

# Revitalizing the Aged Brain

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## KEYWORDS

• Cognition • Fitness • Memory • Brain • Health • Older

In the last decade, interest in staying sharp has taken central stage in the minds of older adults.<sup>1</sup> More and more older adults are asking primary care providers (PCPs) to give them advice regarding how to prevent Alzheimer disease (AD) and ways to fix the day-to-day forgetfulness they are experiencing. Optimal cognitive and emotional function is vital to independence, productivity, and quality of life.<sup>2</sup> New research has shown that age-related decline in memory and thinking abilities is smaller than previously believed and is reversible with lifestyle modification.<sup>3</sup> At the same time, new research has also found that even senior moments may be the earliest signs of neurodegenerative disorders.<sup>4</sup> Also, cognitive impairment without dementia may be seen in 16% to 33% of adults older than 65 years and is associated with significant emotional distress.<sup>5,6</sup> PCPs need to be able to give their patients practical guidance in ways to revitalize their aging brain.

The Cognitive and Emotional Health Project commissioned by the National Institutes of Health defined successful cognitive and emotional aging as “the development and preservation of the multidimensional cognitive structures that allows the older adult to maintain social connectedness, an ongoing sense of purpose, and the abilities to function independently, to permit functional recover from illness or injury, and to cope with residual functional deficits.”<sup>7</sup> Thus, cognitive and emotional well-being are inextricably linked. This article uses this definition to qualify revitalizing the aged brain, discuss neuroplasticity, and suggest practical neuroplasticity-based strategies to improve cognitive and emotional well-being of older adults.

## NEUROPLASTICITY

Neuroplasticity is the capacity of the brain to change with experience. The brain has a remarkable capacity to change with experience at all ages, and neuroplasticity is dynamic and flexible.<sup>8</sup> Because experiences can be positive (health promoting) or negative (harming our health), in tandem, neuroplastic changes in the brain can be positive (eg, increased dendritic arborization, synaptogenesis, neurogenesis, stronger

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Financial disclosure: Nothing to disclose.

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Med Clin N Am 95 (2011) 463–475

doi:[10.1016/j.mcna.2011.03.002](https://doi.org/10.1016/j.mcna.2011.03.002)

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signals during neurotransmission) or negative (eg, suppression of neurogenesis, debranching of dendrites, decreased dendritic connections between neurons, weaker signals during neurotransmission).<sup>3,9</sup> Various factors that promote positive and negative neuroplasticity are listed in **Box 1**.<sup>3,10–19</sup>

Cognitive reserve (ability of an adult brain to sustain normal function despite disease or injury to the brain) is probably set early in life (in the first or second decade) and reflects positive neuroplastic changes in the brain caused by an enriched environment during the early years.<sup>20</sup> Older persons who are highly educated have higher cognitive reserve (both functional and structural). Older adults with high cognitive reserve are at an advantage in terms of having bigger and more efficient neural networks and thus may have more efficient neuroplasticity late into their lives. Compensation is another aspect of neuroplasticity and typically involves undamaged neural networks compensating for damaged neural areas involved not only in language and movement but also cognitive functions of attention and memory.

Many cognitive scientists believe that our neglect of intensive learning as we age causes decline in efficiency of various neuronal networks involved in attention and memory function as well as other cognitive functions.<sup>21</sup> Many older adults, after having completed school, rarely engaged in tasks for prolonged periods (months to years) that required focused attention to learn new vocabulary or master a new skill. This situation may have resulted in loss of efficiency of neural networks required for attention. Attention networks are crucial for all forms of learning at all ages. Thus, normal cognitive aging (NCA) may be influenced not only by our genes but also our lifestyle.

