



THE
GREAT
COURSES®

Topic
Better Living

Subtopic
Health & Wellness

Optimizing Brain Fitness

Course Guidebook

Professor Richard Restak

The George Washington University School
of Medicine and Health Sciences



PUBLISHED BY:

THE GREAT COURSES
Corporate Headquarters
4840 Westfields Boulevard, Suite 500
Chantilly, Virginia 20151-2299
Phone: 1-800-832-2412
Fax: 703-378-3819
www.thegreatcourses.com

Copyright © The Teaching Company, 2011

Printed in the United States of America

This book is in copyright. All rights reserved.

Without limiting the rights under copyright reserved above,
no part of this publication may be reproduced, stored in
or introduced into a retrieval system, or transmitted,
in any form, or by any means
(electronic, mechanical, photocopying, recording, or otherwise),
without the prior written permission of
The Teaching Company.



Richard Restak, M.D.

Clinical Professor of Neurology
The George Washington University School
of Medicine and Health Sciences

Professor Richard Restak is Clinical Professor of Neurology at The George Washington University School of Medicine and Health Sciences. He also maintains an active private practice in neurology and neuropsychiatry in Washington DC.

A graduate of Georgetown University School of Medicine, Dr. Restak completed his postgraduate training at St. Vincent's Hospital in New York City, psychiatric training at Georgetown University Hospital, and a residency in neurology at The George Washington University Hospital.

Dr. Restak has written 20 books on the human brain, 2 of which were bestsellers and 4 of which were chosen as Main Selections of the Book-of-the-Month Club. He has penned dozens of articles for national newspapers, including *The Washington Post*, *The New York Times*, *Los Angeles Times*, and *USA Today*. He has contributed brain- and neuroscience-related entries for *World Book Encyclopedia*, *Compton's Encyclopedia*, *Encyclopedia Britannica*, and *Encyclopedia of Neuroscience*.

Dr. Restak has been elected to fellowship in the American Psychiatric Association, the American Academy of Neurology, and the American Neuropsychiatric Association. He served as president of the American Neuropsychiatric Association from 2005 to 2007. In 1992, the Chicago Neurosurgical Center awarded him the Decade of the Brain Award. In 1995, he received the Linacre Medal conferred by Georgetown University Medical School.

Dr. Restak's consulting appointments have included the Weill Music Institute at Carnegie Hall; the Franklin Institute Science Museum of Philadelphia;

the the Office of Interdisciplinary Studies, Smithsonian Institution; and the Advisory Panel, U.S. Congress Office of Technology Assessment. He has served on the Board of Advisors for the School of Philosophy at The Catholic University of America and was a member of the Board of Trustees at the Krasnow Institute for Advanced Study at George Mason University.

Dr. Restak has lectured regularly at the Smithsonian Associates. He has also delivered lectures at the Rubin Museum of Art in New York City; the Massachusetts Institute of Technology; the National Academies; the Library of Congress; the Brookings Institute; the 92nd Street Y in New York City; the National Security Agency; the Center for International and Security Studies at the University of Maryland School of Public Policy; the Johns Hopkins University Applied Physics Laboratory; the New York Academy of Sciences; the Philosophical Society of Washington; the FBI Academy; the Chautauqua Institute; the Franklin Institute Science Museum of Philadelphia; The Cooper Union; the National War College; the NASA Goddard Space Flight Center; the Society of Statesmen; the National Cryptologic School at the National Security Agency; and the Central Intelligence Agency.

Along with national and international lectures, Dr. Restak has presented commentaries for *Morning Edition* and *All Things Considered* on National Public Radio and has appeared on the *TODAY* show, *Good Morning America*, the Discovery Channel, and the *PBS NewsHour*. ■

Table of Contents

INTRODUCTION

Professor Biography	i
Course Scope	1

LECTURE GUIDES

LECTURE 1

How Your Brain Works	4
----------------------------	---

LECTURE 2

How Your Brain Changes	8
------------------------------	---

LECTURE 3

Care and Feeding of the Brain	12
-------------------------------------	----

LECTURE 4

Creativity and the Playful Brain	16
--	----

LECTURE 5

Focusing Your Attention	20
-------------------------------	----

LECTURE 6

Enhancing Your Memory	24
-----------------------------	----

LECTURE 7

Exercising Your Working Memory	28
--------------------------------------	----

LECTURE 8

Putting Your Senses to Work	31
-----------------------------------	----

LECTURE 9

Enlisting Your Emotional Memory	34
---------------------------------------	----

LECTURE 10

Practicing for Peak Performance	37
---------------------------------------	----

Table of Contents

LECTURE 11

Taking Advantage of Technology40

LECTURE 12

Building Your Cognitive Reserve44

SUPPLEMENTAL MATERIAL

Bibliography.....48

Optimizing Brain Fitness

Scope:

You can increase the power of your brain through your own effort. The brain's ability to change in response to experience—called plasticity—is the key to understanding the brain's development. The good news is that no matter how old you are, you can still take an active part in influencing brain plasticity. The brain is dependent on your experiences and continues to evolve throughout your lifespan.

In order to improve your brain, it's necessary to understand how it works. In this course you will learn how the brain is organized, how it develops, and how messages are transmitted through the brain's electrochemical pathways. Neuroscientists like to say that “cells that fire together wire together.” Think of brain circuits like friendships: Those that are maintained and enriched will endure, while those that are neglected disappear.

Enriched environments are the key to optimal brain development. Laboratory animals provided with toys, companions, and more spacious living conditions grow additional brain cells. They also get smarter and perform better on behavioral tests such as wending their way through mazes. In humans, sensory and social deprivation early in life leads to decreases in intelligence, emotional health, and adaptation. But this dependence on the richness of environmental stimulation is not limited to early development. At every moment, your activities and your thoughts are modifying your brain. Intelligence is not something like eye color that you're born with and cannot change—it is a dynamic process that can be favorably influenced by choices you make.

Proper diet, exercise, and sleep are critical for optimal brain functioning. In general, what's good for the heart is good for the brain. By cutting down on empty calories in your diet, you can avoid obesity, which is now recognized as a risk factor for late-life dementia and other cognitive deficits. Research shows that regular exercise brings about positive changes in the brain function of children as well as adults. Simple, straightforward measures to

improve sleep can also lead to big dividends at every age. More sleep, for instance, is characteristic of high-achieving students. Power naps can also help to enhance memory consolidation and cognitive performance.

Attention—also referred to as focus and concentration—must be rock solid in order to marshal the effort needed to improve your brain’s performance. Attention in the mental sphere is the equivalent of endurance in the physical sphere. Just as an athlete cannot perform optimally without endurance, you cannot expect to achieve a superpower brain without being able to laser focus your mental energies. In order to do this, you must successfully manage 2 key factors in our current culture: distraction and multitasking. When you focus your attention on something, you have an easier time learning it and are more likely to remember it. The more you learn and the better you remember it, the greater your power to retrieve and use that information.

But if any piece of information can be instantly retrieved via a Google search, why bother to remember it? Because the act of remembering something facilitates the activation and retention of circuits within the brain that contribute to the brain’s optimal functioning. Overreliance on electronic information aids can result in a disuse atrophy of your memory powers, but this atrophy can be overcome by deliberate efforts to improve memory. You’ll learn how to enlist all of your senses in exercises and techniques that can enhance brain function in visual imagery, imagination, and long-term memory.

Working memory, also known as short-term memory, is the key to the most important mental operation carried out by the human brain: manipulating stored information. By improving your working memory, you can increase your intelligence as measured by standardized tests, along with such indirect measurements of intelligence as occupational achievement and creativity. Deliberate practice is the key to improving performance and creativity in all areas of human endeavor, including work and play.

Modern technology can be distracting, but it can be used to improve brain function. Think of technological aids as coextensions of your brain, capable of acting as brain boosters. A laptop computer, for instance, functions as a powerful and refined electronic extension of brain assistants dating back

to the earliest writing instruments. Video games, wisely used, can help you notice more, concentrate better, respond more quickly, and acquire specific real-world skills.

By challenging your brain to learn new information throughout your life, you build up cognitive reserve. This is analogous to monetary reserve: The more you have accumulated over your lifetime, the less susceptible you will be to deficits in your later years. In general, the more education and knowledge people acquire over their lifetime, the less likely they are in their later years to be diagnosed with dementia. In this practical course, you'll learn what steps you can take in your own life to enhance your brain function. ■

How Your Brain Works

Lecture 1

Listening to this lecture will change your brain. While you are hearing my words, your brain is shaping thoughts and images. You are remembering and associating what I'm saying with your experiences. You're forming new networks of ideas which are encoded in your brain's circuitry.

It was traditionally thought the brain was fully formed by adulthood, but in recent years neurobiologists have discovered that our brains continue to change throughout our lives, thanks to the phenomenon of plasticity. In this course we'll learn how you can take advantage of this exciting new research to optimize your brain fitness.

