processing new information while holding onto other information), do tend to be vulnerable to the effects of age. For example, older adults typically do worse than younger adults on tasks that require holding words in memory while answering text comprehension questions or that require remembering digits while solving mental arithmetic problems. The cause of age differences in working memory is still under debate, but there is consensus that several factors seem to be involved, including age-related cognitive slowing, age-related declines in a basic “cognitive resource” (e.g., attentional capacity), and age-related declines in the ability to inhibit processing of goal-irrelevant information.

Long-term memory, which stores information over longer periods—minutes, days, or even years—is also vulnerable to the effects of aging, although the degree of age-related change varies as a function of the type of memory task and the nature of the to-be-retrieved information. Given this diversity, it is useful to distinguish among episodic, semantic, and procedural long-term memory. In general, age differences are most pronounced in episodic memory, which involves remembering specific events (“episodes”) and their context. An everyday example is trying to recall what one had for lunch yesterday. In the laboratory, older adults' episodic memory difficulties are reflected in reduced accuracy and slowed response on tests of memory for newly learned materials (e.g., words, pictures). Age-related deficits tend to be particularly pronounced when it is necessary to retrieve the contextual details of past events. For example, if statements are presented by two sources, a later recognition test may show only small age differences in memory for the statements but large age differences in memory for the source of each statement.

Although age differences in episodic memory can be attributed in part to age-related declines in processing speed, cognitive resources, and inhibition of irrelevant information, these factors cannot fully explain the decline in episodic memory. Additional causes include age-related decline in the spontaneous use of effective encoding strategies (e.g., imagery, elaborative processing), age deficits in the ability to recollect contextual details, and conservative response tendencies among older adults.

In contrast to episodic memory, semantic memory is relatively immune to age-related decline. Semantic memory includes general knowledge of facts, word meanings, and other information not associated with a specific temporal or spatial context. For example, older adults typically perform as well as, or better than, younger adults on tests of vocabulary and general knowledge. Word-finding problems and “tip of the tongue” experiences, a frequent memory complaint in older adults, appear to be caused by a mild age-related decline in the retrieval of phonological information.

A third form of long-term memory, implicit or procedural memory, is also relatively unaffected by age. Implicit memory is indicated by a change in behavior following exposure to information without intentional or conscious retrieval of that information. For example, when asked to solve anagrams, both younger and older adults are quicker to identify words to which they were recently exposed, even if they cannot consciously remember that prior exposure.

Neural Bases

Although normal aging is associated with structural and functional changes in many brain areas, medial–temporal and frontal cortical regions have been shown to play a crucial role in memory and in age-related memory change. The medial–temporal region is involved in the initial “binding” of conscious experience into coherent memories. Age-related shrinkage of the entorhinal cortex, a medial–temporal structure, has been identified as a predictor of normal age-related episodic memory decline. Neuroimaging studies have shown that parts of the hippocampus, a medial–temporal structure, are less active in older adults than in younger adults during a number of cognitive tasks, including memory encoding and working memory. However, there are also reports of age-related increases in activation in neighboring parahippocampal cortex during recognition decisions.

The prefrontal cortex is involved in coordinating and planning higher cognitive functions, including memory. Prefrontal regions are among those most affected by age-related cortical volume loss, and age-related declines in dopaminergic projections to the pre-frontal cortex may also contribute to this region's role in age-related changes in memory. The prefrontal cortex shows significant changes in use with age during encoding and retrieval from working memory and long-term memory. Both decreases in activation (e.g., of left prefrontal areas during encoding) and increases in activation (e.g., of left prefrontal areas during retrieval, of bilateral dorsolateral prefrontal cortex during working memory) have been observed in older adults. In addition, older adults often activate the same frontal cortical area bilaterally during tasks for which younger adults activate either the left or right side. Although the significance of this age-related decrease in hemispheric asymmetry is still under debate, current evidence favors the view that it helps older adults to compensate for declines in overall processing efficiency.

Role of Physical and Intellectual Activity

Studies using subjective measures of physical health and fitness (e.g., health questionnaires) have not provided clear evidence for a relationship between health and memory in older adults. Objective measures have provided more conclusive, and generally positive, results. For example, in a recent longitudinal study, biological age as indexed by so-called biomarkers (e.g., visual acuity, grip strength, peak expiratory flow) was shown to be a stronger predictor of memory decline than was chronological age. Similarly, results from an ongoing large-scale study (Victoria Longitudinal Study) have indicated a positive association between intellectual activity and the degree of age-related memory decline. However, it is unclear whether this association reflects a protective effect of intellectual engagement or whether it results from self-selection (i.e., individuals with high intellectual ability and low vulnerability to cognitive decline seek out more cognitively demanding activities than do individuals with lower intellectual ability).

Intervention studies have demonstrated that older adults' memory can be boosted by physical and intellectual activity. Little is known about possible life span changes in susceptibility to such interventions because most studies have included only older participants. A recent meta-analysis of intervention studies conducted from 1966 to 2001 found that aerobic fitness training in older adults can improve executive functioning (e.g., coordination, planning) and, to a lesser extent, controlled cognitive processes (e.g., control of attention during the initial learning of a new skill). However, the extent of these improvements depended on characteristics of the training program (e.g., combined strength and aerobic training were optimal, long-term programs were more effective than short-term programs) and of the study population (e.g., mostly female samples showed greater benefits than did mostly male samples). To the extent that executive functioning and cognitive control contribute to memory performance, therefore, the data suggest that fitness training may boost at least some forms of memory.

A recent multisite randomized controlled trial with more than 2,800 participants (Advanced Cognitive Training for Independent and Vital Elderly [ACTIVE] study) confirmed previous findings of performance improvements for both laboratory-type episodic memory tasks (e.g., word list recall) and memory for information relevant to daily activities (e.g., remembering shopping lists) after mnemonic strategy training. The training impact remained significant over a 2-year period, but participants failed to show generalization to memory tasks that were not specifically trained.

- long term memory
- episodic memory
- memory
- young adults
- age and aging
- aerobic training
- executive function

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See also

- Alzheimer's Disease
- Cardiovascular System
- Depression and Other Mood Disorders
- Exercise and Physical Activity
- Geriatric Assessment

- Imaging of the Brain
- Longitudinal Research
- Mental Status Assessment
- Mild Cognitive Impairment
- Neurobiology of Aging
- Normal Physical Aging
- Stroke

Further Readings and References

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