Neuroplasticity informs us about the importance of practice (repetitive engagement in activities that enhance brain health) if one wants to improve brain function

<b>Box 1</b>	
<b>Common factors that influence neuroplasticity</b>	
<b>Positive Neuroplasticity</b>	<b>Comments</b>
Physical activity	Even light exercise (eg, walking) promotes cognitive function
Challenging cognitive activities	Learning something new that is interesting and requires intense focus for prolonged periods has the most dramatic effects
Socially active lifestyle	Intergenerational activities may be particularly beneficial
Healthy nutrition	Diet rich in fruits, vegetables, whole grains, and fatty fish along with adequate amount of water is recommended
Nutritional supplements	Omega 3 supplements (for older adults who do not eat fish) and vitamin B <sub>12</sub> and vitamin D (for older adults who are deficient in these vitamins) may promote positive neuroplasticity
<b>Negative Neuroplasticity</b>	<b>Comments</b>
Chronic psychosocial stress	Meditation and psychotherapy may mitigate effects of stress
Chronic insomnia	Adequate sleep (in quantity and quality) is important for synaptic neuroplasticity and thus, learning and memory
Cardiovascular risk factors (CRFs)	CRFs (eg, hypertension, obesity, smoking, diabetes, dyslipidemia) in middle age have been associated with increased risk of AD in later years
Air pollution	Besides accelerating atherosclerosis, air pollution may have a direct toxic effect on brain function

noticeably. As the brain networks and neurons get activated repetitively, they become more efficient and can process faster. They also require less initial stimulus to fire up the action potential (the initial neuronal activity that starts communication between different cells and eventually between different networks). Revitalizing the brain involves replacing unhealthy habits with healthy habits. Each time we engage in unhealthy habits, it activates certain brain networks. As we engage in these habits, the networks strengthen and require less and less stimulation from the environment to get activated. When we try to engage in healthy habits to replace unhealthy habits, more energy is required because these new networks have not yet become as strong and efficient as networks of unhealthy habits. For this reason unhealthy habits are difficult to break or unlearn. Thus, persistence is key in an effort to replace neural networks that support unhealthy habits with neural networks that support healthy habits.

Although chronic severe psychosocial stress is neurotoxic (hampers neuroplasticity), animal studies have found that a little daily stress may enhance neuronal and synaptic function, promote neurogenesis in the hippocampus, and improve cognitive performance in certain tasks.<sup>22</sup> This finding is not surprising because emotional arousal (associated with stress) can enhance learning and memory via synaptic plasticity of limbic pathways. Stress hormones (eg, glucocorticoids) have an inverted U-shaped dose-response curve in which low to moderate levels of adrenal steroids enhance acquisition of tasks that involve the hippocampus, whereas high levels of glucocorticoids disrupt task acquisition.<sup>23</sup> This finding may explain why many older adults experience a decline in cognitive functioning after they retire from work: work was providing these older adults with an optimum amount of stress and this in turn helped the brain function better.

## **A PRACTICAL APPROACH TO REVITALIZING THE AGED BRAIN**

Three key steps are recommended to PCPs in helping older adults achieve and maintain cognitive and emotional vitality.

### ***Step 1: Comprehensive Physical and Mental Health Assessment***

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A comprehensive assessment of health to identify and treat medical and psychiatric conditions that are prevalent in older adults and can cause current or future cognitive impairment is recommended.<sup>2-4,11-13,24,25</sup> Please refer to **Box 2**. If these conditions are recognized and treated early, much of the negative effect of these conditions on cognitive and emotional well-being can be prevented or reversed. Observational studies strongly support a link between CRFs (especially hypertension, diabetes, smoking, obesity) and future cognitive impairment and depression.<sup>10</sup> Thus, optimal control of CRFs and secondary prevention of stroke are also recommended to promote brain health. Many older adults (especially if they have subjective cognitive complaints and some functional decline) may need neuropsychological testing to clarify severity of cognitive impairment (whether it is subjective cognitive impairment, mild cognitive impairment [MCI] or mild dementia [AD and related disorders]).<sup>4</sup> Neuropsychological testing also provides assessment of preserved cognitive abilities, and this information may help guide appropriate cognitive strategies.