Let's look briefly at 3 of the important functions we'll explore in this course. The first is attention, which means focusing the mind on one thing at a time. Attention is the gateway to top-notch performance in math, reading, and auditory and visual memory. It is the coordinator of brain networks involving things like sensation, movement, emotions, and thinking. The second function is general memory. When we exercise our memory, we activate and maintain widely scattered circuits throughout the brain. In a future lecture we will discuss easy methods for developing a powerful memory. The third function is a special kind of memory: working memory. This is the most important mental operation carried out by the adult human brain. We use our working memory when we simultaneously keep multiple things "in mind" and mentally manipulate them.

As we'll see in later lectures, it's important to understand how to take advantage of the brain's various modes of processing and select the one that at any given moment is best. The more you learn about the brain, the greater your ability to apply meaningful exercises that will help you. Let's first cover a few basic principles of brain operation.

The frontal lobes are the CEO of the brain and the seat of controlled brain processing. They are linked with everything that distinguishes us from other

animals, including foreseeing consequences of our actions, sequencing things, and executive control. But of course many of our actions aren't based on controlled processing: They occur on the basis of automatic processing. With automatic processing, choices are made with no sense of effort. Things just sort of happen, like walking across a room, eating a meal, or driving to the drugstore. When we encounter something unexpected and have to think about it or have to explain something to someone else, we shift to controlled processing.

Automatic processing is centered toward the back of the brain: the occipital, parietal, and temporal lobes. Controlled processing, however, mainly involves the anterior areas of the brain: the prefrontal and frontal areas.

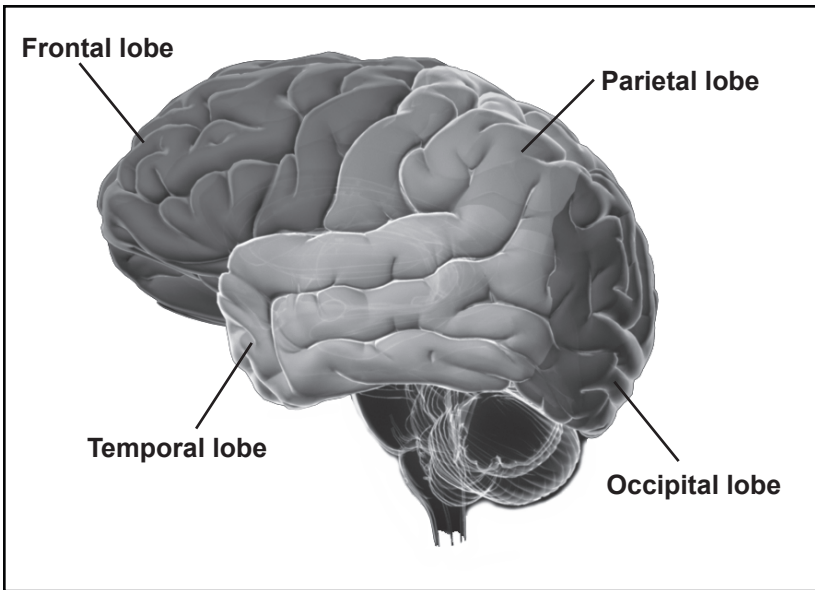
Cognition involves the whole brain and special senses—we have specific processes such as reading, writing, listening, or talking that we can't localize to one particular part of the brain. Emotions are a little bit more localizable: They involve deeper brain structures forming the limbic circuit and the right hemisphere. How does the brain manage to integrate our inner and outer experiences? As you may know, brain function is localized. The right and left hemispheres each have different specializations, and each lobe in the hemispheres is concerned with specific processes. But despite the multiplicity of brain areas and functions, we experience the world as a unity.



© Ryan McVay/PhotoDisc/Thinkstock

Driving can be done with automatic processing, but teaching someone else to drive demands controlled processing.

Here's the key insight about how the brain works—information is the unit of exchange. It can range from the words you're reading now to the chemical exchanges occurring as each of your brain cells communicate with others. What about brain organization: Is the brain one vast interconnected fused



The 4 lobes of the brain are associated with different functions.

network of fibers, or are the nerve cells physically separated from each other? In fact, brain cells are connected similarly to how people on cell phones are connected. They're in touch with each other, but they're not physically connected. There can be strong or weak connections caused by distance, interference, and competing signals. In addition, there is entanglement: The neurons' branches are tightly entangled with each other. Think of the brain as a gigantic bowl of spaghetti, with each noodle highly branched and entangled but not quite physically connected with the others.

So far, we have learned that brain circuits and nerve cells can increase in number, and that each brain is the result of individual experiences and choices. The richer and more varied the experiences, the more enhanced the brain function. In other words, what you do shapes your brain's structure and function. We have also seen that the electrochemical activity in circuits determines their fate: "Cells that fire together, wire together." Information is widely disseminated among neurons, leading to higher-order processing such as memory, imagination, and creativity. The important thing is that

the brain remains modifiable throughout our lives. In the next lecture, we'll learn more about our ability to change our brains through experience as we examine brain plasticity in more detail. ■

Suggested Reading

Fields, *The Other Brain*.

LeDoux, *Synaptic Self*.

Purves, *Neuroscience*.

Purves et al., *Principles of Cognitive Neuroscience*.

Questions to Consider

1. How might the brain processing involved in hitting a baseball differ from that of teaching someone to hit a baseball?
2. What are the capabilities and the limitations of brain imaging?

How Your Brain Changes

Lecture 2

Technology can also bring about changes in the brain thanks to plasticity. Our widespread use of Internet-based technologies leads to changes in our thinking patterns involving superficial approaches to knowledge: scanning, skimming, “idea shopping,” browsing, and multitasking.

Now that we’ve learned something about how your brain is organized, let’s talk about how changes in your brain can improve the way you function in day-to-day life. Intelligence was traditionally considered to be fixed—something we’re born with, like eye color. But there has been a revolutionary transformation in our thinking: Intelligence is not a fixed trait but can be modified over a lifespan. James Flynn, an intelligence researcher at the University of Otago in Dunedin, New Zealand, demonstrated that from 1947 to 2002, Americans gained 24 points on testing for similarities but only 4 points on vocabulary and 2 points on math. Why was there such a gain only in similarities? It is because we’re using our intelligence in different ways. We have more education and more leisure activities, and in the process we have altered the balance between the abstract and the concrete.

Brain research was revolutionized by the discovery of plasticity, the science of which is simple: (1) When you exercise your brain, you release natural growth factors and influence neurotransmitters, which enhance your brain’s level of performance. (2) The efficiency of cell-to-cell communication via chemical messengers increases. (3) There is a remapping of the functional connections among neurons, as new things are learned new maps are created, or old maps altered. (4) Alternative circuits can be established to compensate for lost or injured areas.

Circuits and networks—not the number of nerve cells—are the key to improved function. Learning is the means of establishing and maintaining these circuits. Think of brain circuits like friendships: Those that are maintained and enriched will endure; those that are neglected will disappear.

Maintenance, novelty, and enriched experiences are like fertilizer on the brain and bring about growth and development

How do we know this? Here is a human example of enriched experience. If you have been to London and taken cabs, you have seen that London cab drivers really know the city. You tell them where you want to go, and they don't have to consult anything—they take you right there. That's not by accident: They study the streets of London for 2 years and take a competitive test for their job. Not surprisingly, a study of London cab drivers shows that they have a larger than average hippocampus, with size related to years of driving experience.

In this lecture we have talked about 2 main points: Your brain and your intelligence can change throughout your lifespan. And most important, you are able to shape those changes in your own brain. In the next lecture, we'll move from plasticity to the importance for brain health of what you eat, how you exercise, and how well you sleep. ■

Plasticity-Enhancing Exercises

We often pay insufficient attention to what our senses are telling us, so it is helpful to exercise our elementary physical sensations. There are 3 types of exercises I'd like you to practice: visual and auditory exercises, sensory and motor exercises involving hand dexterity, and peripersonal space exercises. Here are a few examples for you to try.

Visual exercises. Actors have always used sense memory, which they have traditionally practiced with a coffee cup. Give it a try: Hold the cup; recognize and memorize its height, its color, its composition; any ridges or design it has; and light reflections. Now involve your other senses: How does it feel? How heavy is it? You are trying to re-create the cup in your brain. The same brain circuits are involved as when dealing with exploring the real cup. An actor can make the

audience “see” a cup that he’s not actually holding because of this ability. Pick any other object that interests you, and re-create it via a similar exercise.

Auditory exercises. In the 1950s, Jack Foley at Universal Pictures came up with the idea of assembling a studio where he could create live sound effects for movies by using simple and readily available sources. This required a sharp ear for sounds—for instance, crumpling a newspaper sounds like fire. Try it for yourself. Close your eyes, roll a newspaper up, put it to your ear, and crumple it. It sounds just like a fire. Foley artists need a sharp ear for the sounds of everyday objects to create their special effects. For instance, the laser blasts in *Star Wars* were made by taking a hammer and hitting a high-tension wire that supports an antenna. As a sound exercise, listen to the things around you in order to sharpen your sensitivity. Try to figure out what sounds might be substituted for others.

Motor exercises. Exercises involving the hand are functionally related to the brain. Developing nimble fingers is a surefire way of improving brain function: Take up juggling or a hobby that requires fine detail work like knitting, painting, or drawing.

