Change minds for the better

Breakthroughs in the field of brain plasticity—the brain's ability to remodel itself—are changing how scientists think about aging. By providing programming that helps keep the brain healthy and fit, health and wellness organizations can assist their clients in applying this knowledge in their daily lives

by Michael M. Merzenich, PhD

A few decades ago, most scientists believed that the human brain was hardwired in early life. Research demonstrated that the brain developed all its necessary physical structures and connections during a *critical period* of early child development. This led to the intuitive conclusion that normal age-related cognitive decline—those changes in behavior that arise naturally—was an unavoidable consequence of an old machine wearing down.

Many scientists thought that the brain's architecture deteriorated as people aged. Gray matter shrank, trunks demyelinated, synapses disconnected, and that was that. [**Ed.** A glossary that includes these terms appears on page 28.] Scientists, physicians and patients came to believe there was nothing people could do to rebuild the brain and resurrect cognitive skills.

During the past 20 years, there has been a revolution in thinking about the brain. Scientists now know that the brain remains *plastic* (or malleable) throughout life. At any age, the brain has the ability to revise its processing machinery—for better or for worse—in response to stimuli and activities. Just as the brain can deteriorate, it can also grow. Gray matter can thicken, trunks can remyelinate, and neural connections can be forged and refined, reinvigorating cognitive abilities.[1,2,3,4,5] This finding has profound implications for how people approach the aging brain.

Cognitive decline: What causes it?

Most adults lose some mental sharpness as they grow older, even if they avoid Alzheimer's disease or another pathological condition. Research shows that this natural age-related decline begins in the 30s and accelerates after age 50. It's often characterized by memory lapses, slower thinking, and growing difficulties in communicating with others (e.g., words stuck on the tip of the tongue, problems understanding *mumbling* youngsters, and so on). If such cognitive decline isn't simply due to an old machine wearing out, what causes it?

Our research at the University of California at San Francisco, along with the research of other neuroscientists, has shown that functional decline with age is largely a product of negative brain plasticity. If plasticity refers to the brain's ability to change, negative plasticity occurs when the brain changes in a way that slows or impedes cognitive performance. This negative plasticity *collaborates* with, and in important ways actually causes, key aspects of physical, chemical and functional decline.

As the brain grows older, negative brain-plasticity processes cause a self-reinforcing downward spiral of degraded brain function. There are at least 4 components to this decline:

1. **Disuse.** Studies show that keeping the brain active can help maintain cognitive fitness,[6,7] and many people now know they have to *use it or lose it.* But adults often *use it* only by performing the mental activities they feel comfortable doing. This may include reading, doing crossword puzzles, playing bridge, and so on. However, activities that rely on already mastered skills and abilities do not really *use* the brain in the ways necessary to promote brain fitness. Keeping cognitive function at its peak requires ***new*** learning in specific, recurring and challenging forms.

2. **Noisy processing.** The older brain becomes *noisier* due to the deterioration of sensory inputs. For example, the inner ear translates sounds from the outside world into a coded representation the brain can understand. As the inner ear deteriorates, it sends the brain increasingly unclear signals to

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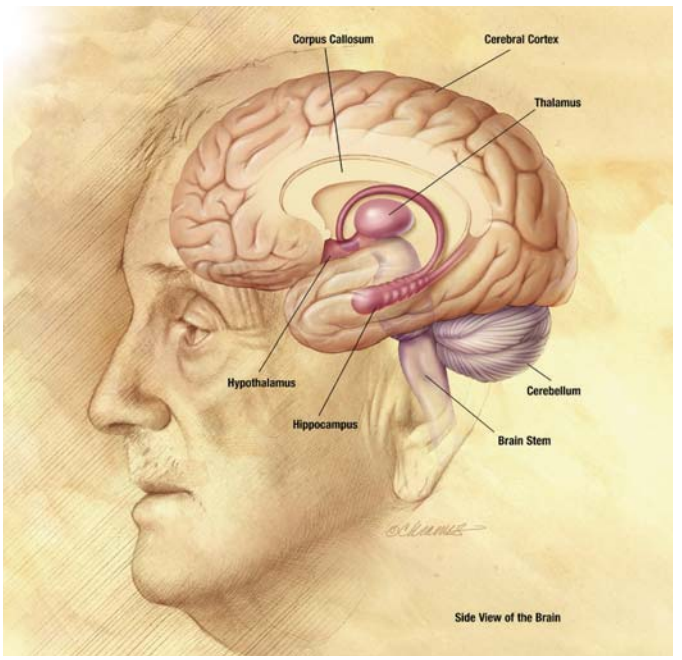

