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Cognitive Training for Older Adults: What Is It and Does It Work?

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Older adults are more likely to fear losing their mental abilities than their physical abilities.[1] But a growing body of research suggests that, for most people, mental decline isn't inevitable and may even be reversible. It is now becoming clear that cognitive health and dementia prevention must be lifelong pursuits, and the new approaches springing from a better understanding of the risk factors for cognitive impairment are far more promising than current drug therapies.

Key points from our analysis of the current evidence include the following:

- Cognitive training can improve cognitive abilities. Dementia drugs cannot.
- No single cognitive training program stands out as superior to others, but a group format based on multiple cognitive strategies seems the most promising.
- Research comparing cognitive exercise approaches is still thin. Rigorous evaluation standards are needed.
- Cognitive training could reduce health care costs by helping older individuals maintain a healthy and active lifestyle.
- No scientific evidence exists that cognitive training can prevent Alzheimer's disease (AD) or other forms of dementia or predementia, and more research is needed before firm conclusions can be drawn.

What Is Known About Cognitive Training Now?

Aggressive marketing notwithstanding, drugs marketed for dementias such as AD do little to maintain cognitive and functional abilities or slow the progress of the disease. In contrast to drugs are mental exercises to improve cognitive abilities. Dr. Richard Suzman, Director of the Division of Behavioral and Social Research at the National Institute on Aging (NIA), states, "These sorts of interventions are potentially enormously important. The effects [of cognitive training interventions] were substantial. There isn't a drug that will do that yet, and if there were, it would probably have to be administered with mental exercises."[2]

Controversy and confusion still surround the efficacy of cognitive training in older adults. A common misconception is that loss of cognitive abilities — memory, attention, and the other faculties that enable one to think clearly, maintain social relationships, recover from disease, and cope with normal age-related decline — is inevitable and unalterable as we age. But human and animal studies suggest that the brain

is malleable, even late in life. Although no conclusive evidence points to any particular cognitive training program as the most effective way to maintain current cognitive abilities or delay dementia's onset, participation in mentally stimulating activities is associated with lowered risk for developing AD and related dementias.

There is an urgent need to lower the risk of developing AD and related dementias quickly, effectively, and at a low cost. According to the NIA, 87 percent of individuals remain cognitively healthy well into old age, while one in seven develop more severe cognitive impairments, including dementia.[3] One in nine adults over the age of 65 has AD, and one in three over the age of 85 has AD.[4] And the aging population is growing rapidly. In 2010, 40 million people aged 65 and older accounted for 13 percent of the total U.S. population. In 2030, the number of people in the United States over the age of 65 is expected to grow to 72 million, accounting for almost 20 percent of the U.S. population.[5]

What Is Cognition, and What Is Cognitive Training?

Cognition is a combination of processes, including paying attention, learning and reacting to objects in the environment, and using language and memory. If cognition becomes impaired, an individual may have difficulty performing everyday tasks. If those tasks become very hard or impossible to perform, AD or another type of dementia is diagnosed, in which case cognitive training may be in order. The key question here is whether training basic cognitive abilities will transfer to everyday abilities, such as managing one's finances or medicines.

Cognitive training is based on the idea that the brain, even in old age, can change for the better. What we know about the brain suggests that it resembles muscles: In the same way that physical training improves physical abilities, cognitive training (or brain training) improves cognitive (or mental) abilities. Cognitive training uses guided practice on a set of tasks related to memory, attention, or other brain functions. This training can take many shapes. For instance, it can be conducted on the computer or delivered in person, either individually or in small groups. But it typically involves using repetitive exercises designed to improve single (e.g., memory) or multiple (e.g., memory and reasoning) cognitive abilities.

Cognitive training programs seem more likely to work if they are delivered in a group format, contain multiple cognitive strategies (e.g., the use of imagery to aid memory and repetition), and grow more challenging as performance improves.[6] Table 1 compares some cognitive training programs to cognitive stimulation and cognitive rehabilitation, all of which aim to increase general cognitive and social function.

