

Brain Health: Bridging Neuroscience to Consumer Application

The study of the human brain is growing more sophisticated with the advent of more advanced neuroimaging technologies. This development—colliding with the aging of the baby boomers—is driving the evolution of a new area of study and practice: brain health.

The study of the human brain is simultaneously mysterious and fulfilling as we continue to learn more about its grand architecture and function. This wonderful two-to-four-pound structure is the single greatest and most complicated system ever designed in the history of the universe. All of our thoughts, emotions, and movements are products of thousands of neurons firing in response to a particular environmental input. Our brain is the birthplace of our identity, and while we should strive to learn everything we can about this part of our being, we can only speculate about and imagine the brain's capabilities.

Despite our primitive understanding of how the brain functions, we are now better informed—and neuroscience has unleashed findings both transforming and exciting. The study of the human brain may be that final great frontier of exploration that yields answers to our most complex questions.

Excitement about human brain study has accelerated with the advent of more advanced neuroimaging technologies, and this is colliding with the aging of the baby boomers (a cohort of seventy-six million strong born between 1946 and 1964), a generation that is passionate and educated about health. What has now evolved is a new area of study and practice known as brain health, one of the most popular and discussed topics in healthcare today.

It is quite common to read about brain health in consumer magazines and major newspapers, or to see programs about it on television. The topic has permeated the business sector, healthcare and the insurance industry, assisted living, libraries, lifelong learning institutes and education, the media, and religion. While such information dissemination is likely positive for educating the general public, there remains a need to define brain health and to rely on scientifically based standards for consumer application.

Underlying the increased attention to the human brain and brain health is a fundamental question: Can the human brain be shaped for health and, if so, how does this occur? Another question of equal importance ponders what we can do, if anything, to promote our brain health.

This issue of *Generations* addresses these questions by providing a critical review of some of the major areas of brain health. The purpose of this issue is multifold: to discuss neural plasticity as a primary mechanism for shaping the brain towards health; to review both the normal changes and pathologic conditions associated with the aging brain (plasticity infers both positive and negative change); to review research on the relationship between lifestyle and brain health; and to serve as a reference point for the consumer to make informed decisions about the ever-proliferating information on brain health.

Brain Health Defined

There is no uniform definition of brain health; terms such as “brain fitness,” “cognitive fitness,” and “mental fitness” are often used to mean the same thing. While the contents of this *Generations* are not meant to be the ultimate standard for defining brain health, it is important and

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useful to put forth a definition that applies especially to this issue of the journal.

Brain health *is the result of a dynamic process in which a person engages in behaviors and environments to shape the brain toward a healthier existence.* The articles that follow support the idea that environmental input (our choice of actions and external stimuli) has an impact on our brain. The focus is to try and identify those behaviors and environments that help to shape the brain toward health. Several

useful reviews have been published on the relationship between environment and the shaping of the brain towards health (Diamond and Hopson, 1998; Kotulak, 1997; Nussbaum, 2003), and this *Generations* will build upon these early reviews.

Brain health is also distinguished from brain fitness and other similar terms for purposes of this issue; it is presented as more comprehensive in scope and considers environmental input and effects that extend beyond cognition. While cognition is important, the brain is more than a cognitive system; health must include the emotional, spiritual, nutritional, social, and physical aspects that can affect the brain. Brain fitness refers to a more specific shaping of cognition. Today, brain fitness typically refers to online software programs that offer mental exercises.

Neurophysiology of Brain Health

There needs to be an underlying neurophysiological basis or explanation for a brain that can be shaped. Neural plasticity offers such an underlying explanation for brain health. Plasticity is not a new concept. Donald Hebb, who is sometimes referred to as the pioneer of plasticity at the cellular level, presented a

theory in the middle part of the twentieth century that learning occurs based upon the capacity of the neuron to be strengthened, changed, or associated with other cells from repeated activation. This is thought to represent the foundation for a model of plasticity in the central nervous system (Spatz, 1996).

For our purposes, neural plasticity shall refer to *a brain that is dynamic, constantly reorganizing, and malleable.* This contrasts with some traditional ideas of the human brain as a fixed, rigid—and even degenerative—system from early age. Neuroscience and psychosocial research have demonstrated continued development of the brain across the lifespan, supporting the idea for plasticity at all ages (see the articles by Perls,

Patterson and Perlstein, and Wilson on pages 21, 27, and 58, respectively). A brain that is dynamic and malleable can be shaped towards health.

Related to the work on neural plasticity has been the emergence of the theory of brain reserve (Katzman, 1995; Albert, 1995). Brain reserve (sometimes referred to as intellectual reserve, cognitive reserve, and synaptic density)

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describes the brain's development of neuronal connections (neuronal changes) and related knowledge or intelligence in response to particular environmental input across the lifespan.