Figure 1. A side view of the brain and its components

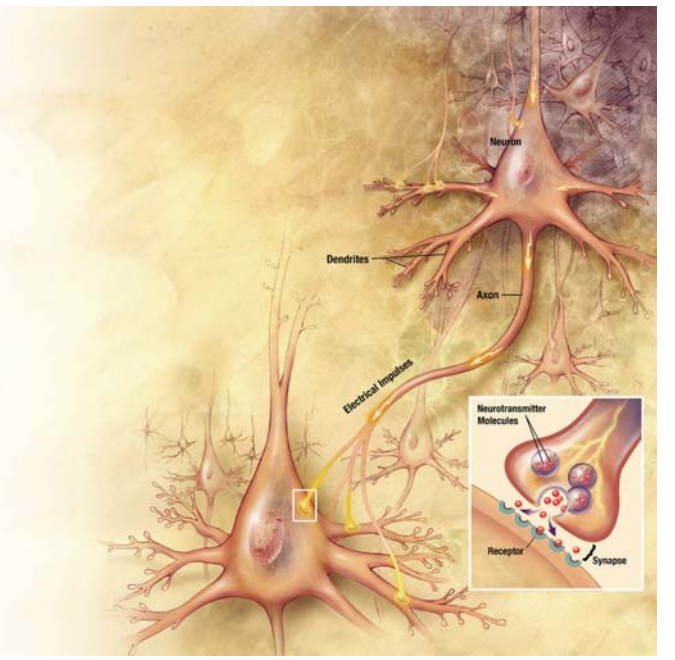

Figure 2. How neurons in the brain connect

Images courtesy of the Alzheimer's Disease Education and Referral Center, a service of the National Institute on Aging

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interpret. This leads the brain to adjust its *sampling rates* and *time constants*—the brain literally slows down as it tries to decipher these fuzzy signals. With time, the brain's representations of what a person hears, sees or feels gradually become more imprecise and incomplete. The result is poorer memory and less agile thinking.[8]

3. **Weakened neuromodulatory function.** The aging brain often produces fewer *neuromodulators* (brain chemicals that play a vital role in learning and memory). The decreased production of these chemicals weakens the brain's control over its plasticity, lowering learning rates and trapping the brain in potentially inappropriate or unhelpful patterns of activation.

4. **Negative learning.** As people start to feel less mentally sharp, they often compensate in ways that accelerate functional decline, rather than focusing on activities that might hone their skills. For example, instead of paying closer attention to speech as their hearing declines, individuals often turn up the television or disengage from conversations. They practice such behaviors at the expense of behaviors that might help keep their brains fit.

Preventing and reversing cognitive decline

The new viewpoint on the root causes of cognitive decline is helping scientists define methods for improving brain function at any age. Decades of research in experimental and cognitive psychology and in brain plasticity have shown that appropriate training strategies can drive positive brain plasticity, which improves brain function[9,10,11,12,13,14,15] To help prevent, arrest or even reverse the effects of cognitive decline, activities must target the factors that contribute to it, as follows:

- To combat disuse, *activities must engage the brain with new and demanding tasks.* These tasks must progressively and repeatedly challenge the brain.
- To help the brain clear up fuzzy input, *activities must require careful attention and focus.* Specially designed stimuli can sharpen neural representations and pathways, and speed up connections.
- To upregulate the production of key neuromodulators, *activities must include aspects that trigger neuromodulator production.* Activities that are rewarding or surprising, or require focused attention, are especially good at increasing the production of these brain chemicals.
- To guide people out of maladaptive compensatory behaviors, *activities must require people to confront challenges* rather than avoid them.

Programming that promotes brain health

By offering programs that help keep the brain healthy and fit, health and wellness organizations can assist their clients in applying the above findings in daily life. Possible strategies include providing a range of activities that engage the brain's great processing systems, and offering brain fitness programs.