Peripersonal space exercises. These exercises have to do with a virtual envelope around the skin’s surface that extends our body boundaries. Try this exercise: Move your hands toward each other so that your fingers touch. It’s not very hard to do. But try it with your eyes closed, and you’ll find that it’s difficult because you don’t have much experience doing it. You’re not initially able to do well because of your brain’s overreliance on vision. Take up a sport that demands an awareness of your body boundary and its extensions. Tennis is a good example: You have to know where your arm is, where you’re standing, and how to correlate exactly where to place the ball so it’s just within the court. This type of exercise will help you achieve an enhanced kinesthetic sense.

Suggested Reading

Fields, *The Other Brain*.

LeDoux, *Synaptic Self*.

Nisbett, *Intelligence and How to Get It*.

Purves, *Neuroscience*.

Purves et al., *Principles of Cognitive Neuroscience*.

Restak, *Mozart's Brain and the Fighter Pilot*.

Schwartz and Begley, *The Mind and the Brain*.

Care and Feeding of the Brain

Lecture 3

Older adults with a history of exercise have better-preserved brains than those who have not exercised.

There are 3 prongs to the care and feeding of the brain: diet, sleep, and exercise. First we examine diet. Obesity is cognitively harmful, and controlling your weight is a way of improving your brain. But how much caloric restriction is necessary? The class of foods chosen is less important than the number of calories eaten. Sixty-five years of animal research shows that the rate of degenerative disease is slowed by caloric restriction, which means a balanced reduction of protein, fat, and carbs without reduction of nutrient content. It's been shown that animals that eat 35% fewer calories live 35% longer. They are also healthier and have enhanced cognitive performance.

Would a severely decreased caloric diet work in humans as well? A National Institute of Aging study showed that a 25% caloric restriction resulted in a lowering of body temperature and insulin levels, which suggests that such a diet might work. But a key issue here is that few people would be willing to conform to such a diet. Fortunately, keeping calories low enough to prevent obesity may be sufficient.

Let's explore the harmful cognitive effects of obesity. Animal research shows that diets high in saturated fats lead to animals' underperformance on tests of memory and tests of reinforcing rewards (e.g., pressing a button to get food). Similar effects are likely in humans—reduction in fats and “empty calories” will improve memory and brain function. A new insight is that addiction and obesity are linked together. High-fat, high-calorie diets decrease the responsiveness of the brain's pleasure centers. Changes in brain chemistry involving dopamine and opioids lead to compulsive eating patterns. Obesity and addiction may result from similar maladaptations in the brain's reward systems.

The bottom line is that eliminating obesity isn't always easy, but it is worth the effort because of the effects on the brain. Start by eliminating from your diet those foods that can be proven to cause harm. First eliminate trans fats—fats that are formed when liquid oils are transformed into solid fats by adding hydrogen to vegetable oil. Avoid hydrogenated and partially hydrogenated foods. Fast foods are the worst: fried chicken, fried fish, biscuits, French fries, potato chips, doughnuts, and muffins. Substitute them in your diet with fruits, vegetables, chicken, whole-grain breads, and green leafy vegetables.

Another important food source is omega-3 unsaturated fatty acids. They're found in oily fish like mackerel, salmon, trout, herring, and sardines. Omega-3s improve mental clarity and may decrease the likelihood of depression. Two servings a week is probably sufficient, and farmed fish is probably better than wild fish.

The second prong of care and feeding of the brain is sleep and naps. In our hard-driving culture, we tend to hate downtime and disapprove of sleep and naps. As a result, we are sleeping 45 minutes less per day than a generation



A healthy diet with ample vegetables and fish can improve mental clarity.

© Hemera/Thinkstock.

ago. But sleep and naps are actually not a waste of time: Sleep-impaired judgment and performance are as disabling as alcohol intoxication. The more people sleep, the better they perform. The top students at any school sleep more than their compatriots.

Consolidation is the fixing of memories that occurs whether we're awake or asleep. Enhancement, which is improving upon what you have learned, occurs during sleep; it's what's called an off-line effect. This all has practical implications: You can improve your learning by scheduling sleep. The initial consolidation of something new takes about 6 hours, so don't take up a new activity within that same framework. Sleep on what you've learned; your brain circuits will be refreshed.

Let's talk about the power of naps. A power nap is nearly as powerful a skill-memory enhancer as a night's sleep. For instance, finger dexterity increases

The more people sleep, the better they perform.

16% after a nap. Learning facts, words, concepts, and creativity are also improved. But there's a paradox involved in establishing the nap habit: You can't force it. The more you try to force

yourself to sleep, the more awake you will be. And naps must be short so as not to interfere with nighttime sleeping. Think of naps as an opportunity for memory consolidation and enhancement, refreshing the brain circuits involved in learning and memory, and an easy way to power down and increase your creative powers.

The third prong in care and feeding is exercise. The benefits of exercise include increased blood flow and new capillaries around neurons, increased production of new neurons and more interconnections between neurons, and the protection of dopamine neurons from neurotoxins. Exercise also leads to elevations in nerve growth factor and preferentially enhances prefrontal executive processes. The positive balance in neurotransmitters brought about by exercise can even function just like an antidepressant. And a daily 1-mile walk reduces dementia risk by 50%.

We can optimize brain function by paying attention to what we eat, how well we sleep, and how much we exercise. Look for ways to make fitness fun: Get together with friends and take long walks or play a sport. In the next lecture, we'll see how brain optimization can be fun—we'll talk about creativity and puzzles. ■

Suggested Reading

Arehart-Treichel, “Obesity Linked to Changes in Cognitive Patterns.”

Barberger-Gateau, “Dietary Patterns and Risk of Dementia.”

Mahoney and Restak, *The Longevity Strategy*.

Morris, “Association of Vegetable and Fruit Consumption.”

Questions to Consider

1. How do your dietary choices impact your brain function?
2. How do the effects of sleep and naps differ?

Creativity and the Playful Brain

Lecture 4

William Dement asked his students this riddle: “Consider the letters H, I, J, K, L, M, N, O. Now, this sequence should suggest one word. What is that word?” Some students got it right away. Other ones didn’t, and he asked them to dream about it and come in the next day and tell him about their dreams. The students dreamed of hunting sharks, skin diving, being caught in a heavy rain. Does that give you a hint? We’re talking about the chemical formula for water: H_2O is the answer, which is the letters H to O in the sequence.

Although everyone agrees about the value of creativity, until recently we knew little about the brain processes underlying it. You may know that the 2 brain hemispheres are specialized: The left is more important for verbal and symbolic processing; the right is important for processing visual-spatial information and is involved with emotional perception and expression. The brain uses the most appropriate hemisphere for a specific task, with assistance from the other hemisphere. For instance, the right hemisphere is not the language hemisphere but can do a little bit of reading. There is an important principle here: You can increase efficiency by activating different brain areas.

Creativity is based on 3 thinking patterns: verbal language, in which unwarranted assumptions can trip us up; music and math, which require the understanding of fundamentals; and visual thinking, which is often the key to creative thinking by envisioning and manipulating information.

Mind wandering (a.k.a. daydreaming) is an everyday power-down state. It’s traditionally frowned upon but also very common: 30% of people admit to mind wandering. There’s nothing wrong with it: Mind wanderers tend to score high on creativity. When the mind wanders, the brain’s executive centers are activated along with a default network. The combination of these 2 networks may explain the link between mind wandering and creativity.

As a practical solution let your mind putter around for a bit so your brain is free to wander productively. But don't overdo mind wandering; it's best in small doses. You need to allow your mind to wander if you want to be creative, but you also need to catch the creative idea. Also important is the contribution of sleep, with or without dreams. Several scientific discoveries have been attributed to ideas that came in dreams.

We are verbal creatures, and our brains thrive on words.

Both creativity and divergent thinking involve fluency, which means rapidly producing multiple possible solutions to the problem; elaboration, which means thinking through the details of the problem; flexibility, which means entertaining multiple approaches to the problem simultaneously; and originality, which means coming up with ideas that don't occur to most people.

The goals for divergent thinking are (1) to achieve a spontaneous, random, unorganized, and free-flowing manner of thinking and (2) to loosen the control of the left hemisphere and allow the emergence of less structured, nonverbal material to emerge from the right hemisphere. Some methods for this are brainstorming, mind mapping, and free writing.

Now that we know something about brain geography, let's see how we can use that knowledge to enhance our creativity—and even have some fun in the process. One way to enhance brain function is through creative play. Puzzles, word games, and humor are marked by uncertainty and ambiguity, which test our brains in unaccustomed ways. We tend to resist not having answers to questions that we are asked, which leads to premature closure—reaching a conclusion or accepting an explanation before examining the facts and the logical conclusions flowing from these facts.

I suggest that you embrace ambiguity as a means of enhancing your brain. Puzzles are uniquely appropriate for this. Here's one: What occurs twice in a moment, once every minute, yet never in a billion years? To solve it, forget about analyzing units of time. Think in terms of the words and letters: moment, minute, and a billion years. The answer is the letter "m."

Develop an interest in word games. We are verbal creatures, and our brains thrive on words. As we learn new words, we expand our mental horizons. Word puzzles call on our left hemisphere, which mediates words and language.