Table 1. Three Approaches to Improve Cognitive Abilities

	Cognitive Training	Cognitive Stimulation	Cognitive Rehabilitation
Description	Uses repetitive exercises keyed to specific cognitive abilities. May be computer-assisted or delivered in person individually or in small groups.	Engagement with activities involving some mental processing in a social context. Aims to be enjoyable.	Tailored to the individual and involves working on personal goals, often using external cognitive aids. Usually implemented in real-world settings.
Example 1	The ACTIVE study trained one of three abilities: *Memory* *Reasoning* *Information processing speed*[7]	Experience Corps uses the time, skills, and experience of older adult volunteers to improve the health and well-being of the volunteers and the educational outcomes of disadvantaged elementary-school children. Volunteers are trained for 30 hours in literacy support, violence prevention and other skills.[9]	A personalized memory notebook system, much like a Daytimer, is tailored to an individual's memory deficits. Sections may include: *Orientation* (personal and medical info) *Names of emergency contacts*
Example 2	The IMPACT study used six computerized exercises to improve the speed and accuracy of auditory information processing.[8]	Senior Odyssey is a community-based intervention: older adults tackle a program of problem solving and brain teasers. Teams meet weekly for 16 weeks to develop and test solutions for a long-term problem and to practice working as a group on spontaneous problems.[10]	Rehabilitation may also cover specific everyday tasks, such as making change or balancing a checkbook.

Throughout the past 15 years, cognitive training interventions have been used to improve cognitive performance in healthy older adults. To date, the largest trial of cognitive training in cognitively healthy older adults is the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study. Its participants were assigned to one of three intervention groups (i.e., memory, reasoning or information processing speed) or to a no-contact control group. The *memory training* intervention aimed to create multiple ways to make the to-be-remembered information more meaningful, such as remembering it by categorizing, visualizing and associating it with something familiar or well-known. The *reasoning training* intervention aimed to improve the ability to identify patterns from a series of letters, numbers and words that act as an aid to organizing daily activities, such as following a medication regimen and thus reducing the burden on memory. (If one knows how to read a bus schedule, one doesn't have to remember when the bus comes.) The *information processing speed training* intervention aimed to improve mental processing speed so that increasingly complex information could be understood increasingly fast. How quickly could someone, for instance, identify whether an object in the middle of their visual field was a car or a truck while simultaneously noting where — in their peripheral field of vision — another car was located.

Results from the ACTIVE study showed that training had immediate and long-term effects lasting up to five years on memory abilities[11] and up to 10 years on reasoning and information processing speed,[12] far longer, in both cases, than what is documented for other programs. Training also had real-world effects. Ten years after initial training, all three training groups reported less difficulty in the instrumental activities of daily living (e.g., medication management, meal preparation) than the control group, and at least 60 percent of participants in all trained groups continued to report less difficulty performing such activities after 10 years, compared to 49 percent of nontrained participants. After 10 years, 60 to 70 percent of participants said that they were as good as or better than when they started the ACTIVE study.

> "[ACTIVE] found that community-dwelling seniors who received cognitive training had less of a decline in certain thinking skills than [those] who did not have training. The study addresses a very important hypothesis — interventions can be designed to maintain cognitive function."
>
> - Richard J. Hodes, M.D., NIA Director

Can the training effects of ACTIVE and other cognitive training trials be compared to the treatment effects of drug trials with dementia patients? The short answer is that it's difficult. Both the primary outcome measures used in these studies and the approach to quantifying treatment differ from those used in drug trials. Even more important, the participants differ. All ACTIVE participants were healthy elderly whose cognitive trajectory was assumed to be relatively stable over the study period, whereas AD drug study participants are amid progressive brain degeneration so their cognitive skills are on a steep downhill trajectory, such that even 6 to 12 months makes a big difference in their cognitive abilities. That said, an earlier AD intervention trial found that the most effective current treatment available for the disorder improved cognitive scores between 0.24 and 0.31 standard deviation units over a 6-month treatment period.[13] In comparison, ACTIVE participants improved their cognitive scores between 0.26 and 1.46 standard deviation units after a 5-6 week 'treatment' period.[7]

A recent evidenced-based review summarizing more than 30 cognitive training interventions for older adults showed overall significant differences between memory-trained and control group participants.[14] On average, the memory performance of those who completed training improved more than that of participants in the control group (Table 2).

