

Enhancing the Cognitive Vitality of Older Adults

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Abstract

Aging is associated with decline in a multitude of cognitive processes and brain functions. However, a growing body of literature suggests that age-related decline in cognition can sometimes be reduced through experience, cognitive training, and other interventions such as fitness training. Research on cognitive training and expertise has suggested that age-related cognitive sparing is often quite narrow, being observed only on tasks and skills similar to those on which individuals have been trained. Furthermore, training and expertise benefits are often realized only after extensive practice with specific training strategies. Like cognitive training, fitness training has narrow effects on cognitive processes, but in the case of fitness training, the most substantial effects are observed for executive-control processes.

Keywords

aging; plasticity; cognitive enhancement

One of the most ubiquitous findings in research on cognition and aging is that a wide variety of cognitive abilities show an increasing decline across the life span. Declines in cognitive function over the adult life span have been found in both cross-sectional and longitudinal studies for a variety of tasks, abilities, and processes. Cross-sectional studies, which compare the performance of one age group with that of another, have found linear decreases in a number of measures of cognition over the adult life span (Salthouse, 1996). Longitudinal studies, which range in length from a few years to more than 40 years, have found that the rate and onset of decline is variable, depending on the ability, and that accelerated decline occurs in the late 70s (Schaie, 2000). Although there are a number of factors that may be responsible for the different results obtained in the cross-sectional and longitudinal studies (e.g., differential attrition, non-age-related differences between age groups in cross-sectional studies, effects of practice, and study length in longitudinal studies), the important common observation is a reduction in cognitive efficiency with age.

Although age-related cognitive decline is quite broad, there are some notable exceptions. It has generally been observed that knowledge-based abilities (also called crystallized abilities) such as verbal knowledge and comprehension continue to be maintained or improve over the life span. In contrast, process-based abilities (also called fluid abilities) display age-related declines.

An important current issue concerns the source (or sources) of age-related declines in process-based abilities. A large number of mostly cross-sectional studies have found that age-related influences on different skills are highly related, prompting the suggestion that a common factor may be responsible for age-related declines (Salthouse, 1996). Many proposals concerning the source or mechanism responsible for this general decline have been advanced. For example, reduced processing speed, decreased attentional resources, sensory deficits, reduced working memory² capacity, impaired frontal lobe function, and impaired neurotransmitter function have all been cited as possible mechanisms of age-related cognitive decline.

Contrary to the general-decline proposals, a growing body of literature has pointed out a number of situations in which age-related differences remain after a general age-related factor has been statistically or methodologically controlled for (Verhaeghen, Kliegl, & Mayr, 1997). Such data suggest that a variety of different mechanisms may be responsible for age-related declines in information processing and that

these mechanisms may be differentially sensitive to age.

DOES EXPERIENCE MODULATE AGE-RELATED COGNITIVE DECLINE?

Over the past several decades, researchers have examined whether previous experience in content areas (domains) such as driving, flying, and music serves to (a) reduce age-related decline in basic abilities, (b) aid in the development of domain-specific strategies that can compensate for the effects of aging on basic abilities, or (c) both reduce decline and help develop compensating strategies. In general, these studies have found that well-learned skills can be maintained at relatively high levels of proficiency, well into the 70s. However, these same studies have found that general perceptual, cognitive, and motor processes are not preserved in these highly skilled individuals. Thus, preservation of cognitive abilities for highly skilled individuals appears to be domain-specific and compensatory in nature. For example, Salthouse (1984) examined the performance of young and old adult typists and found a significant age-related decline in the performance of general psychomotor tasks, but no age-related deficit in measures of typing proficiency. Furthermore, the older typists were better able than the young typists to use preview of the text to decrease their interkeystroke times, thereby enhancing their typing. Thus, the older typists were able to employ their accrued knowledge of the task domain to implement a strategy that compensated for declines in processing speed.

Krampe and Ericsson (1996) examined how amateur and expert pianists' expertise influenced their

general processing speed, as well as performance on music-related tasks (i.e., single-hand and bimanual finger coordination). The general processing-speed measures showed an age-related decrement, regardless of the level of the individuals' music expertise. However, in the case of the music-related tasks, age-related effects were abolished for the expert pianists, although not for the amateur pianists. Furthermore, among the experts, high levels of deliberate practice over the past 10 years were found to be associated with decreases in age-related differences in music-related performance.

Despite the impressive cognitive sparing observed in the studies just discussed, as well as other studies, a variety of studies have failed to demonstrate an effect of expertise on age-related decline. The variability of the findings could be the result of several factors, including (a) the recency and amount of deliberate practice, (b) the degree to which the criterion tasks were specific to the domain of expertise, and (c) the age and health of the study participants.