Here's a fun word puzzle: Have a friend cut the words from the caption of a cartoon and rearrange them. See if you can restore the punch line by putting the words back in their correct order. Puzzles involving cartoons strengthen the brain's ability to switch points of view and think about things in unusual ways. They also challenge the brain to work with ambiguity and uncertainty. As another word challenge, have someone cut and scramble the frames of a comic strip, and then see if you can rearrange them into their correct order. This exercise tests your puzzle-solving ability, sense of timing, and logic.



©iStockphoto/Thinkstock

Challenge yourself with word puzzles; they will enhance your brain function!

So how should we approach solving puzzles? First, just try something! Getting started may be the hardest step. Even a wild guess is fine, because figuring out why the guess doesn't work helps you decide where to focus your efforts. Second, persist! The biggest reason for not solving puzzles is giving up. If you feel you can't persist any longer, then look up the answer. It's OK: Looking at the answer isn't cheating but simply helping your brain learn principles that will be useful in future puzzles. Understand why the answer was correct, and then imagine how you might have gotten the answer yourself. You can also try setting time limits. The brain can almost always work faster if you ask it to.

Puzzles, riddles, and jokes enhance the brain by encouraging reasoning, logic, visual imagination, spatial thinking, working memory, and

creativity. Equally important, puzzles, riddles, brainteasers, and jokes are just plain fun! ■

Brain Teaser

Brain teasers can help you enhance concentration, visual thinking, and creativity. Here is one of my favorites.

You are in a room with 3 light switches that turn on 3 light bulbs in another room. You can turn on only 2 of the switches, and you're allowed only 1 trip into the room to check which 2 light bulbs are on. How do you decide which switch turns on which bulb?

There is an unwarranted assumption here—a premature closure. The terms “light bulb,” “lights,” and “turn on” suggest a visual approach, but think about what other senses might be even more helpful in solving the puzzle. Touch, the most primitive sense, will actually provide the solution.

Have you come to the solution yet? Turn 2 switches on for 10 or more minutes. Turn 1 of them off, and then go into the other room. The bulb that is still lit is controlled by the switch you left on. Now touch the other 2 bulbs. The switch you turned off controls the one that is warm. The third switch controls the other light bulb.

Suggested Reading

Chatfield, *Fun Inc.*

Edelman and Tononi, *A Universe of Consciousness.*

Focusing Your Attention

Lecture 5

The brain really thrives on getting information and paying attention. ... The arts, sports, and everyday living all provide opportunities to strengthen attention.

Attention—also referred to as focus or concentration—must be rock solid to marshal the effort needed to improve your brain’s performance. Attention in the mental sphere is akin to endurance in the physical sphere. Like an athlete, you can learn to focus your mental energies, but to do that you must successfully manage challenging factors in our culture: distraction and multitasking.

To be fully attentive, first of all, we have to be awake. This is a fairly commonsense idea; if we’re asleep, we’re not attending to anything. When we’re awake, our attention depends on the degree of wakefulness—if we’re drowsy, day dreaming, or stressed, we have decreased focus and attention. We have to be in the narrow continuum where we have highly focused attention; then we’ll be able to look at something and get all the details about it.

Let’s talk about inattention. As a rule, we don’t realize that we’re being inattentive. You can think of it as a psychic blind spot. Road accidents, for instance, occur as a result of inattentive drivers and/or pedestrians. We think we see more than we do, and that has consequences. Attention failures are especially serious in our current culture, dominated by fast-response technologies. You’re sitting there thinking about something, and you fire off an e-mail before paying attention to the consequences. Or you reach for that cell phone while driving on the highway at 70 mph, leading to an accident.

The biggest impediment to sustained attention in our culture is multitasking. First of all, multitasking is a myth: We’re actually doing things sequentially, not concurrently. Interference effects with the use of the same channel dictate that I can only listen to so many conversations at one time. However,

I may be able to listen to a conversation and read something simultaneously, because they're not interfering with one another.

The more people multitask, the worse they do. They become more distractible, and they have problems distinguishing relevant from irrelevant information. There's also loss of organization and of the ability to think for oneself. We need to slow down and pay attention to think most efficiently and creatively—in a word, ponder.

Let's talk about the benefits of attention training. It improves concentration, frontal functioning, I.Q., sequencing, context, drive, and executive control. This lecture guide includes short-term memory exercises that you can use to improve your attention. They will help you with math and reading proficiency, and enhanced performance in attention, concentration, sequencing, and auditory and visual short-term memory. They're also linked with I.Q., which of course is the first thing to decrease with aging.

**Multitasking is a myth:
We're actually doing things
sequentially, not concurrently.**

Music training is also wonderful for attention. Research shows that after 15 months, structural changes occur in brain circuits used for music processing. Enhanced

musical ability is related to motor and auditory skills; in some instances, I.Q. increases as well. Athletics are also good for attention. Sports combine all sensory spheres and eventually lead to the development of what is referred to as muscle memory (but is actually brain memory). Concentrate on your areas of weakness. For instance, if you play tennis and have a weak serve, focus on that.

The greatest challenge that we face in our culture may be trying to enrich our powers of attention while accommodating our society's increasing demands for multitasking. We have to do some multitasking, but we don't want to drive away our attentional powers. In the next lecture, we'll talk about something closely related to attention: memory. If you can't attend, then you obviously can't remember. We'll look at how improving your attentional powers can enhance your memory. ■

Short-Term Memory Exercises

Here are some techniques to keep in mind for memory exercises:

- Focus—be sure to pay attention.
- Use as many senses as you can.
- Put the information in the form of an image—the more dramatic the better.

Visual exercise. Look at a series of pictures rapidly. Then close your eyes and try to describe them. This measures both your attention and your memory.

Auditory attention exercise. Try a game called “Clap Your Name.” Let’s say your name is Richard. Spell it out, R-I-C-H-A-R-D, by slapping your thigh for each of the consonants and clapping your hands for each of the vowels. You will develop your attention to the auditions, the sound of it. For an added challenge, you can do this simultaneously with someone else.

Sustained and selective attention exercise. Quickly dictate into a voice recorder a long string of randomly selected letters and numbers. Later on, listen to them and tally only the numbers or only the letters. This works even better if you get someone else to read them for you: You respond by signaling only when you’ve heard either a letter or a number.

Divided attention exercise. Practice attending to 2 tasks at once. For instance, rapidly tap your finger while attending to a news story on the radio.

Processing speed exercise. See how quickly you can shuffle a deck of cards and then break the cards into suits and put them in order.

Suggested Reading

Restak, *Mozart's Brain and the Fighter Pilot*.

———, *Think Smart*.

Enhancing Your Memory

Lecture 6

A lot of times we go through life without remembering what we're doing. Have you ever noticed someone looking at a watch and then a second later you ask them, "What time is it?" and they look again? Why would that be? Didn't they just look? Don't they remember exactly what they saw? It's an example of where we are not paying attention to our sensory input.

With this lecture, we begin to explore the many forms of memory and what you can do to improve your memory. When you think about it, memory is the natural extension of attention and learning. You can't use information that you can't recall—but you can't recall what you haven't attended to. The act of memory facilitates the formation, activation, and retention of circuits that contribute to the brain's optimal functioning. In a way, we are the sum total of the memory we retain. Without memory we wouldn't know who we were.

Memory is controlled by a key region, the hippocampus, which regulates the inward flow of information prior to its distribution to the rest of the brain. Memory forms the basis for personal identity and is also key to thinking. Hippocampal disease is accompanied by disturbances in memory—Alzheimer's disease is a well-known example. Recalling the past and imagining the future are both functions of the hippocampus. To imagine a future event, you have to have some memory of many past events.

The plethora of technology in our modern society means we don't have to remember things. This leads to disuse atrophy—but you can overcome it by deliberate effort to improve your memory. This can stave off Alzheimer's disease, hone your attentional abilities, and link memory with other cognitive processes such as learning and creativity. Some people have great memories—you ask them something, and they're able to tell you the answer and to remember it even months later. Other people have weak memories. The distinguishing feature is retrieval. Memories are best coded and retrieved when linked with an image or an emotion.

There are many types of memory, but here we will concentrate on declarative memory. Declarative memories are consciously accessible memories that are infinite. Vocabulary is a good example; there's no limit to how many words you can learn. A nondeclarative memory, in contrast, is something that really can't be put into words. Knowing how to ride a bicycle or do a double-flip off a diving board are examples of nondeclarative memory. These are things that you have to learn by doing.

The most important principle for improving your memory is focusing your attention on what you're trying to learn.

Remember: The most important principle for improving your memory is focusing your attention on what you're trying to learn. You

should start with sense memory because that's the brain's initial recording of physical sensations as they impinge on our sense organs. This includes what we see, hear, touch, taste, and smell. Too often, sensation occurs outside of awareness. Here are some exercises that can help you enhance memory via heightening your conscious awareness.