In mildly cognitively impaired older adults at risk of further impairment, computer and other cognitive interventions hold promise. Combining physical and cognitive exercises has helped both healthy older adults and those with AD improve cognitive abilities, reduce memory complaints, and maintain emotional well-being.[15] Physical exercise is good for the body and the brain. In older adults, aerobic exercises help to maintain independent living, improve cognitive

abilities, ameliorate depressive symptoms, and may slow reductions of brain areas vital to memory.[16]

Table 2. What Are the Effects of Memory Training?

	Effect size	95% Confidence Interval	Number of Participants at Post-Training	Number of Studies
Overall	0.31	(0.22, 0.39)	3,797	35
Training	0.43	(0.29, 0.57)	1,930	35
Control	0.06	(-0.05, 0.16)	1,867	33

Legend. Effect sizes specific to training groups represent standardized pretraining to post-training changes (in standard deviation units) in memory for the group of studies included in the meta-analysis. **Effect sizes of 0.20 can be considered small; 0.50 can be considered medium; 0.80 can be considered large.**

Source: Gross A. L., Parisi, J. M., Spira, A. P., Kueider, A. M., Ko, J. Y., Saczynski, J. S., . . . Rebok G. W. (2012). Memory training interventions for older adults: A meta-analysis. *Aging and Mental Health*, *16*, 722–734.

How Can Consumers Know Which Cognitive Training Programs Work Best?

The popularity of brain-exercise products, currently a $300 million worldwide industry, has skyrocketed recently and is expected to be worth more than $2 billion in revenue by 2015, as the Baby Boomer generation ages.[17] This business is unregulated, and its claims of cognitive performance improvements often come from producers' marketing departments, not from science. Public policy makers should join researchers in asking whether and how to evaluate claims about cognitive benefits. For starters, rigorous evaluation standards are needed to help consumers better choose among cognitive improvement products. Consumers should ask questions and insist on getting scientific evidence that a cognitive training program is effective. For example, has the company done scientific research on the product? If so, are the research findings published? Where are they published? Have the results been replicated? Does the company have a scientific advisory board to guide product development?

What's the Role of New Technologies in Cognitive Training for Older Adults?

There is some evidence that even relatively simple cognitive exercises can help to improve cognition. Contrary to the popular opinion, older adults — the fastest growing segment of Internet users — can benefit from cognitive interventions based on such technologies as commercial video games and neuropsychological software programs.[18] The Improvement in Memory with Plasticity-Based Adaptive Cognitive Training (IMPACT), a large, randomized controlled trial of computerized cognitive training for older adults, found that older adults who trained for one hour a day, four to five days a week for eight to 10 weeks enjoyed improvements in memory, attention and information processing speed (Table 3).[19] This training was as successful as drug trials in improving the ability to do tasks not directly targeted in training.

Table 3. What Were the Effects of the IMPACT Study?

Measure	Pretraining to Post-Training	Post-Training to 3-month Follow-Up
Auditory Memory and Attention index score	0.23	0.09
Processing speed*	0.87	0.80
Overall memory index score	0.30	0.25

* Lower scores represent better performance

The effect size represents the treatment group (training vs. control) by time (pretraining vs. 3-month follow-up) and interaction

Source: Zelinski, E. M., Spina, L. M., Yaffe, K., Ruff, R., Kennison, R. F., Mahncke, H. W., . . . Smith, G. E. (2011). Improvement in memory with plasticity-based adaptive cognitive training: Results of the 3-month follow-up. *Journal of the American Geriatrics Society*, *59*, 258–265.

