Welcome To Your Brain

by Sandra Aamodt and Sam Wang

Changes and additional material
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Corrections to text

Page 10, Did you know? box: In the "Accurate" list of movies, add *The Diving Bell and the Butterfly*

Page 41, Did you know? box, second line from the bottom: Delete the word "new"

Page 49, 2nd full paragraph, lines 6-7: after "from the outside of the ear to the cochlea" insert ", or by damage to hair cells"
Line 9: change "Hearing loss caused by damage to hair cells" to "If hair cell damage is severe, the resulting profound hearing loss"

Page 77, Practical tip box, line 6: Change "many things at the same time" to "more than one thing at a time"

Page 158, Myth box, lines 3-4: After "Indiana" change "Republican" to "congressman" and on the next line, delete "congressional"

Page 220, Sandra Aamodt's biography. Line 1: before "editor in chief" insert "former." Change the **last two sentences** to read "She enjoys motorcycling and lives with her husband, a professor of neuroscience, in California. They are currently spending a year sailing to the South Pacific and back."

Afterword: Myths and Facts about Brain Training

After this book was published, in many lectures and interviews we were asked the question: "What kinds of training will make my brain work better?" It became clear to us that our readers were curious about the science-based evaluation of "brain fitness" programs that claim to improve mental function.

We wrote about some of the issues relating to brain training in an editorial piece for the *New York Times* that became the paper's most e-mailed article for several weeks. Given such public interest and the complexity of the scientific research on the topic, we thought it might be useful to expand that article for the book. The publication of the paperback edition has provided us with an opportunity to include this extra material.

You may be surprised at our bottom-line recommendation: Instead of using brain training software, get regular *physical* exercise. Fitness training can have an effect that is several times larger than any demonstrated benefit of computer-based brain exercise.

Programs to improve brain performance are a booming business. In the United States, consumers spent about $80 million in 2007 on brain exercise products, up from $2 million in 2005. Advertising for these products often emphasizes the claim that they are designed by scientists or based on scientific research. Though a few may live up to this characterization, most such claims are better described by what comedian Stephen Colbert calls "truthiness," meaning that they only *sound* like truthful statements. To be charitable, we would call them inspired by science--not to be confused with actually proven by science.

The research tells a story that is much less clear than the hype would have us believe. As we explained in Chapter 11, environmental enrichment does improve mental function in laboratory animals. Rodents and monkeys who get playmates or toys learn to complete a variety of tasks more easily, at all ages. They also have larger brains, larger brain cells, and more synaptic connections than animals raised alone in standard cages. But here's the rub: standard laboratory environments are tremendously boring. Laboratory animals rarely need to search for food or avoid predators. In contrast, most of us get plenty of everyday stimulation in activities like finding a new address, socializing with friends, or navigating the treacherous currents of office politics. So we may not benefit from further enrichment.

Another line of evidence cited by marketers comes from studies of elderly people who improve certain skills by practicing a challenging computer-based task. Although most programs work to some extent, the gains tend to be specific to the trained task. That is, practice can certainly make people better at Sudoku puzzles or help them remember lists more accurately. The improvement can even last for years. Similarly, people tend to retain skills and knowledge they learned thoroughly when they were younger. Unless the activities span a broad spectrum of abilities, though, there seems to be no benefit to general mental fitness. The belief that any single brain exercise program late in life can act as a quick fix for general mental function is almost entirely faith-based.

Several problems make it difficult to design studies to prove convincingly that these programs work. First, they typically require many hours of training over several weeks, giving people a strong desire to believe that they haven't wasted their work. This motivation can cause a placebo-like effect in which after training, participants may put more effort or attention into doing well on the tests than they did before training. To control for such placebo effects, one group of participants must be given an ineffective form of training that requires an equivalent amount of work. This condition is rarely if ever met. Second, so far the largest reported effects of training exercises have been small, about one-quarter of a standard deviation. If you are ranked number 10 out of a group of 20 people, that's equivalent to going to...number 8. Not exactly an impressive effect. Cross-training effects are even smaller--or nonexistent.

Does brain training ever have broader effects? Training on a task that requires a particular brain region can "cross-train" another mental capacity that uses the same region. In Chapter 21, we discussed one such example: willpower. Like a muscle, willpower seems to become stronger with use. In psychological studies, even something as simple as using your non-dominant hand to brush your teeth for two weeks can increase willpower capacity for other tasks. People who stick to an exercise program for two months report reducing their impulsive spending, junk food intake, alcohol use and smoking. They also study more, watch less television and do more housework. Other forms of willpower training, like money-management classes, work as well. So even though wrong-handed toothbrushing is a bit silly, it enhances a facet of brain function that can be used for something less silly.

Another type of mental training may lead to general benefits: exercising your working memory. As you may recall from Chapter 24, working memory is used to remember information for seconds to minutes while it is being used actively. People with high IQ scores are more likely to have strong working memory skills than those with low IQ scores. And working memory can be improved by training.