A powerful short-term memory strengthening exercise is called the digit-span exercise. Try it first with auditory recall. Read into a recorder a series of 5-, 6-, 7-, and 8-digit strings. You'll probably want to group them so that all the 5-digit strings are together, the 6-digit strings are together, and so on. Then put them aside for a while and clear your mind. Several hours later, listen to the lists, pause, and then write down as many of the strings as you can recall. Then play the recording to check for accuracy. You can also do this exercise visually by writing the digit lists on a piece of paper. Write a list, turn it face down, look at it quickly, and then try to remember the sequence. The visual and auditory spans focus attention and concentration. A typical adult digit span is between 5 and 7. Start at 5 and build it up through practice.

Why bother to practice and lengthen the digit span, you might ask? Don't be fooled by the apparent simplicity of this exercise; this is a powerful way of improving brain function in multiple areas. The digit span is a predictor

of math and reading abilities and of enhanced performance in attention, concentration, sequencing, and auditory and visual short-term memory.

Short-term memory needs to be in active rehearsal in order to be moved to long-term memory. But rehearsal alone isn't sufficient; depth of processing is required. Rote repetition is not as effective as working with the information. Memorization of dates, for instance, is not as effective as writing an essay on what happened on a particular date. Depth of processing increases the web of connections among stored memories.

Repeated testing is also key for long-term memory. Tests should include old as well as new material. Do you remember those ornery professors

Spices and Sense Memory

Olfaction sensory fibers are the most direct point of sensory input—they connect directly to the brain. Let's sharpen our special senses of taste and smell. Start by taking an array of spices and setting them out on a table. Close your eyes, and identify by smell alone such things as oregano, mint, minced onion, sage, sweet basil, orange, cumin, and black pepper.

Next, take this knowledge and progress to identifying spices in a meal that you are eating. If you're in a restaurant, ask what spices the chef used. When you're making a meal with spices, try not putting the spices in a certain half. Do you taste the difference?



© iStockphoto/Thinkstock

from college who unexpectedly went back and retested you on things you had already been tested on? Well, it turns out those professors were on to something. Repeated testing is more effective for long-term learning. Why? The neuronal networks are strengthened each time the memory is retrieved. It's similar to physical training: After you build up a muscle or muscle group, you have to keep exercising it to avoid disuse atrophy.

In our next lecture, we'll discuss the most important memory process of all—working memory. ■

Suggested Reading

Gluck, Mercado, and Meyers, *Learning and Memory*.

Schacter, *The Seven Sins of Memory*.

Exercising Your Working Memory

Lecture 7

Our intelligence is related to our ability to transfer information from working memory to long-term memory. ... In fact, the greater the working memory, the higher the verbal score on the Scholastic Aptitude Test and ... IQ tests.

Working memory is central to the most important mental operation carried out by the human brain: manipulating stored information. Working memory involves a relatively small number of items that are simultaneously kept track of, and the number of items and the ease of recall varies from one person to another. The good news is that working memory can be improved by practice.

First let's look at an example of when we might use working memory in our everyday lives. Perhaps you want to throw a dinner party composed of people who may or may not be compatible. Imagine a group of 12 people composed of neighbors, coworkers from your job, coworkers from your husband's job—a mixed group. You have to mentally review people, their personalities, and your impression of them to plan a dinner party that will be harmonious.

What are the brain areas involved with working memory? This type of memory is really the key function of the frontal areas. Think of a scratch pad maintained in the frontal lobes that the rest of the brain can then consult and become familiar with over time. Since working memory depends primarily on the prefrontal cortex, it varies with age. Young children have difficulty organizing themselves, keeping their attention focused, and managing multiple things at a time.

If working memory is a scratch pad, then long-term memory is its filing system. A transfer occurs from working memory into long-term memory, where knowledge is organized into complex concepts. Our intelligence is related to our ability to transfer information from working memory to long-term memory. Information in our working memory is known as cognitive

load. If that load is exceeded, information isn't encoded and cannot be transferred to long-term memory. Technology, especially the Internet, increases cognitive load and interferes with the formation of long-term memory.

So let's start building our working memory with an easy example: backward digit span. This is similar to the earlier exercise we did, but this time if you hear or read 1234, instead of 1234, you respond with 4321. Try it for 4-digit numbers, 5-digit numbers, 6-digit numbers, and maybe even 7-digit numbers. After doing numbers, try spelling words backward. "World" is D-L-R-O-W. Progress to

"hospital," "democracy" (which is a tough one)—and if you really get good, try a word like "irresponsibility." Always work on maintaining or building up your skill level.

Here is another exercise for you to try. Put out some coins—dimes, nickels, and quarters. If someone were to ask you how you would total these, you would more than likely first count all of, say, the nickels; then the dimes; and then the quarters. If you really want to test your working memory, count them in such a way that you have to keep a separate running total of each type of coin. Another way to do it is to total the coins in terms of their value. Keep them on separate tracks—so if you have 2 quarters, you have 50 cents; 3 nickels are 15 cents; and 2 dimes are 20 cents—and then at the end, add



Card games are great exercise for your working memory.

© Jupiterimages/Pixland/Thinkstock

them up. You should start with 2 types of coins and then work your way up, if you can, to 4. This is very difficult.

Recreational games are also good exercise for your working memory. The card game bridge forces you to remember and manipulate cards in play

If working memory is a scratch pad, then long-term memory is its filing system.

while you're also exercising your general memory by remembering how that particular hand did the last time you were playing. On tests of working memory and reasoning, bridge players outperform people who don't play

bridge. Poker, incidentally, is just as good. Card counting is probably the most quintessential example of multitasking in some ways, but it's mostly a test of working memory.

Notice that the exercises in working memory also involve creativity. They involve looking at things in great detail and being able to put them together. They also require heightened alertness and awareness, as well as the discovery of linkages between the past and the present. Working memory exercises can be a great learning and refreshing tool. ■

Suggested Reading

Gluck, Mercado, and Meyers, *Learning and Memory*.

Schacter, *The Seven Sins of Memory*.

Putting Your Senses to Work

Lecture 8

It's been shown that the retrieval context should equal the encoding context. There's an amusing experiment done with a diving club. Some of the people in the diving club memorized a list of numbers while they were underwater, and the others learned the number list while they were on land. It was found later that the ones that were tested in the same situation, either underwater or on land, did better than those who learned underwater and were quizzed on land or vice versa.

Throughout history, many imaginative techniques have been suggested to improve memory. In this lecture, we will discuss some contemporary examples of powerful ways of supercharging your memory. First, let's review a few general principles. The first principle is focus: Pay attention to what you're trying to memorize. Second, search for meaning in the information; of course, this meaning will vary according to circumstance and to you as an individual. Use as many sensory faculties as possible—see it, hear it, and touch it. You can also put information in the form of an image. The clearer the image, the more likely you are to remember it. Third, you can also create a system of memory pegs, which we'll discuss below.

Since paying attention is the most fundamental rule for improving memory, here are some quick warm-up exercises to sharpen attention—apply them just before memorizing. Rapidly scan a few pictures and then describe what you saw. Then look back and check for accuracy. Also try drawing something and then verbally describing what you have drawn.

Now that you're warmed up, let's learn how to use memory pegs. My personal method is to memorize a dozen neighborhood sites. For me, they are (1) my home, (2) a library, (3) a photo store, and so on. I rehearse them for a long time, forward and backward; they are very clear in my mind. Then I take each of the items I want to remember, like on a grocery list, and compose a vivid bizarre image of that item on a site that I have in my

memory. For instance, if I'm going to the store to get some soda, I might see a soda can reading a book in front of my home.

Make up your own list of places in your neighborhood. You could use your house or apartment, but I advise using the neighborhood because it's more expansive. Practice the list until you can rapidly name it and see it. Then place your memory items in these pegs.

Now let's move on to memorizing nonverbal material, which is a lot tougher. The key concept here is to increase your memory for nonverbal material without resorting to words or any type of internal dialogue. This calls on the right hemisphere, which handles activities like processing visual-spatial information. Jigsaw puzzles, for instance, are great stimulators of the right hemisphere.

Let's practice a few right hemisphere exercises. Close your eyes and envision the room that you are in. Open your eyes and check for accuracy. Repeat this

Exercise Your Brain with Television!

Here are exercises involving visual sequences that you can practice at home.

- Watch a television drama while recording it, and then replay it in your mind scene by scene. Watch it again to check the correctness of your memory.
- Do the same with a documentary: Mentally replay the program with its interviews and commentary. Then watch it again, and check how well you did.
- Watch a basketball or hockey game while recording it. After a score occurs, review in your mind what you think you observed—then play the program back and see how clearly you remembered the scoring situation.

exercise, paying attention to small details—like the number of magazines on a table. During the day, carry a camera with you and take pictures of various scenes. You can check later what you can remember and the accuracy of your recall.

We are visual creatures: The more vivid, dramatic, and bizarre the image, the more likely we are to remember it.

Here are some pattern exercises that enhance right hemisphere functioning. Draw free-form designs, memorize them, and reproduce them—this is not only

a test of memory but also of eye-hand coordination and motor memory. Memorize and sketch the layout of a room or the seating arrangements at a dinner table. Here's a personal example of a waiter in one of my favorite restaurants. He never writes anything down, so I asked him how he does this. He told me he first visually memorizes the menu. As the customer orders, he substitutes that item on the menu with a mental picture of the customer. In the kitchen he reconverts from the picture to the menu item.