Cognitive training programs can also enhance well-being and life satisfaction. Older adults who play video games report higher levels of happiness. "The research … suggests that there is a link between gaming and better well-being and emotional functioning," said Jason Allaire, Ph.D., senior author of the study.[20] Web-based programs are more cost effective and easier to disseminate widely than traditional in-person training or training in laboratory or clinical settings. These programs generally cost around $15 a month, whereas smartphone apps cost less than $5 for a one-time download. In clinical settings, occupational therapists or rehabilitation specialists charge around $100 per hour.

More than traditional face-to-face interventions, computer- and Internet-based cognitive interventions individualize training to meet particular needs and reach homebound or institutionalized older

adults. These programs do not need users to be technologically savvy to benefit from such programs either.[18] Yet, most people who begin any kind of self-improvement programs discontinue them soon after, for various reasons. For example, about half of all people who begin research-based exercise programs quit within six months.[21] Does this mean that older people who begin cognitive exercise programs will do the same?

Many newer video games incorporate physical activity to promote exercise among users. In 2010, three of the top 20 video games sold were designed to promote physical activity during play.[22] New "exergames" for use with commercial platforms, such as the Nintendo Wii®, PlayStation®, or Microsoft Xbox®, combine virtual-reality exercise systems with computer-simulated environments. Interactive video game features have gained in popularity rapidly. Research suggests that older adults not only enjoy using exergames, regardless of their fitness level or exercise performance ability, but they also get greater cognitive benefits and stick with the program more than with traditional exercise.[23]

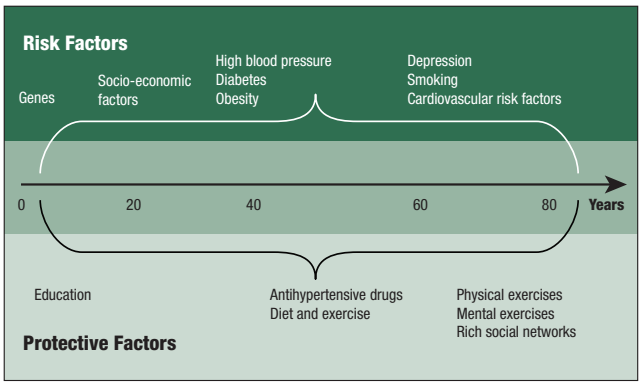
Although much has been discovered about the potential of cognitive training programs to improve cognitive abilities, hurdles remain for understanding and implementing such programs. Most cognitive training improves only the targeted ability, not the ability to perform everyday tasks of independent living. And, research suggests, these programs are less effective for individuals who already have cognitive impairments or AD,[24] which is a strong reason to start working on cognitive health maintenance in early and midlife, before these problems arise.

What Types of Cognitive Training Programs Are Needed Now?

Interventions that target only one cognitive or physical function may not be enough to improve or maintain cognitive abilities because older adults experience declines in both cognitive and physical abilities and also undergo emotional changes that can affect their cognition. Starting multiple-component interventions (e.g., getting regular physical and cognitive exercise, eating healthy food, managing weight and blood pressure, and treating depression) in midlife or — better yet — earlier, could slow down some forms of cognitive decline and dementia.

Meanwhile, cognitive training is rapidly evolving. Novel technologies and interventions now combine traditional cognitive training programs with physical exercise, nutritional supplements, and pharmacological interventions. As Figure 1 shows, risk and protective factors across the whole life span could be targeted with interventions that influence different cognitive abilities. Finding where the greatest payoff lies among the range of intervention strategies is now a high research priority; so is pinpointing the optimal times and ways to introduce interventions for maximal benefits.

Figure 1. Factors Influencing Cognitive Abilities Across the Lifespan



How Can Cognitive Training Reduce Health Care Costs?