To spur new learning and broadly stimulate the brain, activities do not have to be intellectual/cognitive. Physical activities that require the progressive mastery of motor control can strengthen the brain as well. Once organizations have created a schedule of programs, they should actively encourage clients to try new activities—even if they seem challenging. It is essential to challenge the brain to create positive change.

The best activities require people to make fine distinctions about what they hear, see or feel, and to use that information to achieve complex goals. Such tasks drive the brain to change its abilities at every level of its complex machinery. Activities prove especially successful when they are also novel or rewarding, encouraging the upregulation of key neuromodulators. Examples of excellent activities include the following:

- **Music.** Learning to play a new instrument or studying musical *voices* and theory requires the brain to strengthen and sharpen its neural pathways related to sound.
- **Foreign languages.** Beginning to speak any new language calls for careful listening and the manipulation of new information in ways that can help keep the brain sharp.
- **Juggling.** Developing the motor control necessary to juggle successfully requires the brain to make positive changes.[16] Sharpening motor control for juggling should also improve motor control for other tasks, such as writing.
- **Dancing.** Learning a new dance is a great way to exercise both the brain and the body. Mastering new steps and rhythms can hone brain function for gross motor control.[17]
- **Jigsaw puzzles.** Completing a difficult jigsaw puzzle (with at least 500 pieces) involves fine visual judgments. It entails mentally rotating the pieces, manipulating them manually, and shifting attention from the small pieces to the *big picture,* all of which can enhance brain processes.
- **Ping Pong.** Undertaking refined, visually guided movement behaviors that challenge the brain is another good form of exercise. Together with

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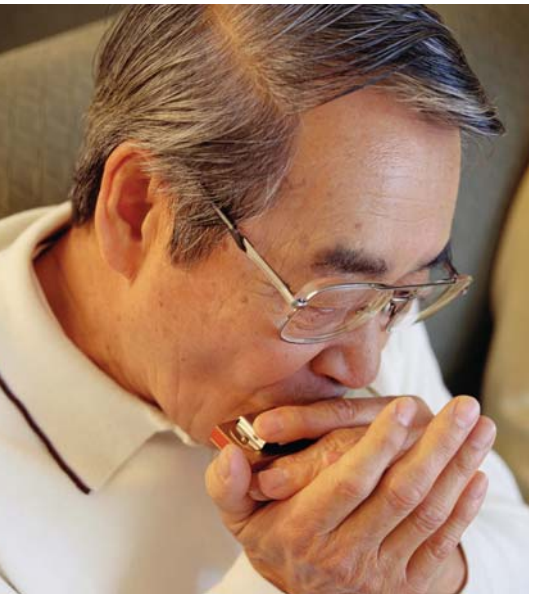

improved hand control, faster and more successful responses indicate positive changes in the brain.

By choosing activities that incorporate the latest scientific thinking about how to preserve and promote brain function, health and wellness organizations have the potential to help clients stay mentally acute.

Another way to help individuals combat cognitive decline is to make brain fitness programs available to them. One scientifically validated program comes from Posit Science. Based on the neuroscience findings in this article, this program provides such tools as educational materials, assessments, and computer-based brain health exercises. (See "BridgePoint at San Francisco: one community's approach to cognitive fitness" on page 29 and the memory quiz on page 30 for more information.)

Achieving success with a brain fitness agenda

Whatever brain fitness approach an organization chooses to implement, its chances of success can improve with the following steps:

- **Get buy-in at all levels.** A brain fitness program is more likely to succeed if leadership, staff and clients are all excited about the program. Introduce the program to staff and clients to generate interest in and commitment to the program. Work together to make it function smoothly and meet client needs.
- **Create an inviting physical space.** Improving brain health requires hours of work. Help clients stick to the program by providing a comfortable, nonthreatening space for them to use. Make the space interesting and personal by including information that will engage program participants and remind them of their accomplishments.
- **Encourage healthy habits.** Eating right, exercising regularly and getting enough sleep are all important to brain fitness. Just as health and wellness professionals might encourage these habits for a healthy heart, they can encourage them for a healthy brain.

Brain exercise: are there implications for more serious dysfunction?

