FIT BODY, FIT MIND?

How can you stay sharp into old age?
It is not just a matter of winning the genetic lottery.
What you do can make a difference

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A sorrow is if you do not work out, your muscles get flaccid. What most people don’t realize, however, is that your brain also stays in better shape when you exercise. And not just challenging your noggin by, for example, learning a new language, doing difficult crosswords or taking on other intellectually stimulating tasks. As researchers are finding, physical exercise is critical to vigorous mental health, too.

Surprised? Although the idea of exercising cognitive machinery by performing mentally demanding activities—popularly termed the “use it or lose it” hypothesis—has been known, a review of dozens of studies shows that maintaining a mental edge requires more than that. Other things you do—including participating in activities that make you think, getting regular exercise, staying socially engaged and even having a positive attitude—have a meaningful influence on how effective your cognitive functioning will be in old age.

Further, the older brain is more plastic than is commonly known. At one time, the accepted stereotype was that “old dogs can’t learn new tricks.” Science has proved that this dictum must be discarded. Although older adults generally learn new pursuits more slowly than younger people do and cannot reach the peaks of expertise in a given field that they might have achieved if they had started in their youth, they nonetheless can improve their cognitive performance through effort. Forestalling some of the declines in cognition that come with advancing age. As John Adams, one of the Founding Fathers and the second U.S. president, put it: “Old minds are like old horses; you must exercise them if you wish to keep them in working order.”

The news comes at a propitious time. The proportion of older adults in the U.S. and in other industrial nations continues to grow: in 1900, 4.0 percent of U.S. citizens were older than 65; by 2000, that amount had jumped to 12.6 percent. By 2030, 20 percent of us will be in that category. From a societal point of view, prolonging independent functioning is both a desirable goal in itself and a way of deferring costs of long-term care. For individuals, maintaining optimal cognitive functioning is worthwhile simply because it promises
The Power of Walking

Older adults who participated in aerobic exercise (walking) outperformed those in programs for stretching and toning (control) in cognitive task areas: executive (related to planning and multitasking), controlled (effortful processes in response to novel situations), spatial (dealing with spatial information in perception or memory), and speed.

MENTAL TRAINING
HOW TO KEEP MINDS YOUNG OVER AN ENTIRE LIFE SPAN

One of the earliest writings on mental training was a book by Roman emperor Cicero put it: "It is exercise alone that supports the spirits, and keeps the mind in vigor." Modern research in this field began in the 1970s and 1980s, with studies that demonstrated that healthy older adults can improve performance to a greater extent than had been previously assumed. The earlier research did not fully address certain questions, such as how long adults could retain the skills they had acquired through training, whether those specifically developed skills would spread to other areas of cognitive function, or whether the studies done with small numbers of subjects would be broadly applicable.

Cognitive training can lead to substantial benefits for older adults on the tasks trained, and some of these benefits are maintained over time and may transfer to other tasks. Toward the end of the 20th century the National Institute on Aging funded a consortium of researchers to conduct a large-scale training study in a sample of older Americans. In 2002 psychologist Karlene Ball of the University of Alabama at Birmingham and her colleagues published initial results on more than 2,300 individuals older than 65 who had received about 30 sessions of cognitive training. Participants were randomly assigned either to a cognitive-process training group to learn how to excel in one of three areas: memory, reasoning, or visual search—or to a control group of subjects who did not receive training. At a follow-up two years later, the team randomly selected a set of the initial participants for booster training prior to evaluation. The results showed strong transfer-effect sizes in each group as compared with controls. In tests five years later, measurable training benefits were still present.

More impressive, however, are recent training studies that focus on what psychologists call working memory and executive function—how a person plans a strategic approach to a task, controls what is attended to, and how he or she manages the mind in the process. Psychologist Chandramauli Baner, then at the University of Illinois, and her colleagues showed that training in a real-time strategy video game that demands planning and executive control not only improved gaming performance but also enhanced performance on other tasks measuring aspects of executive control.

Some studies have also increased the amount of practice provided. For instance, Florian Schmiedek and one of us (Lindenberger) of the Max Planck Institute for Human Development in Berlin and Martin Lövén of the Karolinska Institute in Stockholm asked 101 younger and 103 older adults to practice 12 different tasks for 100 days. Each of the tasks belonged to one of three different sets of cognitive skills—working memory, episodic memory, and perceptual speed. Both younger and older adults showed general improvements in working memory. Younger adults also broadly improved in memory and reasoning tasks, and maintained their gains in reasoning over a period of two years.