What do all these various memory exercises have in common? They force you to pay attention to what you're trying to learn. They also encourage you to emphasize a visual format. We are visual creatures: The more vivid, dramatic, and bizarre the image, the more likely we are to remember it. Using memory techniques will hone your attentional abilities, help you link your memory with cognitive processes like learning and creativity, and may help stave off Alzheimer's disease. Developing a superpower memory also links you to larger cultural currents. If you remember more, you experience more—so enriching your memory can enrich your life! ■

Suggested Reading

Restak, *Mozart's Brain and the Fighter Pilot*.

Enlisting Your Emotional Memory

Lecture 9

If you wanted to decide whether someone is lying to you, would you sooner meet them face-to-face, or would you sooner talk to them on the telephone? ... Most people would respond they would sooner encounter the person face-to-face. They are convinced they could tell in an instant if the person was lying by doing such things as staring them in the eye. Actually, the telephone is better since emotional leakage is greater in the auditory than the visual sphere. The reason for that is from our earliest years, we've learned to control our facial expressions.

In this lecture, we look at an aspect of memory that we do not usually consider—emotional memory. Despite its importance, most of us have lost touch with how we experienced the world in the past. Let me give you an example. I recently went to my high school reunion. I noticed that I recognized some people but not others; I recognized some of my good friends more quickly. We began to reminisce about football games, dances, and whatnot. We remembered all the incidents and events, but the memories of the emotions that accompanied them were not as clear.

Emotional memory becomes increasingly elusive the further we dig into the past. To experience the loss of emotional memory, page through some personal pictures. Start with photos taken a few weeks ago and work your way back to photos from a few years ago. Emotional memory is associated with the right hemisphere processing. Patients with right hemisphere injuries can't detect emotions in other people's faces or voices. They have a general loss of emotional interpretive and expressive ability.

Let's try several sense memory exercises based on the principle that the more vivid the sense memory, the greater the chances of establishing emotional memory. Indeed, by trying one of these exercises, you can learn much about emotional perception and memory. You may be able to evoke, explore, and even revisit your emotions—but approach these exercises in the spirit of play. Not taking yourself too seriously will give you a greater chance of making the exercises work.

The first exercise involves a partner. Sit together on the floor, maybe 2 or 3 feet apart, knees crossed, facing each other. Ask the other person to close her eyes and think of an emotion that is very sad. She is not to make any facial movements; she is only supposed to think these thoughts. Study her face as she's thinking about this. Then have her clear her face and think of something neutral. Then have her think of something happy. Observe her carefully. After that's over, you switch roles and work through the exercise again—sad, neutral, happy.

Afterward, compare notes about what you were thinking and what you saw in each other's faces. Was there anything that you noticed in her face? And when she had her eyes open, was there anything you saw in her eyes? It's important here not to inhibit facial expression but to remain vulnerable. It's a very unusual opportunity to be able to learn what someone is actually thinking—because she's going to tell you—and then compare that to what you picked up while you were looking at her. You can compare the things that she picked up in your facial expression and your eyes that you didn't in hers, and vice versa. The aim is for you to participate in her experience and for her to participate in yours.

The second exercise involves olfaction, which is the surest sense for enhancing emotional memory. Smell and taste are evocative because of the direct connection of olfactory nerve with the brain's limbic system. Invite some friends to your home, and have each of them bring something with a distinctive, pleasing smell: fresh cookies, sandalwood, mowed grass. Line the items up and have each person smell them and see what they bring forth in terms of memory. See if you can come up with a specific emotionally



Distinctive smells can bring up memories, allowing you to revisit the feelings you experienced then.

charged incident associated with a scent. Use that memory to re-create and express the feelings aroused at that time.

Here is a third exercise of your emotional memory. Look at a picture of yourself taken when you were half your current age. Then write a letter from the perspective of you at that time to you now. Write all your concerns about school, career, whether you're going to get married, your friends, and so on. When you're finished, respond with a letter to that earlier you in which you relate how all of the things you were so concerned about resolved themselves and you now have other issues in your life. This exercise, if done in the spirit of playfulness, can unite the emotions of earlier years with current emotions—an integrative process.

The goal of all these exercises is to relive not only the memory of your experiences but also the emotions accompanying those experiences. Create memory exercises of your own, remembering to remain alert to current sensations and link them with similar sensations in the past and the emotions they evoked. If the exercises are successful, you will recover memories of experiences you haven't thought about in years. ■

Suggested Reading

LeDoux, *The Emotional Brain*.

McGaugh, *Memory and Emotion*.

Questions to Consider

1. How does emotional memory differ from other types of memory we have studied in this course?
2. Why is it important to reestablish contact with our emotional memory?

Practicing for Peak Performance

Lecture 10

Many world-class performers have weighed in on the side of deliberate practice. Marlon Brando, for instance, in a famous interview with Larry King, made the comment [that] with the proper training anyone—literally anyone—could be an actor.

Deliberate practice is the key to improving brain performance and creativity. Neuroscience and psychological research have recently confirmed the effectiveness of this ancient method, which takes advantage of the brain's ability to respond when pushed to the limits. The most important components of deliberate practice are to remain fully aware of what you are doing and to concentrate on those aspects of your performance that you find most difficult.

The goal of deliberate practice is the formation of a flexible memory representation. In one experiment, experienced professional musicians were pitted against good amateur musicians. They were both asked to play under changed conditions. They were asked to play every other note, play using only one hand, or transpose into a different key. Experienced musicians had no problem with that, but good amateurs failed miserably. This experiment illustrates what is meant by encoding and retaining a mental representation: Once it is encoded, it can be manipulated and altered.

In essence, people with extraordinary abilities learn to use their brains differently. For example, chess masters activate their frontal and parietal cortices—the areas involved in long-term memory. Chess amateurs, in contrast, activate their medial temporal lobes—those involved in coding new information. The chess masters are using long-term memory to recognize positions and retrieve their frontal-lobe storage of vast amounts of chess information based on years of practice and learning. Chess amateurs are employing the less effective, case-by-case approach.

Experts develop a long-term working memory. In the lecture on working memory, we defined it as the ability to actively manipulate information. The

results of working memory may later be stored in long-term memory depending on our interests and goals. Long-term working memory involves incorporating the accumulated reservoir of information gathered over many years into an instantly accessible form. The degree of expertise depends on how much the person knows and how quickly and easily that information can be retrieved. PET scans confirm increased frontal activity in experts.

Is the ability to form unusually large long-term memories a genetic trait, or is it based on individual effort and persistence? The answer to that question has important implications: If genius is genetic, then most of us are out of luck; but if individual effort is the essential component, then most people are capable of achieving impressive levels of performance. It turns out that deliberate practice is more important than natural talent in determining success.

One piece of evidence comes from a study of musical trainees at the Music Academy of Berlin. It was found that superior students, those who went on to have concert careers, practiced 24 hours a week while good students practiced only 9 hours per week. Similar patterns of long and intensive practice are found among athletes, chess players, mathematicians, and memory virtuosos.



Years of practice allow masters in a field to draw upon long-term memory, making them more adept than amateurs.

So exceptional performers are not necessarily endowed with superior brains. Rather, the brain, thanks to its plasticity, can be modified by deliberate practice. That approach will enable you to achieve high levels of performance in your area of interest. But to do that you have to be willing to put in a lot of effort. ■

Suggested Reading

Restak, *Think Smart*.

Questions to Consider

1. What distinguishes the approach of an amateur from that of a professional to sports or playing a musical instrument?
2. How many years of deliberate practice does it take to achieve mastery in a particular field of endeavor?

Taking Advantage of Technology

Lecture 11

Think of technological aids as extensions of the brain. Our species, if you go back in history, started with sharpened stones in prehistory and evolved to handwritten scrolls, then to the printing press, pencils and pens, then to typewriters, and finally computer keyboards. Each aid offered an advance in information management.

You may have heard that the brain operates like a computer, but in fact that's not true. It might surprise you to know that the lion's share of brain processing takes place unconsciously, as when we're dancing or driving a car. If you are learning a new dance step, the worst thing you can do is become actively aware of your feet and where they are. Don't try to micromanage your brain by giving it too much conscious direction. I'm referring here to the cognitive unconscious, which is the mental processing that takes place outside of conscious awareness.

The cognitive unconscious is the main part of our mental processing. It starts at the level of the neuron and extends upward to the level of everyday behavior. For example, neuronal responses in the primary auditory cortex are tuned to the personal meaning of a sound. The more important the sound, the more attuned the cell becomes. You've had the experience of being at a loud party and hearing someone say your name across the room. You hear it, but your friend does not. They didn't hear it because their brain isn't attuned to the sound of your name. This preferential recognition has been measured: Your brain responds to the ring tone of your cell phone more quickly than to other cell phone rings.

Culture, rather than biology, is now the greatest influence on brain development. Our culture is inseparable from technology and has been so since the development of the microchip, which is the heart of modern technology. We use portable computers to extend the brain's power. Software programs enhance our speed of response, our working memory, our imaging ability, our reasoning, and our ability to calculate and abstract.