Let's start with an example. Ten hours of information processing speed training, a commercially available, computer-based component of the ACTIVE study, decreased predicted medical expenditures by 3.2 percent between baseline and the one-year follow-up after the training. That could translate into potential savings for Medicare if a large group of individuals were to receive training.[25] As the ACTIVE study's lead author, Dr. Fredric Wolinsky points out, "The onset of cognitive limitations in older adults is associated with increased health services use and medical expenditures." But because the ACTIVE

cognitive training has not yet been found to affect the rates of new cases of dementia,[26] enhanced training and/or longer, more in-depth follow-up may be needed to explore cognitive training's capabilities in delaying the onset of dementia. For the consumer, this extra time may be the ultimate value of cognitive training programs.

Public policy aimed at improving cognitive health should follow a health prevention model, focusing on training programs' sustainability and long-term health benefits. How do we motivate older adults to keep using these training programs when the novelty wears off or when progress seems slow? How do we make the programs meaningful and integrate them with older adults' daily life activities? What is the best way to make such programs accessible and affordable for all who may benefit? Should older adults receive health insurance benefits for undertaking cognitive training, and should Medicare pay for such training?

Given older adults' strong desire to remain independent and the high costs of institutionalized care, raising public awareness of cognitive training's potential for maintaining an active, healthy lifestyle may be key to improving the overall health of an aging population. Also key is the work being done at the U.S. Department of Health and Human Services, the Veterans Administration, and other federal agencies to inform the public about research findings on the physical, cognitive, and emotional changes associated with aging and their management. These efforts, in combination with finding more effective ways to translate findings from small research studies in highly controlled settings to populations in real-world settings, will govern the nation's health as the aging population grows.

NOTES

1. Research!America. (2006). *Top concerns about aging: Failing health, mental ability*. Retrieved from http://www.researchamerica.org/release_06feb2_agingpoll_parade
2. Dember, A. (2002, December 13). Cognitive training helps elderly keep mental sharpness/but value in daily life questioned. *Boston Globe*. Retrieved from http://www.sfgate.com/health/article/Cognitive-training-helps-elderly-keep-mental-2711624.php
3. Wagster, M. V., King, J. W., Resnick, S. M., & Rapp, P. R. (2012). The 87%. *Journal of Gerontology Series A: Medical Sciences*, *67*, 739–740.
4. Alzheimer's Association. (2013). *2013 Alzheimer's disease facts and figures*. Retrieved from http://www.alz.org/downloads/facts_figures_2013.pdf
5. Federal Interagency Forum on Aging-Related Statistics. (2012). *Older Americans 2012: Key indicators of well-being*. Washington, DC: U.S. Government Printing Office.
6. Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging, 7*, 242–251.
7. Ball, K., Berch, D. B., Helmers, K. F., Jobe, J. B., Leveck, M. D., Marsiske, M., . . . Willis, S. L. (2002). Effects of cognitive training interventions with older adults: A randomized controlled trial. *JAMA*, *288*, 2271–2281.
8. Smith, G. E., Housen, P., Yaffe, K., Ruff, R., Kennison, R. F., Mahncke, H. W., . . . Zelinski, E. M. (2009). A cognitive training program based on principles of brain plasticity: Results for the improvement in memory with plasticity-based adaptive cognitive training (IMPACT) study. *Journal of the American Geriatrics Society*, *57*, 594–603.
9. Fried, L. P., Carlson, M. C., McGill, S., Seeman, T., Xue, Q. L., Frick, K., . . . Rebok, G. W. (2013). Experience Corps: A dual trial to promote the health of older adults and children's academic success. *Contemporary Clinical Trials*, *36*, 1–13.
10. Stine-Morrow, E. A. L., Parisi, J. M., Morrow, D. G., & Park, D. C. (2008). The effects of an engaged lifestyle on cognitive vitality: A field experiment. *Psychology and Aging, 23*, 778–786.
11. Willis, S. L., Tennstedt, S. L., Marsiske, M., Ball, K., Elias, J., Koepke, K. M., . . . Wright, E. (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *JAMA, 296*, 2805–2814.
12. Rebok, G. W., Ball, K., Guey, L.T., Jones, R. N., Kim, H-Y., King, J. W., . . . Willis, S. L. (2014). Ten-year effects of the ACTIVE cognitive training trial on cognition and everyday functioning in older adults. *Journal of the American Geriatrics Society, 62,* 16–24.