During such a comprehensive assessment, patients can also be counseled regarding the risk and potential benefits of over-the-counter (OTC) brain enhancers. In general, the risks are not insignificant (eg, drug-supplement interaction) and benefits are not proved for any of the currently available OTC supplements and herbal remedies. Drugs approved by the US Food and Drug Administration for treatment of AD and Parkinson disease (eg, cholinesterase inhibitors, memantine) are not

<b>Box 2</b>	
<b>Common reversible causes of cognitive impairment in older adults</b>	
<b>Causes</b>	<b>Comments</b>
Medications	Benzodiazepines and drugs with anticholinergic activity are common culprits. Cognitive impairment is not the hallmark of all anticholinergic drugs. For example, darifenacin, solifenacin, and tolterodine may not have a significant effect on cognition in cognitively intact healthy older adults
Harmful alcohol use	Excessive alcohol not only causes direct neurotoxicity but also interacts with many commonly prescribed medications
Sleep disorders	Chronic primary insomnia, obstructive sleep apnea, and restless leg syndrome are common culprits
Malnutrition	Dehydration, protein energy malnutrition, vitamin deficiencies (eg, vitamin B12, D) and celiac disease are prevalent in older adults, especially frail older adults (eg, nursing home population)
Electrolyte imbalance	Hypernatremia or hyponatremia can cause cognitive impairment and are often associated with malnutrition, diuretic use, and being secondary to some medications
Depression and anxiety	May directly cause cognitive impairment through increase in stress hormones and indirectly by impairing nutrition and engagement in physical and social activity. Severe depression may be misdiagnosed as dementia
Hearing and vision deficits	Optimizing hearing and vision (eg, with aids and environmental changes [eg, increased lighting]) is recommended before any cognitive testing
Hormonal deficiency	Hyperthyroidism, hypothyroidism, and testosterone deficiency are the most common endocrine disorders associated with cognitive impairment
Diabetes	Hypoglycemic episodes and severe hyperglycemia are commonly associated with cognitive impairment
Hypertriglyceridemia	High levels of triglycerides are associated with cognitive impairment
Chronic severe pain	Chronic pain is associated with cognitive impairment, and this association may be mediated through negative neuroplasticity caused by severe and chronic emotional stress as well as cognitive adverse effects of medications given to treat pain (eg, opiates)
Congestive heart failure (CHF)	Association of CHF with cognitive impairment may be related to decreased ejection fraction, resulting in decreased cerebral blood flow
Blood pressure dyscontrol	Excessively high or low blood pressure may impair cognition by reducing cerebral blood flow

recommended for treatment of NCA or to improve cognition in patients who do not have these conditions. Vitamins are also not recommended if the primary goal is to improve cognition unless there is documented vitamin deficiency. In addition, vitamin supplements in some individuals may prevent health-promoting effects of physical exercise.<sup>26</sup>

During initial assessment, evaluation for substance abuse (prescription and illicit street drugs and alcohol) and smoking is also recommended. All drugs with potential for abuse have negative effects on the brain and these effects can be permanent depending on severity and duration of abuse. The need for substance abuse treatment

among Americans older than 50 years is projected to double by 2020, according to a report by the Substance Abuse and Mental Health Services Administration (SAMHSA). As baby boomers age, illicit drug use among the population older than 50 years also is rising. Illicit drugs include marijuana and the nonmedical use of prescription drugs. An estimated 4.3 million adults aged 50 years or older used an illicit drug in the past year, according to SAMHSA. Age-related physiologic and social changes make older adults more vulnerable to the harmful effect of illicit drug use. Counseling regarding harmful effects of illicit drug use, prescription drug abuse, excessive alcohol intake (more than 1–2 drinks per day) and smoking can be initiated by the PCP and followed up by the nurse.