You do not have to have specialized training, however, to achieve gains in cognitive function. Everyday activities such as reading can help. We reviewed evidence on activity-related cognitive benefits in more than 30 trials. In 2004 one of us (Wulson) and his colleagues at Rush University Medical Center in Chicago recruited more than 6,000 elderly residents from a geographically defined community and rated their frequency of participation in seven cognitive activities (for instance, reading magazines). At three-year intervals for a mean of nearly six years, participants completed in-home interviews that included brief tests of cognitive function. More frequent cognitive activity at the outset was associated with a reduced rate of cognitive decline over time. But not all studies of cognitive training agree, as some studies that looked at practice for minutes to complete and included tests of language, verbal memory, numerical memory, conceptualization, and visual-spatial ability. They found that the best predictors of cognitive change over a two-year period included strenuous activity and peak performance/gain training.

In an investigation published in 2004 epidemiologist Jennifer Warr, then at Harvard University, and her colleagues also examined the relationship between physical activity and cognitive change over a two-
year period in 30,668 nurses who were older than 70. Participants logged how much time they spent per week in a variety of physical activities (running, jogging, walking, hiking, netball sports, swimming, bicycling, aerobic dance) over the past year and provided self-reports of walking pace in minutes per mile. We were able to observe a significant relation between energy expended in physical activities and cognition, across a large set of cognitive measures.

Researchers that have described the effects of mental or physical performance over relatively short periods—just a few years. A few studies have begun to look at what happens over longer timescales. In 2005, Sari Rovio, now at the University of Turku in Finland, and her colleagues examined the relation between physical activity at middle age and risk of dementia an average of 21 years later, when the cohort was between 65 and 79 years of age. Subjects indicated how often they participated in leisure-time physical activities that lasted at least 20 to 30 minutes and caused breathlessness and sweating. Conducting such activity at least twice a week was associated with a reduced risk of dementia in later life. Indeed, participants in the most active group had a 52 percent lower odds of having dementia than the more sedentary group did.

In 2010, Kirk Erickson and his colleagues at the University of Pittsburgh extended previous research examining the relation between physical activity, cognition and dementia by assessing self-reported physical activity alongside measures of regional brain volume. They reported an association between walking and prioritization of brain volume, which in turn predicted a reduced risk of dementia in 259 older adults over a period of 13 years. Interestingly, it is not just aerobic forms of physical activity (such as walking, jogging, swimming and bicycling) that have been associated with improvements in cognition. Teresa Liu-Ambrose, a professor of physical therapy at the University of British Columbia, reported in 2010 that resistance exercise, over a one-year period, improved aspects of executive control in older women.

MIND-BODY CONNECTION
It makes sense that training or participation in novel stimuliating activities would help cognition, but it is perhaps less immediately obvious why physical activity would have such an effect. Consider the increasingly well-documented link between physical activity and disease. A plethora of studies have examined the health benefits of exercise and a non-sedentary lifestyle for prevention of disease. For example, we now know that physical activity reduces the risk of cardiovascular-related death, type 2 diabetes, colon and breast cancer, and osteoporosis. On the other hand, cardiovascular disease, diabetes and cancer have been associated with compromised cognition. Therefore, you might expect that increased physical activity and exercise would maintain cognition by reducing risk of diseases associated with cognitive decline.

In a study published in 2008 by psychologists Stanley J. Cochrane, then at the University of Illinois, and his colleagues examined the influence of fitness training on potential changes in brain structure. The six-month trial included 50 healthy but sedentary community-dwelling volunteers, age 60 to 79. Brain scans after fitness training showed that even relatively short exercise interventions can begin to restore some of the losses in brain volume associated with normal aging. In 2011, Erickson and his colleagues reported on work done at the University of Illinois, which showed that one year of walking, an hour a day for three days a week, increased the volume of the hippocampus in older adults. The hippocampus supports important aspects of memory such as associating an individual's face with her name and discussions that you might have had with her.

Researchers have found that different brain regions that need to communicate to support memory, reasoning and problem-solving become more poorly connected as we age. A study by Michelle Voss of the University of Illinois and her colleagues found, however, that when older adults participated in a six-month walking program, connectivity increased in a number of brain networks, and this increased connectivity was associated with improvements in executive control processes (such as scheduling, planning, dealing with ambiguity, and working memory). Other recent studies have replicated and extended these results. These studies and those presented earlier in the article suggest improvement in cognition, brain structure and function in response to improvements in fitness.