Reversing normal age-related cognitive decline can greatly improve quality of life, and as such is a key goal in itself. However, our research may also have implications for more serious forms of cognitive dysfunction, such as mild cognitive impairment (MCI) and Alzheimer's disease (AD). Current studies are exploring whether carefully designed brain fitness activities can slow the progression of (or even reverse) MCI and early stage Alzheimer's. Future studies may help us determine whether targeted brain exercise can help delay the onset of pathological cognitive conditions in the first place. All of these investigations are part of our effort to find ways to help people ensure their *brain spans* match their life spans, so they can enjoy mental vitality throughout their later years.

Michael M. Merzenich, PhD, is the Francis A. Sooy Professor at the Keck Center for Integrative Neuroscience at the University of California at San Francisco. His discoveries and insights in the field of brain plasticity have led to his election to the National Academy of Sciences. Merzenich is also chief scientific officer at Posit Science. This organization has collaborated with dozens of leading brain plasticity researchers and cognitive neuroscientists from around the world to design scientifically validated brain-fitness programs. For more information about Posit Science, visit www.PositScience.com.

References

1. Buonomano, D. V., & Merzenich, M. M. (1998). Cortical plasticity: from synapses to maps. *Annual Review of Neuroscience, 21,* 49–86.
2. Mattson, M. P., Duan, W., Lee, J., & Guo, Z. (2001). Suppression of brain aging and neurodegenerative disorders by dietary restriction and environmental enrichment: molecular mechanisms. *Mechanisms of Ageing and Development, 122*(7), 757–778.
3. Mohammed, A. H., Zhu, S. W., Darmopil, S., Hjerling-Leffler, J., Ernfors, P., Winblad, B., Diamond, M. C., Eriksson, P. S., & Bogdanovic, N. (2002). Environmental enrichment and the brain. *Progress in Brain Research, 138,* 109–133.
4. Stevens, B., Porta, S., Haak, L. L., Gallo, V., & Fields, R. D. (2002). Adenosine: a neuron-glial transmitter promoting myelination in the CNS in response to action potentials. *Neuron, 36*(5), 855–868.
5. Xerri, C., Merzenich, M. M., Jenkins, W., & Santucci, S. (1999). Representational plasticity in cortical area 3b paralleling tactual-motor skill acquisition in adult monkeys. *Cerebral Cortex, 9*(3), 264–276.
6. Verghese, J., Lipton, R. B., Katz, M. J., Hall, C. B., Derby, C. A., Kuslansky, G., Ambrose, A. F., Sliwinski, M., & Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. *New England Journal of Medicine, 348*(25), 2508–2516.
7. Wilson, R. S. (2005). Mental challenge in the workplace and risk of dementia in old age: is there a connection? *Occupational and Environmental Medicine, 62,* 72–73.

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8. Schneider, B. A., & Pichora-Fuller, M. K. (2000). Implications of Perceptual Deterioration for Cognitive Aging Research. In: F. I. M. Craik and T. A. Salthouse (Eds). *The Handbook of Aging and Cognition,* p. 755. Mahwah NJ: Lawrence Erlbaum Associates.
9. Bao, S., Chang, E. F., Davis, J. D., Gobeske, K. T., & Merzenich, M. M. (2003). Progressive degradation and subsequent refinement of acoustic representations in the adult auditory cortex. *Journal of Neuroscience, 23,* 10765–10775.
10. Byl, N. N., Nagajaran, S., & McKenzie, A. L. (2003). Effect of sensory discrimination training on structure and function in patients with focal hand dystonia: a case series. *Archives of Physical Medicine and Rehabilitation, 84,* 1505–1514.
11. Merzenich, M. M., Miller, S. L., Jenkins, W. M., Saunders, G., Protopapas, A., Peterson, B., & Tallal, P. (1998). Amelioration of the acoustic and speech reception deficits underlying language-based learning impairments. In: C. von Euler, I. Lundberg, R. Llinas (Eds.) *Basic Mechanisms in Cognition and Language,* pp. 143–172. Amsterdam: Elsevier.
12. Recanzone, G. H., Jenkins, W. M., Hradek, G. T., & Merzenich, M. M. (1992). Progressive improvement in discriminative abilities in adult owl monkeys performing a tactile frequency discrimination task. *Journal of Neurophysiology, 67*(5), 1015–1030.
13. Recanzone, G. H., Merzenich, M. M., & Jenkins, W. M. (1992). Frequency discrimination training engaging a restricted skin surface results in an emergence of a cutaneous response zone in cortical area 3a. *Journal of Neurophysiology, 67*(5), 1057–1070.
14. Recanzone, G. H., Merzenich, M. M., Jenkins, W. M., Grajski, K. A., & Dinse, H. R. (1992). Topographic reorganization of the hand representation in cortical area 3b owl monkeys trained in a frequency-discrimination task. *Journal of Neurophysiology, 67*(5), 1031–1056.
15. Recanzone, G. H., Merzenich, M. M., & Schreiner, C. E. (1992). Changes in the distributed temporal response properties of SI cortical neurons reflect improvements in performance on a temporally based tactile discrimination task. *Journal of Neurophysiology, 67*(5), 1071–1091.
16. Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature, 427*(6972), 311–312.
17. Verghese, J., Lipton, R. B., Katz, M. J., Hall, C. B., Derby, C. A., Kuslansky, G., Ambrose, A. F., Sliwinski, M., & Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. *New England Journal of Medicine, 348*(25), 2508–2516.