### ***Step 2: Counseling Patients About Practical, Individually Tailored Lifestyle Modification Strategies to Promote Cognitive and Emotional Health***

In general, what is good for the heart is good for the brain. Thus, lifestyle modification strategies involve stress reduction strategies, physical activity and exercise, nutritional strategies, and a socially active lifestyle. Stressing the benefits of a brain-healthy lifestyle may work better than emphasizing the negative effects of an unhealthy lifestyle (eg, sedentary lifestyle, regular intake of fast foods). This information can be provided by a nurse, and a patient handout (refer to **Box 3**) may facilitate patient participation.

#### ***Stress reduction strategies***

Psychosocial stress suppresses neurogenesis, causes dendritic shrinkage, and may accelerate the cognitive decline and synaptic loss in individuals at risk for AD.<sup>27</sup> Routine engagement in strategies to reduce stress and promote emotional

#### **Box 3**

##### **Patient handout: to improve brain health, all you need is “SLEEP N Pills”**

**S:** Adequate daily sleep is essential to recharge the brain and maintain good thinking skills and memory. New information gets processed and new memories get consolidated during different phases of sleep.

**L:** Lose it or use it. Brain is a plastic organ, meaning that it constantly changes with experience and activity. Brain functions and skills not used are lost rapidly. Age-related decline in brain function may be more related to decline in our time spent learning new skills and activities after age 30 years rather than decline because of aging.

**E:** Excess disability such as memory problems caused by nutritional deficiencies, sleep disorders, medication adverse effects, depression, anxiety disorder, chronic pain, chronic stress, attention-deficit/hyperactivity disorder (ADHD) and other conditions should be identified and treated for other strategies to have their beneficial effect.

**E:** Exercising regularly and leading a physically active lifestyle are also crucial to preserving brain function. Exercise not only boosts blood supply to the brain but also helps create new brain cells, even late in life.

**P:** Positive emotions (eg, relaxation, joy, serenity, happiness, laughter, optimism, feeling connected to others) not only prevent negative effects of stress on the brain but may directly improve the capacity of the brain to learn new things and remember day-to-day events.

**N:** Nutrition that is brain healthy (eg, a Mediterranean diet) is crucial to preserve brain function.

**Pills:** Nutritional supplements (eg, omega 3, vitamins [only if there is vitamin deficiency]) and medications for cardiovascular (eg, hypertension, diabetes) and neuropsychiatric disorders (eg, ADHD medications, antidepressants) may be necessary for some people to maximize the effects of other strategies mentioned earlier.

well-being promotes positive neuroplasticity in a variety of ways. For example, meditation and other mindfulness-based strategies (eg, yoga) have been found to increase white-matter connectivity and gray-matter volumes (especially in hippocampal and frontal lobes).<sup>28,29</sup> One of the simple stress reduction strategies is daily practice of relaxation exercises (eg, breath-awareness exercises, progressive muscle relaxation, relaxation using biofeedback and neurofeedback). Please refer to **Box 4** for a patient handout for breath-awareness exercises. During relaxation exercises, the brain rearranges itself so that the 2 cerebral hemispheres communicate better. This characteristic helps the brain better able to solve day-to-day problems. Another neurophysiologic effect of relaxation exercises is quieting down of limbic networks but an increase in activity in certain networks in the frontal lobe that are involved with attention and decision making. Thus, if an individual engages in the daily practice of relaxation training, gradually the capacity to pay attention (and thus remember) and problem solve improves. The calming response induced by relaxation exercises also releases nitric oxide, which in turn enhances dopaminergic and endorphin neurotransmission. The latter has the effect of enhancing a general sense of well-being. Humor is another strategy that not only reduces stress but may also promote the health of diverse brain and body functions such as insight, the capacity to problem solve, and the immune system.