There is theory that brain reserve (Albert, 1995; Wilson et al., 2010) helps to delay onset of neurodegenerative diseases such as Alzheimer's and related dementias (see Weirenga and Bondi article on page 37). Much of this work has been correlational in nature, but the literature is relatively robust in showing behavioral and neuroanatomical effects associated with environmental input (Mocerri et al., 2000; Sapolsky, 1998; Snowdon, 2001; Stern et al., 1994). Brain reserve theory explains how a brain with plasticity is shaped toward health by environmental input. The important point to keep in mind while reading this issue of *Generations* is that the human brain has plasticity and this plasticity enables the brain to be healthier through mechanisms of brain reserve.

One major example of plasticity (and perhaps brain reserve) is the finding that the human brain can generate new brain cells (neurogenesis) (Eriksson et al., 1998). These authors provided evidence for neurogenesis in the dentate gyrus of the hippocampus of the human brain, the same region found to demonstrate neurogenesis in animal models (Diamond and Hopson, 1998). While other reports support

neurogenesis in the human brain (Beck, 2000; Roy et al., 2000), questions remain regarding the functional or biological significance of neurogenesis in the adult human brain.

The following are logical questions to ask: What leads to neurogenesis in the hippocampus of the human brain? Does neurogenesis occur in other parts of the brain? The literature on the relationship between enriched environments and the brains of rodents (Diamond and Hopson, 1998) may help find answers to these questions. Diamond's work demonstrated that socialization, physical activity, and mental stimulation are important parts of an enriched environment and she reported that rodents raised in enriched environments evinced healthier brains at autopsy (larger cortex and neurogenesis in the hippocampus) compared to rodents raised in isolation.

In order to better understand what the research teaches us about particular impacts on the human brain, this issue's articles will expand on the findings of the enriched environment, and review five major parts—socialization, physical activity, mental stimulation, nutrition, and spirituality—of what I call a “comprehensive brain health lifestyle” (Nussbaum, 2010).

Novelty and Complexity

In my own study of and work on brain health and lifestyle I have described the importance of stimuli that are “novel and complex.” This is akin to Diamond's ideas on the importance of enriched environments for shaping the brain. When the brain is engaged with stimuli that are novel and complex, the cortex is called upon to process at a deeper level relative to overlearned information, and this is potentially a critical factor in development of brain reserve. An example of an activity that is novel and complex is one in which a person has little ability, minimal or no experience with the task, and will feel uncomfortable trying

Public Perceptions of Brain Health

In 2006, I served on a panel of experts to review and discuss survey data on the *Attitudes and Awareness of Brain Health* (American Society on Aging, 2006). Commissioned by the American Society on Aging and MetLife Foundation, surveyors telephoned 1,000 Americans and gathered data that reflected the rapid emergence of brain health as an area of study and practice by the general consumer. Data were weighted so that findings from the sample were projected for the national population, ages 42 and older. A profile of the respondents is as follows:

- 75 percent of interviews were conducted with people below age 65, including nearly 50 percent with members of the aging baby boom generation;
- 66 percent report they work full time or part time, or are active as volunteers; 33 percent are retired;
- 25 percent describe themselves as belonging to a racial or ethnic minority group;
- Among those who reported household income information, 20 percent are below \$25,000 annually; 21 percent are between \$25,000 and \$49,000; 28 percent have from \$50,000 to \$99,000; and the remaining 18 percent more than \$100,000;
- 25 percent have some college or technical/vocational education; 28 percent report earning college degrees; 40 percent are high school graduates or have completed a GED program; and 7 percent did not complete high school;
- Sample balanced by gender (53 percent female and 47 percent male), geographic region (East, 26 percent; South, 26 percent; Midwest, 24 percent; and West, 24 percent); and involvement in religious activity (51 percent “yes” and 49 percent “no”).

The survey yielded tremendous amounts of data regarding the public’s perceptions of brain health and some of the major findings are as follows:

1. We are optimistic about brain health.

Nearly nine out of ten people think that it is possible to improve brain fitness.

- 53 percent believe it can improve a lot
- 35 percent believe it can improve a little

And: An overwhelming majority says that thinking abilities should be checked routinely, just like a physical checkup.

- 59 percent say it is very important to get a checkup
- 32 percent say a checkup is somewhat important

But: Brain health is a low priority compared to other health issues.

- 3 percent rate it the most important health subject for people their age
- 7 percent consider it the second most important topic

2. Our memory is good today, but we have doubts about tomorrow.

We give ourselves high scores on our current brain fitness, regardless of age.

- 34 percent rate their current memory as excellent
- 62 percent rate their current memory as good

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But: The younger we are, the sooner we anticipate that most people will begin to worry about their memory.

- People ages 42 to 49 perceive that worries begin at age 52
- People ages 50-plus identify age 59 as the time when worries begin

3. We know about activities that are good for brain health.

Most people recognize that many activities are very useful for improving mental fitness. At least 60 percent say to avoid tobacco, eat fresh fruits and vegetables, do puzzles, reduce stress, limit alcoholic drinks, spend time with family and friends, and see the doctor regularly.

And: 84 percent report they spend time, usually daily, in activities that are good for brain health.