In the book *Total Recall*, Gordon Bell, who is the principal researcher at Microsoft Research, tells of the power unleashed by combining digital recording, digital storage, and digital search. He writes, “With the speed of modern computers, it has become possible to index every word and phrase in every document and to search all of them in an instant. Indexing is the mechanism by which associative memory becomes possible.” Automated research has limitations, of course. A research program isn’t able to notice correlations and connections that come naturally to you. You can also recognize opportunities to change the program midstream and look at things from a different perspective.

There’s also a dark side to technology and its influence on the brain. By juggling e-mail, cell phones, laptop computers, and e-books, we’re bringing about changes in how our brains operate. We’re in the age of distraction, where attention and focus are becoming endangered species. We simply have too many sources of information. The top-down processing by the frontal lobes is interfered with by excessive bottom-up informational processing from the sensory channels. As a result, the deep processing of information is replaced by skimming and surfing.

Nonetheless, the computer has brought about dramatic changes in the way we think. A personal computer brings about a fundamental change in subjective experience: We can link past, present, and future to create personal synthesis and integration. We can revisit earlier thoughts and productions; the you of right now can revisit the you of an earlier time. You can think of it as a form of experiential time travel. ■



© Jupiterimages/BananaStock/Thinkstock

Technology has obvious benefits but can also lead to decreased attention and focus.

Video Gaming: Friend or Foe?

Video gaming has burgeoned in recent years: 500 million people around the world now spend more than an hour a day playing video games. The most avid gamers spend 25 hours a week. So what are the positive and negative brain effects of video gaming?

Pros:

- Action video games improve peripheral visual attention and enhance eye-hand coordination and reflex responses.
- Video games increase contrast sensitivity, which is important in night driving.
- Games involving teamwork increase collaboration skills.
- Video games can increase some components of IQ. In fact, action video games are more likely to enhance your brain function than the brain gyms that are advertised.

Cons:

- There's evidence that video games can be harmful, addictive, and habit forming. Here in the United States, efforts are being made to add video game addiction to the next edition of the *Diagnostic and Statistical Manual*.
- Some gamers experience high intensity immersion, in which they become so absorbed they isolate themselves from everybody else.
- Gamers can experience situated immersion: the illusion of existing within the game. The richness and quality of one's personal life offsets the likelihood of immersion.

So how can you safely enjoy video gaming? First, play no more than 2 to 3 hours per week, and limit your sessions to an hour. Second, avoid games that feature gratuitous violence. Studies have found evidence that violent video games may lead to desensitization to real-life violence. A study of U.S. and Japanese children found that children who play violent games tend to be more aggressive in real life. The challenge is to reap the benefits of action video games while avoiding the potential downsides.



© Stockbyte/Thinkstock.

Suggested Reading

Carr, *The Shallows*.

Chatfield, *Fun Inc.*

Powers, *Hamlet's BlackBerry*.

Restak, *Mozart's Brain and the Fighter Pilot*.

Building Your Cognitive Reserve

Lecture 12

Neuroscientists have recently come up with another surprising finding called super-aging. The brains of some elderly people lack tau-tangle formation or have fewer tangles than are typically found in normal aging. ... This has profound implications for our understanding of the aged brain: Perhaps degenerative changes are not inevitable.

We've learned a lot in this course about how our brain works and how to care for it. In this final lecture, I want to leave you with some straightforward recommendations for things you can start doing immediately to organize your brain fitness. By challenging your brain to learn new information throughout your life, you build up your cognitive reserve. This works the same way as planning for retirement by building up a monetary reserve: You improve your cognitive capacity in later years by acquiring education and knowledge throughout your life and feeding your curiosity.

The more cognitive reserve you've built up over your lifetime, the less you will be affected by brain disease. People with higher cognitive reserve are better at recruiting alternative nerve-cell networks or increasing the efficiency of existing networks in response to age-related changes. Yaakov Stern of Columbia University has found that greater cognitive reserve is linked with greater activation in the frontal lobes. As you've learned in this course, the frontal lobes are key to our most advanced brain functioning. If not stimulated, the frontal lobes function less well as we age.

We want to be really reasonable in our expectations of increasing our cognitive abilities, so keep 2 caveats in mind. First, it's possible that people who start with higher IQs are drawn to activities that will increase their cognitive reserve. Some people of higher IQ may even get increased satisfaction from cognitive stimulation. Second, conditions such as Alzheimer's disease are indeed diseases and in some cases are inherited. But it's better for us to assume we are part of the majority who will benefit from building up our cognitive reserve.

So, what should you do right now? Start with things that you are attracted to do and do well at—but also work on things that don't come so easily. Try things that you usually don't do. If you're a lawyer, get interested in math or physics; if you're already a mathematician, get into literature or history. Whatever you do, the goal is to build the brain you want to live with for the rest of your life.

In choosing projects to build up your cognitive reserve, make sure they are the right ones for you as an individual. If you are a competitive person, poker may be better for you than bridge (where teamwork is important). Practice your reasoning skills, memory training, and speed of processing with puzzles and games. Your quest for cognitive excellence will also be aided by healthy and positive mental states. If you feel depressed or otherwise not right, don't ignore it—try to find out why so you can return to a healthy state.

**Only with practice will you
have the best chance of
optimizing your brain function.**

Remember to keep things in perspective. Take what the ancients called the long view, linking the past, present, and future. This, of course, involves frontal cortex.

Don't waste mental energy on things you can't control; most stressful situations arise when we feel dependent on circumstances we can do little about. Avoid sinking into learned helplessness, which is perceiving yourself as helpless and unable to control stress. The remedy is to focus on decisions that you can make now.

Most of all, beware of golden shackles dilemmas. These are situations in which something is pretty good, you're getting benefits from it, but the situation on the whole is negative. These scenarios can require a painful decision, such as finding a new job or getting a divorce. Keep in mind that the stress of not acting can lead to depression, anxiety, sleep disturbance, memory loss, impaired concentration, and impaired well-being. Don't let momentary feelings govern your behavior. Feelings can affect behavior, but it also works the other way: Behavior can affect feelings. So try doing it until you feel it. If you act enthusiastically, you will begin to actually feel enthusiastic.

A special recommendation I have for you is to develop a magnificent obsession. Successful people often have obsessive character traits; they sometimes use these to their advantage but sometimes use them to fret about things. The antidote is a magnificent obsession. Take up a subject that interests you but is unrelated to your background, education, profession, or life experience. Devote an hour a day to improving your performance in this area of interest.

Please actively practice the exercises that I've suggested during this course. Find ways to tailor them to your own interests so that you'll look forward to practicing them, because only with practice will you have the best chance of optimizing your brain function. ■

Optimize Your Brain Fitness with a Healthy Lifestyle

What actions should you take to keep your brain in good condition? Here are some immediate steps you can take.

- Get enough sleep at night, and take naps.
- Eat right and exercise. Both of these are things you can do with friends, which is important because isolation and loneliness can impair brain function.
- Increase your capacity for sustained attention and concentration with attentional exercises. Here, too, you can add a social element, as with playing bridge or chess.
- Increase your finger and hand dexterity: Try Jenga, juggling, model building, video games, playing a musical instrument, or enhancing your penmanship.
- Spend less time watching television.

- Try to maintain a healthy sense of humor. (Humor appreciation has been associated with longevity.)
- Develop an appreciation of different styles of art. It's thought now that different brain areas are activated by different styles of painting.
- Develop an appreciation of different styles of music. Music can elevate your mood and activate regions of the brain involved in emotion, reward, motivation, and arousal. Attend a concert with a friend—or even better, go dancing with friends to combine the benefits of music, socialization, and exercise.

Suggested Reading

Restak, *Think Smart*.

Stern, “What Is Cognitive Reserve?”

Bibliography

General References

Blakeslee, Sandra, and Matthew Blakeslee. *The Body Has a Mind of Its Own: How Body Maps in Your Brain Help You Do (Almost) Everything Better*. New York: Random House, 2008.

Changeux, Jean-Pierre. *Neuronal Man: The Biology of Mind*. Princeton, NJ: Princeton University Press, 1997.

Crick, Francis. *Astonishing Hypothesis: The Scientific Search for the Soul*. New York: Scribner, 1995.

Damasio, Antonio R. *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Penguin, 2005.

Edelman, Gerald M. *Bright Air, Brilliant Fire: On the Matter of the Mind*. New York: Basic Books, 1993.

Edelman, Gerald, and Giulio Tononi. *A Universe of Consciousness: How Matter Becomes Imagination*. New York: Basic Books, 2001.

Fields, R. Douglas. *The Other Brain: From Dementia to Schizophrenia, How New Discoveries about the Brain Are Revolutionizing Medicine and Science*. New York: Simon and Schuster, 2009. This insightful book points out that the brain cells are outnumbered by glia cells, whose exact total contribution to brain function are at this point unknown.

Gluck, Mark A., Eduardo Mercado, and Catherine E. Meyers. *Learning and Memory: From Brain to Behavior*. New York: Worth, 2008. This is the best overall introduction to learning and memory. It contains a wealth of references as well as excellent descriptions of the different kinds of memory.

Gordon, Dan, ed. *Cerebrum 2009: Emerging Ideas in Brain Science*. New York: Dana Press, 2009. This book, and the one that follows, contains articles

written by scientists as well as science writers, covering a broad range of topics and provides an illuminating guide to the 21st century.