### ***Physical activity and exercise***

A large body of research has shown the beneficial effects of physical activity and exercise (especially aerobic but also strength training) on many aspects of brain function and have suggested that they may even increase brain volume in aging humans.<sup>14,30,31</sup> The benefits have been seen at the molecular as well as at the behavioral level in all age groups including frail elderly people. Executive function (ability to plan, organize, and learn from previous experience) and attention has been found to improve with regular

#### **Box 4**

##### **Patient handout**

#### **Breath-awareness Exercises To Improve Memory and Promote Resilience**

Find a quiet spot. Sit on a flat but comfortable surface. Close your eyes and begin to pay attention to your breathing. Inhale through your nose. Slow down your breathing as you feel your breath enter and leave your body. Feel your lungs expand with the inhalation, retain the breath for a few seconds, and then exhale gently. As you continue to breathe, try and keep your attention on all 3 aspects of breathing (inhalation, pause, exhalation). The slower the breathing, the greater are the benefits. Whenever possible, exhalation should be longer than inhalation. During exhalation, the heart slows down, the blood pressure drops and stress hormone levels also drop. Also, try and do abdominal breathing/diaphragmatic breathing. Thus, during inhalation, your tummy should bulge outwards and during exhalation, your tummy should go toward the spine. Count your breaths. If you notice that you have lost count of your breaths, gently bring your attention to breathing and start counting again. Continue this for at least 2 minutes. Try and increase it to 20 minutes twice a day (early morning and before sleep). Alternatively, one can engage in this for 2 minutes several times a day. Find your own rhythm, frequency and duration. This exercise is best done when you are not tired. When you are doing this for the first time, you may experience dizziness. Generally, it is mild and transient and passes quickly.

#### **Potential benefits of breath-awareness exercises**

Improved memory (through improved capacity to focus, pay attention, be aware), improved capacity to tolerate negative emotions (anxiety, anger, resentment, guilt, grief, sadness) and improved ability to manage stress and problem solve in creative and healthy ways.

moderate physical activity in middle-aged as well as older adults, even those in their 80s. Mechanisms postulated for the beneficial effects of exercise on brain function include not only direct effects (eg, increased cerebral blood flow, increased synaptogenesis and neurogenesis) but also indirect effects (eg, reversing the negative effects of high-fat diets on neurotrophic factors in the brain that are needed for neuroplasticity and learning). “Achieving a physically active lifestyle requires effective time management, with a particular focus on reducing sedentary activities such as screen time (eg, watching television, surfing the Web, playing computer games) and making daily choices to move rather than be moved (eg, taking the stairs instead of the elevator),” is recommended by the American Heart Association (AHA) guidelines as a lifestyle modification strategy to improve cardiovascular health. These recommendations may also improve cognitive and emotional well-being.<sup>2</sup>

### ***Nutritional strategies***

A healthy diet may reduce fatty buildup in arteries (atherosclerosis) and counteract the neurotoxicity mediated by toxic protein(s) (eg, A $\beta$  amyloid, hyperphosphorylated  $\tau$ ) that is believed to be the underlying mechanism of AD.<sup>15</sup> The Mediterranean diet has been associated with lower risk of future AD. The Mediterranean diet is characterized by high consumption of fruits, vegetables, legumes, nuts, and fish; a low intake of meats and poultry; the use of olive oil as the main source of fat; and a low to moderate intake of wine. Lowering intake of saturated fat to less than 7% and limiting trans fats to less than 1% is recommended by the AHA to promote cardiovascular health. These dietary changes may also improve neuronal function through improved cerebrovascular function and decreased neurodegeneration and thus may promote cognitive and emotional well-being. In individuals with limited life expectancy (eg, elderly people living in nursing homes, frail elderly people living in the community), liberalization of diet may do more to promote emotional well-being and improved nutritional status and thus cognitive performance than following therapeutic diets (eg, heart-healthy diet, diabetic diet, low-sodium diets).