Supporting these findings, a large body of nonhuman animal research has demonstrated a number of changes in brain structure and function after animals are exposed to enriched, or complex, environments. Enriched environments usually include running wheels, a multitude of toys and objects to climb that are changed frequently, and animal companions. Exposure to such environments yields several physiological benefits. First, it increases the formation of new dendrite branches and synapses—the areas of neural cells that receive...
and send communication signals. It also increases the number of glial cells, which support the health of neurons, and expands the brain’s oxygen-supplying capillary network. Enriched environments foster the development of new neurons and create a cascade of molecular and neurochemical changes, such as an increase in neurotrophins—molecules that protect and grow the brain. Finally, physical activity in animals results in improvements in learning and memory. Doin’ push-ups and push-ups are helpful for some—but other factors also boost mental fitness. For one, getting involved in social groups both improves cognition in general and seems to help thwart the arrival of dementia. The traditional focus of this research has been on relatively objective measures of social isolation versus connectedness, including the extent to which a person participates in activities that prominently involve social interaction (such as doing volunteer work), the number of friends and relatives with whom a person interacts regularly (in other words, the size of a person’s social network), and marital status. Findings about the positive aspects of attitudes and behaviors on cognition are spotty. In large part, positive beliefs and attitudes may have important indirect effects on cognitive enrichment because of their influence on the kinds of behaviors (for instance, exercise and mentally stimulating activities) that are known to be associated with cognitive enrichment.

More generally, individuals who are optimistic, agreeable, open to new experiences, conscientious, positively motivated and goal-directed are more likely to undergo successful aging, to take advantage of opportunities, to cope effectively with life circumstances, to effectively regulate emotional reactions to events, and to maintain a sense of well-being and life satisfaction in the face of challenges. And just as maintaining some activity patterns in old age may reduce risk of cognitive decline, the persistence of other patterns of behavior may increase the risk. Chronic psychological distress—resulting from depression, anxiety, and negative emotions such as anger and shame—is associated with a variety of negative outcomes in adulthood, including cognitive decline. The tendency to experience psychological distress is often called neuroticism. Studies have consistently found a higher level of neuroticism to be linked to an increased incidence of Alzheimer’s disease and mild cognitive impairment in old age.

ENRICHING COGNITION

Clearly, there is no magic pill that invigorates the individual against cognitive decline in old age. Thus, public policy should follow a health prevention model. Policy leaders might promote intellectual activities that are inherently meaningful for older adults, perhaps as embodied in larger social contexts (for example, the Eldercare movement or adult continuing education). A critical issue for future research will be to understand how an engaged way of life can be promoted and implemented in midlife, during the working years. Given inevitable conflicts between work demands and time available for other roles (parenting, for example) and activities, it would be useful to know whether work-related activity programs (such as availability and use of physical exercise facilities at or near the workplace) could help foster an enriching lifestyle. At the same time, the public must be aware that there is still much that is not known about cognitive fitness in old age, as well as some controversy about the magnitude and durability of mental exercise outcomes. People are marketing computer games and other means of exercising the mind, often making strong claims about the effectiveness of expensive products that have not been backed by actual scientific studies. Consumers should look for evidence demonstrating the benefits of such products—particularly with regard to everyday activities such as driving, memory for daily activities and better financial decision-making.

The next decades offer much promise for expanding our knowledge about aging and cognition. We may soon discover whether the limits on successful cognitive functioning in old age that were once seen as insurmountable can ultimately be viewed as pessimistic assumptions that focused on observable age-related decline rather than the potential for maximizing human performance through cognitive enrichment. Just as advances in medical science may lead to increased longevity through vehicles such as effective treatments for dementia causing illnesses, advances in psychological science may make important contributions to improving the quality of life of long-living older adults. In part, these advances will empirically demonstrate that attitudes and behaviors can promote cognitive functioning in old age and, more generally, show how behavioral interventions can help us all age successfully.

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MORE TO EXPLORE


Plasticity of Brain Networks in a Randomized Intervention Trial of Exercise Training in Older Adults. Michelle K. Voss et al. in Frontiers in Aging Neuroscience. Vol. 2, Article 82, pages 1-9; August 2010.