Glossary

brain plasticity: the brain's lifelong ability to remodel itself as you learn and remember.

demyelinated trunk: a brain pathway in which the axons *(wires)* of neurons have lost part of their insulating envelope of myelin. This common deficit in aging leads to noisier, slower and less reliable signal transmission.

gray matter: brain regions occupied by neuron cell bodies and neuron-to-neuron interconnections. The cerebral cortex is a layer of gray matter that covers the outer and interior surface of the cerebrum.

myelin: the insulating material around nerves that critically enables the fast transmission of information in the nervous system. Like the insulation around a telephone wire, it assures fast and reliable signal transmission.

neural pathway: route that interconnects different gray matter regions, thereby enabling their close intercommunication.

neural connection: a point of communication between 2 nerve cells, achieved through *synapses* that transmit information from one neuron to another.

neural representation: the brain's encoded translation of sensory input, represented by the distributed activity of populations of brain neurons.

neuron: an impulse-conducting cell in the nervous system (especially the brain, spinal cord and nerves).

neuromodulator: a neurotransmitter (brain chemical released at special synapses) that amplifies or suppresses neuronal responses, or that enables or blocks learning-induced plasticity. Acetylcholine, dopamine, serotonin, norepinephrine, and endogeneous opioids are important brain neuromodulators.

remyelinate: to regrow myelin, the insulating envelope around a nerve fiber or axon that facilitates the transmission of nerve impulses.

sampling rates: the speed at which the brain can assess naturally fluctuating sensory signals (like aural speech, or visual displays) and represent them through neuronal responses.

synapse: a point of contact through which one neuron communicates with another. Selective changes in the strengths of synapses underly brain plasticity.

time constant: a measure of the time it takes for a process (e.g., a specific neurological process) to be completed.

BridgePoint at San Francisco: one community's approach to cognitive fitness

Kisco Senior Living is an organization that believes in wellness. The California-based organization promotes health and well-being to 3,400 residents and 1,700 associates through its award-winning Healthy Strides program. This wellness program embodies Kisco's commitment to making a difference in people's lives. "Healthy Strides goes beyond bingo, bridge, and birthday parties," says Kirsten Jewell, the program's director. "It's a way of being," she explains.

Healthy Strides embraces the whole-person wellness model. Through its programming in all 6 dimensions of health, the organization promotes successful aging and encourages independence for everyone. One area of focus is cognitive fitness.

BridgePoint offers workouts for the brain

In 2005 Kisco piloted a brain health initiative at BridgePoint at San Francisco, an independent- and assisted-living community (which has since been sold and renamed Sunrise at Golden Gate Park). Executives at BridgePoint created a Brain Fitness Center to help residents exercise their brains. This center featured the Posit Science Brain Fitness Program, a scientifically validated, computer-based program built around 6 core exercises.