### ***Socially active lifestyle***

An active and socially integrated lifestyle may protect against cognitive decline caused by aging and late-life dementias.<sup>32</sup> A socially active lifestyle may not only benefit cognitive functioning by providing mental stimulation (through increased use of language during conversations and increased engagement in pleasurable activities) but also by providing a buffer against negative effects of day-to-day stress. In addition, enriched social environment may also promote synaptogenesis and neurogenesis.<sup>33</sup> Rats in an enriched environment (eg, more social contact and novel stimuli) were found to complete a maze task faster than rats assigned to the standard environmental condition.<sup>34</sup> Thus, social activities have the potential to also promote problem-solving abilities.

### ***Step 3: Counseling Patients Regarding Cognitive Strategies***

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Nurses can also take a leadership role in providing counseling to patients regarding cognitive strategies to improve memory and other cognitive problems. Please refer to **Box 5** for a list of strategies a nurse can use to counsel older adults who reports mild memory problems. Cognitive strategies (including cognitive training, engagement in mentally stimulating and challenging activities, brain exercises, and computer games) are necessary to optimally revitalize an aged brain because neuroplasticity is totally dependent on engaging the neural networks (ie, use it or lose it).<sup>16,35</sup> Cognitive strategies have been found to increase gray matter in the nucleus accumbens and

**Box 5****Counseling patients regarding practical strategies to improve memory**

1. *Use of imagination:* visual memory is stored at a different place than verbal memory. Storing memory in multiple places increases the likelihood of recalling the information. Patients can be encouraged to use all of their senses to imagine a particular scene or conversation they would like to remember.
2. *Use of mnemonics* may help some patients improve their memory by associating (chunking) information with easy-to-remember alphabets or words.
3. *Importance of cross-training:* exercising brain networks not involved in memory enhances the functioning of memory pathways in the brain. For example, learning a new language improves one's ability to remember words of one's own language. Singing, reading aloud, writing an autobiography, writing a poem, doing calculation/arithmetic with a child, solving puzzles (crosswords, sudoku, jigsaw puzzles), joining a book club, or taking a dance class are other examples of exercising nonmemory networks that may improve memory.
4. *Importance of repetition and rehearsal:* repetition is a key step to consolidate memory. Thus, encouraging patients to repeat the information in their mind (one can add visualization to this) is important.
5. *Keeping the stress down:* mild stress enhances attention but excessive stress not only impairs attention but also ability to recall information. Thus, one needs to be patient with oneself during one's attempt to remember.
6. *Importance of being present and attentive:* patients can be encouraged to focus (concentrate) with all their senses on the situation (eg, a conversation with a friend), paying attention to not only what the person is saying but their emotional intensity, and paying attention to their facial expressions. Multitasking involves splitting attention and thus is not good for remembering well. It is also important to minimize distractions (such as turning off music/TV, moving out of a noisy room to a quiet room) because with aging, one is more easily distracted. Also, full attention activates a larger area of the brain than paying less attention.
7. *Using tools:* taking notes (eg, checklist of things to do today, names of new people one meets, information obtained during visit to one's health care provider) and using a personal digital assistant are useful as memory aids. Our current hypercognitive culture can quickly overwhelm the best of us with information, and hence this strategy is used by even younger adults with normal memory.
8. *Creating a context:* giving the content emotional meaning and having an internal dialog to create the context in which information needs to be remembered promotes consolidation of memory. For example, we are more likely to remember names and events that had an emotional effect.

hippocampus but this effect is temporary, and once engagement in cognitive activity is stopped, these benefits are lost.<sup>36</sup> Engagement in cognitive activities such as reading, doing puzzles (crossword puzzles, sudoku), and playing bridge or chess provide a good brain workout. Engaging in learning new skills that are interesting/fun, especially in a social setting (eg, learning line dancing) or along with another individual (eg, learning a new language) have the potential to provide an even better brain workout, because learning something new requires an intense focus for prolonged periods of time and repetition, the 3 key ingredients to revitalize the brain. Older adults are encouraged to try new technologies (eg, texting) because it may not only provide a cognitive challenge but may enhance their social life (eg, increased contact with grandchildren).