13. Seltzer, B., Zolnouni, P., Nunez, M., Goldman, R., Kumar, D., Leni, J., . . . Donepezil "402" Study Group. (2004). Efficacy of donepezil in early-stage Alzheimer disease: A randomized placebo-controlled trial. *Archives of Neurology, 61*, 1852–1856.

14. Gross A. L., Parisi, J. M., Spira, A. P., Kueider, A. M., Ko, J. Y., Saczynski, J. S., . . . Rebok, G. W. (2012). Memory training interventions for older adults: A meta-analysis. *Aging and Mental Health*, *16,* 722–734.

15. Jean, L., Bergeron, M-E., Thivierge, S., & Simard, M. (2010). Cognitive intervention programs for individuals with mild cognitive impairment: Systematic review of the literature. *Journal of the American Geriatrics Society, 18*, 281–296.

16. Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science: A Journal of the American Psychological Society, 14*, 125–130.

17. Fernandez, A. (2010). Transforming brain health with digital tools to access, enhance, and treat cognition across the lifespan: The state of the brain fitness market. Retrieved from http://www.sharpbrains.com/executive-summary/printpage/

18. Kueider, A. M., Parisi, J. M., Gross, A. L., & Rebok, G. W. (2012). Computerized cognitive training with older adults: A systematic review. *PLoS One*, *7* (7):e40588

19. Zelinski, E. M., Spina, L. M., Yaffe, K., Ruff, R., Kennison, R. F., Mahncke, H. W., . . . Smith, G. E. (2011). Improvement in memory with plasticity-based adaptive cognitive training: Results of the 3-month follow-up. *Journal of the American Geriatrics Society*, *59*, 258–265.

20. Whitlock, L. A., McLaughlin, A. C., & Allaire, J. C. (2012). Individual differences in response to cognitive training: Using a multi-modal, attentionally demanding, game-based intervention for older adults. *Computers in Human Behavior*, *28*, 1091–1096.

21. Wilson, K., & Brookfield, D. (2009). Effect of goal setting on motivation and adherence in a six-week exercise program. *International Journal of Sport and Exercise Physiology*, *6*, 89–100.

22. Entertainment Software Association. (2011). *Essential factors about the computer and video game industry: 2011.* Retrieved from http://www.theesa.com/facts/pdfs/ESA_EF_2011.pdf

23. Anderson-Hanley, C., Arciero, P. J., Brickman, A. M., Nimon, J. P., Okuma, N., Westen, S. C., . . . Zimmerman, E. A. (2012). Exergaming and older adult cognition: A cluster randomized clinical trial. *American Journal of Preventive Medicine, 42*(2), 109–119. doi:10.1016/j.amepre.2011.10.016

24. Faucounau, V., Wu, Y. H., Boulay, M., De Rotrou, J., & Ridaud, A. S. (2010). Cognitive intervention programmes on patients affected by mild cognitive impairment: A promising intervention tool for MCI? *The Journal of Nutrition, Health, and Aging, 14*, 31–35.

25. Wolinsky, F. D., Mahncke, H. W., Kosinski, M., Unverzagt, F. W., Smith, D. M., Jones, R. N., . . . Tennstedt, S. L. (2009). The ACTIVE cognitive training trial and predicted medical expenditures. *BMC Health Services Research*, *9* (109). doi: 10.1186/1472-6963-9-109

26. Unverzagt, F. W., Guey, L. T., Jones, R. N., Marsiske, M., King, J., Wadley, V., . . . Tennstedt, S. L. (2012). ACTIVE cognitive training and rates of incident dementia. *Journal of the International Neuropsychological Society*, *18*, 669–677.

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