In summary, the answer to the question of whether experience can reduce age-related cognitive decline is affirmative. However, this answer must be qualified. Sparing seems to be domain-specific, rather than general, and appears to depend on deliberate practice of the relevant skills and possibly also development of compensatory strategies.

CAN LABORATORY-BASED TRAINING REDUCE COGNITIVE DECLINE?

In this section, we discuss the results of laboratory-based practice and training studies on development and improvement of cognitive skills. We also address the specificity of these skills. We begin with a discussion of cross-sectional studies of the effects of training and conclude with an examination of longitudinal studies, in which specific individuals served as their own controls.

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Cross-Sectional Training Studies

In general, old and young adults have been found to learn new tasks and skills at approximately the same rate and to show the same magnitude of benefit from training. Such data clearly suggest that older adults can learn new skills. However, given that older adults' baseline performance on most tasks is lower than that of younger adults, these data also suggest that age-related differences in level of performance will be maintained after training.

There have, however, been some interesting exceptions to these general observations. For example, Baron and Mattila (1989) examined the influence of training on the speed and accuracy with which young and older adults performed a memory search task; that is, the subjects memorized a set of items and then compared a newly presented item to the items in memory, to decide whether the new item was a member of the original memory set or not. Subjects were trained for 44 hr with a deadline procedure in which they were required to constantly increase the speed with which they performed the task. Prior to training, young and older adults performed the task with comparable accuracy, but the older adults were substantially slower. During training with the deadline procedure, both young and older adults performed more quickly, but with a substantially elevated error rate. Interestingly, when the deadline procedure was relaxed, the young and older adults performed with equivalent accuracies, and the speed differences between the groups were sub-

stantially reduced. Thus, these data suggest that the older adults improved their speed of responding more than the younger adults did.

A similar pattern of results was obtained in a study of training effects on dual-task performance (Kramer, Larish, Weber, & Bardell, 1999). Young and old adults were trained to concurrently perform two tasks, a pattern-learning task and a tracking task (i.e., a task that involved using a joystick to control the position of an object so that it constantly matched the position of a computer-controlled object), with either of two training strategies. In the fixed-priority training condition, subjects were asked to treat the two tasks as equal in importance. In the variable-priority training condition, subjects were required to constantly vary their priorities between the two tasks. In both training conditions, subjects received continuing feedback on their performance.

Several interesting results were obtained. First, as in previous studies, young and old adults improved their dual-task performance at the same rate when using the fixed-priority training strategy. Second, variable-priority training led to faster learning of the tasks, a higher level of mastery, superior transfer of learning to new tasks, and better retention than did fixed-priority training. Finally, age-related differences in the efficiency of dual-task performance were substantially reduced for individuals trained in the variable-priority condition.

Although these studies and several others found that training decreased age-related performance differences, other studies have failed to demonstrate such training effects. What is the reason for these seemingly contradictory results? Although there is quite likely not a single answer to this question, one possibility centers on the nature of the training procedures. The training strategies in the two studies we just summarized explic-

itly focused on aspects of performance on which young and older adults showed large differences. For example, the deadline strategy employed by Baron and Mattila encourages individuals to emphasize speed rather than accuracy, something older adults are hesitant to do. Similarly, older adults have been observed to have difficulty in flexibly setting and modifying processing priorities among concurrently performed tasks. The variable-priority training strategy explicitly targets this skill. Thus, although additional research is clearly needed to further examine the situations in which the age gap in performance can be reduced, one potentially fruitful area of inquiry concerns targeting training strategies to specific difficulties encountered by older adults.

Longitudinal Studies of Practice and Training

A central focus of longitudinal studies has been to examine the extent to which training remediates or improves elders' performance on tasks for which there is long-term data. Given the wide individual differences in timing of age-related ability decline, two questions arise: First, is training effective in remediating decline for elders who have shown loss in a specific ability? Second, can training enhance the performance of elders showing no decline in a specific ability?

Data from the Seattle Longitudinal Study provide some initial answers to these questions. In this study, elders were classified as to whether they had shown reliable decline over a 14-year interval on two fluid abilities known to show early age-related decline—inductive reasoning and spatial orientation (Schaie & Willis, 1986). These individuals then received 5 hr of training on either inductive reasoning or spatial orientation. More than

two thirds of elders who received training on each ability showed reliable improvement on that ability. Of those who had declined on the ability trained, 40% showed remediation, such that their performance was at or above their level of performance 14 years prior to the training. Elders who had not declined also showed reliable improvement. Moreover, the effects of training on inductive reasoning lasted up to 7 years after training (Saczynski & Willis, 2001).