Engaging in brain exercises to improve one's capacity to focus (pay attention) is also essential to improve brain function (especially memory). To remember something we

have recently heard, first we must hear it clearly (with our full attention) because the memory can be only as clear as its original signal. Reward is also crucial to learning new things. When we reward ourselves for engaging in a challenging task, our brain releases certain neurotransmitters such as dopamine and acetylcholine. These neurotransmitters are crucial in consolidating changes at the molecular and synaptic level that occur during learning. Engagement in creative activities may improve cognitive health directly by exercising neural networks not engaged routinely and also through psychosocial benefits.<sup>17</sup> Every person at all ages has at least 1 unique creative skill or talent. Engaging in this skill can reignite a passion that can not only improve cognition in that older person but may also reestablish their zest for life.

Simple strategies such as doing 1 task at a time (ie, avoiding multitasking), doing things slowly, and reminding oneself that the activity is completed (eg, locking the door and reminding oneself that one has locked the door so that one does not have to return to check if the door was locked), taking in one's surrounding before proceeding (eg, when parking, making a mental note as to where the car is parked), taking notes and visualizing the information all have the potential to mitigate senior moments and prevent associated emotional distress. High-technology strategies can involve engaging in computer-based brain exercises that are designed to enhance a specific group of cognitive functions (eg, ability to detect patterns, reaction time/processing speed) as well as engagement in computer games that promote physical fitness (eg, Wii games).

There is no one cognitive activity, or combination of activities, that is uniquely beneficial.<sup>16</sup> Cognitive activities that use multiple sensory systems (eg, tactile and auditory during dancing; gustatory and olfactory during cooking) may magnify the cognitive benefits of a challenging task. Nurses can help the older person create a personal program of cognitive fitness that is focused on their strengths and preserved abilities.

## REALISTIC EXPECTATIONS

None of the research to date is conclusive that lifestyle modification or control of CRFs prevents dementia. Nevertheless, the benefits of the strategies described here have been proved to reduce one's risk of heart attacks and strokes, improve longevity, and in general have minimal downside and considerable potential to promote healthy brain aging.<sup>2</sup> Our experience and research have shown that the effect of these strategies is variable, with most seeing at least modest cognitive benefits and a small subgroup showing dramatic benefits. The latter group typically has multiple reversible causes of cognitive impairment (eg, depression, alcoholism, nutritional deficiencies, chronic pain, obstructive sleep apnea, drug-induced cognitive impairment), and on correction of these problems, show a dramatic improvement in cognitive function.

The capacity for the brain to revitalize depends on cognitive reserve and physical health. Thus, starting an individualized cognitive fitness plan as early as possible is important for optimal outcomes. Also, the brain retains capacity to improve even in the ninth decade and beyond. Thus, it is never too late to start making brain health a priority. Investments by communities, businesses, and government in creating fundamental changes in the food supply (access to affordable, tasty, and healthier options), technology that is easier for older adults to use, and social infrastructure (eg, a social environment that promotes physical activity and socialization) are necessary if healthy cognitive aging for all older adults is to be a reality. Please refer to **Box 6**

**Box 6****Suggested resources for clinicians and patients***For Clinicians*

Desai AK. Guest editor. Healthy brain aging: evidence based methods to preserve brain function and prevent dementia. *Clinics of Geriatric Medicine* 2010;26:1–170.

Vance DE, Roberson AJ, McGuinness TM, Fazeli PL. Now neuroplasticity and cognitive reserve protect cognitive functioning. *Journal of Psychosocial Nursing* 2010;48(4):23–30.