The Posit Science program directly targets the contributors to cognitive decline for auditory processing:

- **Disuse.** To combat this factor, the program intensely engages the brain.
- **Noisy processing.** The program's exercises are designed to improve the brain's processing in ways that sharpen and strengthen the manner in which the brain represents information received through sound.
- **Weakened neuromodulatory function.** The program aims to increase natural production of these chemicals by exercising the brain's attention-, reward- and novelty-driven systems.
- **Negative learning.** By focusing on the correction of degraded neuro-behavioral abilities, the program attempts to guide users out of compensatory behaviors that speed cognitive decline.

Preliminary studies indicate that more than half the people who complete the program may improve 10-plus years in cognitive functioning, including memory and processing speed.

BridgePoint residents who enrolled in the brain fitness program attended hour-long classes 5 days a week for 8 weeks. These individuals, along with their family members and Kisco staff, all commented on the improvements they noticed. Here's a snapshot of one participant's experience:

Ruth's story

At age 71, Ruth (not her real name) seemed to be retreating from the world. Although she had lived in BridgePoint's assisted living facility for more than a year, she had not participated in many activities or formed any strong friendships. She preferred to eat alone, and seemed palpably depressed. She admitted that she didn't feel as sharp as she once did, and that it frustrated her to go into a room and not remember why she had gone there. Even her daughter admitted that sometimes it was a real effort to visit the mother she loved. It was hard to see her once-vibrant mother unhappy and struggling.

A staff member at BridgePoint encouraged Ruth to enroll in the Posit Science program. After 8 weeks in the class, Ruth said she felt "much more engaged," "more competent," and "just more interested in things." She also reported far fewer frustrating memory lapses. The staff also noted that Ruth was "up and on the go." She had made new friends in the brain fitness class, who introduced her to new dinner companions. She also joined an art class.

A participant in Posit Science's brain fitness program uses computer-based exercises to improve her cognitive function. Photo courtesy of Posit Science

Ruth's daughter was thrilled with the difference in her mother. "This program has changed my mother," she told Susan Edwards, the executive director at BridgePoint. "She's her old self."

Brain fitness wins fans at BridgePoint

Edwards proved a keen supporter of Kisco's partnership with Posit Science. "When you see the extra smiles, more confident conversation and a definite improvement in…self-esteem," she said, "you appreciate the value of this [brain fitness] program to everyone."

Residents at BridgePoint were also enthusiastic about improving their brain health. "The Posit Science program generated a lot of excitement," confirms Kirsten Jewell. "At a kick-off in January, 73% of the attendees registered and 22 immediately enrolled for the first class, which started in April."

Today, Kisco remains committed to providing cognitive fitness programs as part of Healthy Strides, and continues to pilot cognitive centers in communities across the United States.

The International Council on Active Aging recently named Healthy Strides as a recipient of its 2005 ICAA Industry Innovators Award. A short profile of Kisco's program appears on pages 69–70. More information about Posit Science's programs is available at www.PositScience.com.

CLIENT HANDOUT

How's your memory?

To get a quick snapshot of how well your memory performs, take the quiz below. This is not a scientific test, but it can indicate how well your memory works. You'll read 5 words and then see how well you remember them. All you need is a quiet room, a piece of paper and a pen or pencil.

1. Repeat the following 5 words aloud 4 times: *carrot, purple, elephant, fork, guitar*. Don't look at the words again until the quiz is completed.

2. With a pen or pencil, draw the face of a clock. Put in all the numbers. Draw the hands of the clock, setting the time to read 10 minutes after 11.

3. Draw a picture of a 3-dimensional cube.

4. Write down all the words you can remember without looking at the original list. If you can't remember all of them, use the following cues to jog your memory:

   One of the words was a vegetable.
   One was a color.
   One was an animal.
   One was a kitchen utensil.
   One was a musical instrument.

5. If you are still unsure, choose the correct word from the following:

   Which vegetable? Carrot, zucchini, broccoli
   Which color? Yellow, green, purple
   Which animal? Rabbit, egret, elephant
   Which utensil? Plate, fork, spoon
   Which instrument? Piano, guitar, flute

6. Check what you wrote against the original list of words. A person with normal memory performance typically remembers at least 4 of the words without cueing.

Source: Beth Cook, PhD, Posit Science Corp.

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