Summary

Cross-sectional training research suggests that both young and old adults profit from training, but that strategies targeted at skills known to decline with age are particularly effective in training of elders. Longitudinal studies make it possible to identify abilities that have declined for a given individual and to assess whether the individual can benefit from training targeted at his or her specific deficits. Using the longitudinal approach, researchers can examine the range of plasticity (i.e., the extent to which an individual can benefit from training) over time within the same individual, rather than comparing the magnitude of training effects for different age groups. Both types of training research support the position that even individuals of advanced age have considerable plasticity in their cognitive functioning. The training findings also support the descriptive experiential studies of cognitive decline in showing that effects are specific to the particular domain that was practiced or trained.

FITNESS AND COGNITIVE SPARING?

The relationship between fitness and mental function has been

a topic of interest to researchers for the past several decades. Their research has been predicated on the assumption that improvements in aerobic fitness translate into increased brain blood flow, which in turn supports more efficient brain function, particularly in older adults for whom such function is often compromised. Indeed, research with older nonhuman animals has found that aerobic fitness promotes beneficial changes in both the structure and the function of the brain (Churchill et al., in press).

However the results from human studies that have examined the influence of aerobic fitness training on cognition have been mixed. Some studies have demonstrated fitness-related improvements for older adults, but others have failed to show such improvements. Clearly, there are a number of potential theoretical and methodological reasons for this ambiguity. For example, studies have differed in the length and the nature of the fitness interventions, the health and age of the study populations, and the aspects of cognition that have been examined.

A recent analysis statistically combining the results of fitness intervention studies that have been conducted since the late 1960s (Colcombe & Kramer, in press) lends support to the idea that fitness training can improve cognitive functioning. Perhaps the most important finding obtained in this analysis was that the effects of fitness were selective rather than general. That is, aerobic fitness training had a substantially larger positive impact on performance of tasks with large executive-control components (i.e., tasks that required planning, scheduling, working memory, resistance to distraction, or multitask processing) than on performance of tasks without such components. Interestingly, substantial age-related defi-

cits have been reported for executive-control tasks and the brain regions that support them. Thus, it appears that executive-control processes can benefit through either training or improved fitness. An important question for future research is whether such benefits are mediated by the same underlying mechanisms.

CONCLUSIONS AND FUTURE DIRECTIONS

The research we have reviewed clearly suggests that the cognitive vitality of older adults can be enhanced through cognitive training, in the form of domain-relevant expertise or laboratory training, and improved fitness. However, it is important to note that these benefits are often quite specific and have not been observed in all published studies (Salthouse, 1990). Therefore, one important goal for future research is to determine when these benefits are and are not produced. Clearly, there are some obvious candidate factors that should be examined in more detail. These include age, health conditions, medication use, gender, education, lifestyle choices, genetic profile, and family and social support.

The nature and length of training, whether cognitive or fitness training, bears further study. It is important to note that many of the previous studies of "training" have examined unsupervised practice rather than specific training procedures that might be well suited to the capabilities of older adults. The development of new methods, such as the testing-the-limits approach³ (Kliegl, Smith, & Baltes, 1989), will clearly also be important in future studies of training and other interventions.

At present, psychologists have little understanding of the mecha-

nisms that subserve age-related enhancements in cognitive efficiency. Possibilities include improvements in basic cognitive abilities, the development of compensatory strategies, and automatization of selective aspects of a skill or task (Baltes, Staudinger, & Lindenberger, 1999). Thus, the nature of cognitive and brain processes that support improvements in cognitive efficiency is an important topic for future research.

Finally, we would like to emphasize the importance of theory-guided research in the study of interventions targeted to enhancing the cognitive function of older adults. Theories of life-span change, such as the theory of selective optimization with compensation⁴ (Baltes et al., 1999), offer great promise in this endeavor.

Recommended Reading

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Notes

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2. Working memory refers to processes needed to both store and retrieve information over brief periods, as well as processes necessary to manipulate the stored information (e.g., remembering a few weight measurements in pounds and converting them to kilograms).

3. Testing-the-limits examines the range and limits of cognitive reserve capacity as an approach to understanding age differences in cognitive processes.

4. This theory suggests that during aging, individuals maintain skill by focusing on selective aspects of broader skills, practicing these subskills often, and sometimes shifting strategies (e.g., shifting from speed to accuracy) to maintain performance.

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