*For Patients*

## Audio CD:

1. Weil A, Small G. The Healthy Brain Kit. Audio CDs, brain-training cards, and workbook. Boulder, CO: Sound True.

## Books

2. Norman Doidge. *The Brain That Changes Itself*. New York: Penguin Books; 2007.
3. Gary Small. *The Memory Prescription: Dr. Gary Small's 14-day plan to keep your brain and body young*. New York: Hyperion; 2004.
4. *Improving memory. Understanding age-related memory loss. A special report from Harvard Medical School*. Boston: Harvard Health Publications; 2006. <http://www.health.harvard.edu/>

Web sites for information on brain fitness, brain training games, and software

5. <http://www.positscience.com/>
6. <http://www.sharpbrains.com/>

for a list of resources for both PCPs and patients. Such resources can be made available at the local library for all older adults in the community and their family.

The strategies to revitalize the aged brain are most effective in patients with NCA. In patients with MCI, these strategies if tailored to the patients' strengths may help improve cognitive function, but in patients with mild to moderate dementia, some of the cognitive interventions (eg, cognitive training, cognitive exercises using computers) may cause considerable stress and thus may do more harm than good.

A personal cognitive fitness program should be adapted to the particular strengths and limitations of each person and also his/her preferences. Consequently, instead of implementing ready-made programs, tailoring programs to the individual and resources available is recommended. Group training programs can also be considered, although mixing patients with NCA and patients with mild dementia may need to be avoided. Strategies mentioned here may not only revitalize the aged brain but also reduce risk of future stroke and may delay onset of dementia in at-risk individuals. Many older adults who engage in optimal behaviors to enrich their brain may nevertheless experience cognitive decline at some later point in their life. Thus, as McFadden and Basting<sup>17</sup> have commented, "this discussion turns eventually toward enduring existential and spiritual questions about life meaning and its roots in individual lives and in community." Cognitive fitness should be part of a holistic approach that also addresses patient's physical, emotional, and spiritual well-being.

**FUTURE RESEARCH**

One of the promising implications of neural plasticity is that many changes that occur in response to experience and aging may be reversible, including neuronal atrophy

and cell loss. Future research needs to clarify to what extent this finding can be exploited in older adults. As the fundamental mechanisms of neural plasticity are discovered and understood, new targets and paradigms for enhancing cognitive function will be revealed and will lead to more effective and faster-acting intervention strategies. Future research needs to clarify to what extent cognition can be promoted by exploiting endogenous permissive neuroplasticity factors, such as neuro-modulators.<sup>37</sup> Future research may identify drugs that selectively target certain receptors (eg, *N*-methyl-*D*-aspartate) and thus influence components of synaptic remodeling (eg, second-messenger signaling, neurotransmitter trafficking and function) and thereby enhance cognitive function and prevent cognitive decline.<sup>38</sup> Large, prospective, multicenter, randomized controlled studies regarding strategies to promote cognitive health in older adults have involved aerobic exercise and cognitive training but lacking for other interventions discussed in this article. Prospective studies evaluating interventions for CRFs for the outcomes of cognition and depression have either been negative or inconclusive (except for control of blood pressure).<sup>10</sup> Thus, future research needs to address these gaps in research.

Cerebrovascular disease (caused by atherosclerosis and arteriosclerosis) and neurodegeneration may cause a subtle decline in cognitive function and mood. It seems possible to improve at least some aspects of cognitive and emotional functioning in older adults through various strategies described in this article. However, the effect of these interventions on quality of life and autonomy in everyday activities needs to be studied in more detail. Future research may guide us to optimally use the knowledge of mirror neurons to gain skills by observation and indirect experience. In the future, healthy older adults at high risk for AD and or other neurodegenerative disorders (assessed through calculation of dementia risk scores) may be prescribed neuroprotective agents to prevent cognitive decline.<sup>10,39</sup>

## SUMMARY

A high level of cognitive and emotional well-being for most older adults is possible, but to achieve this, older adults need to engage in challenging cognitive, sensory, and motor activities on an intensive basis. The brain has a remarkable capacity to improve its function at all ages. Now we have increasing (although not definitive) evidence that many older adults may be able to preserve their cognitive function into their later years by adding neuroplasticity-based simple and practical cognitive strategies to their daily routine of physical activity, good sleep habits, and healthy nutrition.

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