- 68 percent choose some kind of art or creative project, including 48 percent who spend time reading
- 44 percent keep physically active
- 35 percent play games and do puzzles
- 25 percent work
- 22 percent spend time with others

4. Doctors are our preferred source for information about brain fitness.

More than 70 percent think that most people their age would go to a medical professional to find out about the brain and how to keep it fit.

- 76 percent of women and 68 percent of men identify doctors as the best resource for information
- People in their 40s and 50s are more likely than those ages 65-plus to choose the Internet for brain health news

And: We encourage others who are concerned about their memory to see a doctor.

- More than 74 percent would advise close friends or family to talk to a doctor

But: We do not do what we think is best.

- Only 58 percent say they have talked about their memory or brain fitness with anyone
- 47 percent talk with family and 42 percent turn to friends
- Just 37 percent speak with a medical professional: 13 percent with a nurse and only 24 percent with a doctor

The panel of experts who reviewed the survey results offered the following major directives for the nation: It is time to make brain health a national priority; it is time to apply the good news from brain research; and brain fitness activities should be everywhere.

to complete it. We all have activities or tasks that are new and hard for us. In contrast, an over-learned activity may also be considered a talent, or more of a habit in which we do not utilize much conscious processing to complete it: we have tremendous ability and extensive experience with it and we feel comfortable doing the task. Over time, non-enriched environments that are absent of socialization, limited with physical activity, and without mental stimulation can have

a detrimental effect on the human brain (Moceri et al., 2000), and stimuli characterized as passive and rote, rather than novel and complex, may also be detrimental (Friedland et al., 2001).

Brain health is a lifelong and proactive process, one in which the brain is shaped by environmental input. Environments that are enriched and include socialization, physical activity, mental stimulation, proper nutrition, and spirituality can be beneficial to the brain. It

may be that the brain's lifelong processing of novel and complex stimuli that fosters development of brain reserve can yield a brain that is not only healthier, but more capable of delaying the onset of degenerative disease.

Brain Health: Moving Forward

The survey overview on pages nine and ten provides a small window into the public's perception of brain health as recently as 2006. Data suggest we are a nation interested and informed to some degree about brain health, but we do not yet prioritize the practice of brain health as we should. We tend not to follow our own advice for brain health, such as talking to our doctors about our brain function. The panel of experts concluded brain health should be considered a national priority, particularly given the impending explosion of dementia. We remain a nation and world that are more reactive than proactive with our health and lifestyle. The panel also encouraged application of research findings from study of the human brain and lifestyle to our daily lives, a process that has only just begun.

In the five years since the survey was published, we are now more educated about the brain and brain health. However, I believe we have much to do to educate everybody about their brain and the behaviors that are part of a proactive "brain health lifestyle." We also need to offer guidelines to better equip consumers with information on all the programs, services, and products that purport to be "brain healthy" (see Fernandez article on page 63).

As excited and passionate as I am and my colleagues are about teaching the general public about the human brain and the research-based behaviors thought to correlate with brain health (especially reduction in risk of dementia), it is vital to recognize concerns that have been raised about the study and field of brain health. Research on the impact of brain fitness (such as cognitive software programs) has offered some promise with improving self-reported and

performance-based measures of daily function and cognitive abilities (Willis et al., 2006), but others argue for a lack of empirical support for general improvement in cognitive function (Owen et al., 2010).

Similarly, while there is solid literature on the relationship between lifestyle and aspects of brain health across the lifespan (see Nussbaum, 2003, and other articles in this issue), others raise concerns about the association of modifiable risk factors with cognitive decline or

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Alzheimer's Disease and the need for studies that move beyond correlational findings (Davignus et al., 2010). One important consideration regarding these two divergent viewpoints is the idea that health promotion may be something very different from disease prevention. Applying ideas such as intervention and cure may not be appropriate for the practice of health promotion.

Diverse viewpoints should be considered a positive part of discovery and will only enhance our understanding of the human brain and brain health. However, the following ideas about the brain and health, though not yet conclusive, are gradually becoming more accepted: the human brain has plasticity; environmental input can shape the function and structure of the brain; the human brain continues to develop and express in late life; brain reserve may delay onset of neurodegenerative disease; neurogenesis occurs in the hippocampus of the human brain; and lifestyle has a role in promotion of brain health.

These ideas offer hope for the emergence of a more refined understanding of the human brain. We must continue to educate the general public about the basics of the brain and brain function, and use the latest research findings to help consumers apply this information to their

daily lifestyle. To that end, we should conduct well-controlled, double-blind studies to move our understanding from the relational to the causal. We also need to critically review our progress and continue to apply research findings to the practice of brain health.

I am delighted to serve as guest editor for this issue of *Generations*. We are fortunate to have some of the leading scholars, scientists, clinicians, and business minds in the arena of

brain health to provide a state-of-the-art review. Relying on the neurophysiological principles described earlier, we offer here a broad approach to brain health that integrates the critical components of neuroscience, clinical practice, and consumer application. 

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