One recent study reported that practice on an extremely challenging working-memory task could increase scores on an IQ test. During the training, participants heard a string of spoken letters and saw a sequence of visual locations. They had to remember both the letter and the location that was presented several steps earlier in the sequence. This task is hard. In the beginning, most participants could only remember stimuli presented three steps earlier. After three weeks of training, they could remember five steps back. At the same time, they gained an average of four or five points on their IQ test scores.

In another study, people practiced a task in which they had to remember the last four letters in a long list that was presented to them. This task, called updating, activates the striatum, a region where training of working memory also leads to increases in activity. After training in updating, the participants' working memory improved. If these studies are supported by further research, including placebo-trained control groups, it may be possible to use training in working memory and updating to become better at problem solving.

Although the benefits of computer-based training are still uncertain, another form of training has been proven to maintain and improve brain health: physical exercise. In humans, exercise boosts executive function, the set of abilities that allows you to select behavior that's appropriate to the situation, inhibit inappropriate behavior, and focus on the job at hand in spite of distractions. Executive function includes basic functions like processing speed, response speed, and working memory.

Executive function starts to decline when people reach their 70s. But elderly people who have been athletic all their lives have much better executive function than sedentary people of the same age. This relationship might occur because people who are healthier tend to be more active, but that's not the whole story. When inactive people get more exercise, even starting in their 70s, their executive function improves. As little as 30-60 minutes of fast walking several times a week can effectively improve brain function. Exercise also greatly reduces the risk of dementia later in life. How exercise might act to improve brain function is discussed in Chapter 15 (see box, *How can you protect your brain as you get older?*).

To conclude, practicing your working memory seems to be the most promising way to improve general brain function, at least while you are sitting in a chair. Computerized brain exercises are unlikely to do any harm, but if you have $400 that you want to use to improve your brain's health, our best advice is to buy yourself a gym membership. Or turn off the computer and go for a brisk walk. Your brain will thank you, and so will your wallet.

(Box) Practical Tip: How to evaluate marketing claims for medical treatments

Brain training software isn't the only product sold using marketing claims that are unsupported by science. Many such products are popular, including brain scanning to diagnose and treat attention deficit and hyperactivity disorder (ADHD), balancing exercises for dyslexia, chelation therapy for autism, and nutritional supplements to aid memory. These products are often sold by people with impressive medical or scientific degrees and come with ringing endorsements from individuals who are convinced that the treatment helped them. How can you tell whether a treatment may be useful to you?

First, check if the treatment is described in peer-reviewed scientific literature. Commercially available treatments that are likely to be genuinely useful have usually passed peer review in the scientific literature. A key phrase to look for is "controlled study" or "control group," and meta-analyses are hard to fake. It is important to remember that abstracts and posters presented at scientific meetings are usually not peer-reviewed, nor are newspaper and magazine articles. Only actual scientific journal articles count.

Second, ignore testimonials. Websites that make health claims but cite only individual testimonials usually feature those stories because there isn't any support in the peer-reviewed scientific literature. Counterintuitively, even though individual endorsements have the greatest emotional appeal, they are not reliable indicators of whether a treatment will work for you. Individual endorsements have the problem that improvement in a condition may have come about by chance or be due to some other factor unrelated to the experimental treatment. Finally, it is important to remember that celebrities usually don't have any medical expertise!

Third, follow the money. Even in scientific literature, studies can be biased by corporate sponsorship of a study. Unfortunately, it's becoming increasingly difficult for readers to distinguish between scientists with no ax to grind and companies trying to manipulate their data to sell products. When research is funded by a company or individuals that stand to profit from the treatment's success, a risk exists that the studies may be biased, even unknowingly, to support the desired outcome. Corporate sponsorship can also lead to pressure to avoid publishing a result that undermines the product's marketability.

Fourth, get a second opinion. Do your research carefully before purchasing treatments that are not generally accepted by the medical community. Sometimes mainstream doctors are genuinely slow to appreciate innovation, but it's often true that doctors have good reasons to be skeptical of unproven claims.

References and further reading

To delve more deeply into neuroscience, a good place to start is *Neuroscience: Exploring the Brain*, by Mark F. Bear, Barry W. Connors, and Michael A. Paradiso (Lippincott, Williams, and Wilkins) or *Neuroscience* by Dale Purves *et al.* (Sinauer and Associates). An advanced reference with a medical emphasis is *Principles of Neural Science* by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell (McGraw-Hill Medical). The magazine *Scientific American Mind* is an excellent way to keep up with recent discoveries.

For high school students, if you find this book interesting we encourage you to consider a career as a neuroscientist. Working neuroscientists often find it helpful to have some background in at least a few of the following areas: biology, chemistry, computer science, engineering, genetics, mathematics, physics, and psychology. Come on in, the water's fine!

The following references give more details about topics in the book and can be found at http://welcometoyourbrain.com.

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