———. *Cerebrum 2010: Emerging Ideas in Brain Science*. New York: Dana Press, 2010.

Gregory, Richard L. *Eye and Brain: The Psychology of Seeing*. Princeton, NJ: Princeton University Press, 1997.

Hebb, Donald O. *The Organization of Behavior: A Neuropsychological Theory*. Mahwah, NJ: Lawrence Erlbaum Associates, 2002.

Heilman, Kenneth M. *Matter of Mind: A Neurologist's View of Brain-Behavior Relationships*. New York: Oxford University Press, 2002.

James, William. *The Principles of Psychology, Volume I and II*. New York: Dover Publications, 1950.

Johnson, Steven. *Mind Wide Open: Your Brain and the Neuroscience of Everyday Life*. New York: Scribner, 2004.

LeDoux, Joseph. *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*. New York: Simon and Schuster, 1998.

———. *Synaptic Self: How Our Brains Become Who We Are*. New York: Penguin Books, 2003.

Livingstone, Margaret. *Vision and Art: The Biology of Seeing*. New York: Harry N. Abrams, 2002.

Mahoney, David, and Richard Restak. *The Longevity Strategy: How to Live to 100 Using the Brain-Body Connection*. New York: John Wiley and Sons, 1999.

McEwen, Bruce, and Elizabeth N. Lasley. *The End of Stress As We Know It*. Washington, DC: Joseph Henry Press/Dana Press, 2002.

McGaugh, James. *Memory and Emotion: The Making of Lasting Memories*. New York: Columbia University Press, 2003.

Norden, Jeanette. *Understanding the Brain*. DVD. Chantilly, VA: The Teaching Company, 2007. This is a scholarly but accessible and very illuminating description of the details of brain anatomy, physiology, and other aspects of brain function.

Posner, Michael I., and Marcus E. Raichle. *Images of Mind*. New York: Scientific American Library, 1994.

Purves, Dale. *Neuroscience*. 4th ed. Sunderland, MA: Sinauer Associates, 2008. This is a challenging textbook that covers the fundamentals of neuroscience in great depth.

Purves, Dale, Elizabeth M. Brannon, Roberto Cabeza, Scott A. Huettel, Kevin S. LaBar, Michael L. Platt, and Marty Waldorff. *Principles of Cognitive Neuroscience*. Sunderland, MA: Sinauer Associates, 2008. This book is an excellent introduction to neuroscience and the brain and provides a wealth of information about the brain.

Reid, Cynthia A., ed. *Cerebrum 2008: Emerging Ideas in Brain Science*. New York: Dana Press, 2008. This book, along with the 2 above edited by Dan Gordon, contains articles written by scientists as well as science writers, covering a broad range of topics and provides an illuminating guide to the 21st century.

Restak, Richard. *Mozart's Brain and the Fighter Pilot: Unleashing Your Brain's Potential*. New York: Three Rivers Paperback, 2002.

———. *Mysteries of the Mind*. Washington, DC: National Geographic Books, 2000.

———. *The New Brain: How the Modern Age Is Rewiring Your Mind*. Emmaus, PA: Rodale, 2004.

———. *The Secret Life of the Brain*. Washington, DC: Joseph Henry Press/Dana Press, 2001.

Schacter, Daniel L. *Searching for Memory: The Brain, the Mind, and the Past*. New York: Basic Books, 1996.

———. *The Seven Sins of Memory: How the Mind Forgets and Remembers*. Boston: Houghtin Mifflin, 2001.

Stuss, Donald T., and Robert T. Knight. *Principles of Frontal Lobe Function*. New York: Oxford University Press, 2002. This text provides both historical and scientific information regarding the frontal lobe. It's well written and easy to understand.

Sweeney, Michael S., and Richard Restak. *Brain: The Complete Mind; How It Develops, How It Works, and How to Keep It Sharp*. Washington, DC: National Geographic Society, 2009.

Wolfe, Jeremy M., Keith R. Kluender, Dennis M. Levi, Linda M. Bartoshuk, Rachel S. Herz, Roberta L. Klatzky, and Susan J. Lederman. *Sensation and Perception*. 2nd ed. Sunderland, MA: Sinauer Associates, 2009. This is an excellent introduction to the specific perceptual processes of the brain and how perception is translated into brain structure and function.

Zeki, Semir. *A Vision of the Brain*. Oxford: Blackwell Scientific, 1993.

Brain Development

Bloom, Paul. *Descartes' Baby: How the Science of Child Development Explains What Makes Us Human*. New York: Basic Books, 2005.

Brown, Stuart. *Play: How It Shapes the Brain, Opens the Imagination, and Invigorates the Soul*. New York: Penguin Group, 2009.

Gopnik, Alison, Andrew N. Meltzoff, and Patricia K. Kuhl. *The Scientist in the Crib: Minds, Brains, and How Children Learn*. New York: William Morrow and Company, 1999.

Siegel, Daniel J. *The Developing Mind: How Relationships and the Brain Interact to Shape Who We Are*. New York: Guilford Press, 1999.

Brain-Related Topics and Memoirs

Bauby, Jean-Dominique. *The Diving Bell and the Butterfly*. New York: Random House, 2008.

Langston, James William, and Jon Palfreman. *The Case of the Frozen Addicts*. New York: Pantheon Books, 1995.

Levitin, Daniel J. *This Is Your Brain on Music: The Science of a Human Obsession*. New York: Dutton, 2006.

Murphy, Nancey C., and Warren S. Brown. *Did My Neurons Make Me Do It? Philosophical and Neurobiological Perspectives on Moral Responsibility and Free Will*. New York: Oxford University Press, 2007.

Newberg, Andrew B., Eugene G. D'Aquili, and Vince Rause. *Why God Won't Go Away: Brain Science and the Biology of Belief*. New York: Random House, 2002.

Sapolsky, Robert M. *A Primate's Memoir: A Neuroscientist's Unconventional Life among the Baboons*. New York: Simon and Schuster, 2002.

Tharp, Twyla, and Mark Reiter. *The Creative Habit: Learn It and Use It For Life*. New York: Simon and Schuster, 2003.

Care and Feeding of the Brain

Arehart-Treichel, Joan. "Obesity Linked to Changes in Cognitive Patterns." *Psychiatric News* 41 (2006): 25.

Barberger-Gateau, P., C. Raffaitin, L. Letenneur, C. Berr, C. Tzourio, J. F. Dartigues, and A. Alperovitch. "Dietary Patterns and Risk of Dementia: The Three-City Cohort Study." *Neurology* 69 (2007): 1921–1930.

Morris, M. C., D. A. Evans, J. L. Bienias, C. C. Tangney, D. A. Bennett, N. Aggarwal, R. S. Wilson, and P. A. Scherr. "Dietary Intake of Antioxidant Nutrients and the Risk of Incident Alzheimer Disease in a Biracial Community Study." *JAMA* 287 (2002): 3230–3237.

Morris, M. C., D. A. Evans, C. C. Tangney, J. L. Bienias, and R. S. Wilson. "Association of Vegetable and Fruit Consumption with Age-Related Cognitive Change." *Neurology* 67 (2006): 1370–1376.

Phillips, Lisa. "A Mediterranean Diet Is Associated with Living Longer with Alzheimer Disease." *Neurology Today* 7 (2007): 1, 17, 20–21.

Pondrom, Sue. "Caffeine and Fish Oil Found Neuroprotective for Alzheimer Disease." *Neurology Today* 7 (2007): 21–22.

"Six Years of Fast-Food Fats Supersizes Monkeys." *NewScientist*, June 17, 2006.

Stein, Rob. "A Compound in Red Wine Makes Fat Mice Healthy." *The Washington Post*, November 2, 2006.

University of Maryland Medical Center Information Resources: Transfats 101. <http://www.umm.edu/features/transfats.htm>.

U.S. Food and Drug Administration. "Revealing Trans Fats." *FDA Consumer*. September-October 2003. Pub no. FDA04-1329C.

Cognitive Reserve

Katzman, R., M. Aronson, and P. Fuld. "Development of Dementing Illnesses in an 80-Year-Old Volunteer Cohort." *Annals of Neurology* 25 (1989): 317–324.

Scarmeas, N., and Y. Stern. "Cognitive Reserve: Implications for Diagnosis and Prevention of Alzheimer's Disease." *Current Neurology and Neuroscience Reports* 4 (2004): 374–380.

Solé-Padullés, C., D. Bartres-Faz, C. Junque, P. Vendrell, L. Rami, I. C. Clemente, B Bosch, A. Villar, N. Bargallo, M. A. Jurado, M. Barrios, and J. L. Molinuevo. "Brain Structure and Function Related to Cognitive Reserve Variables in Normal Aging, Mild Cognitive Impairment and Alzheimer's Disease." *Neurobiology of Aging* 30 (2009): 1114–1124.

Stern, Y. "What Is Cognitive Reserve? Theory and Research Application of the Reserve Concept." *Journal of the International Neuropsychological Society* 8 (2002): 448–460.

Cognitive Neuroscience

Cacioppo, John T., Gary G. Berntson, Ralph Adolphs, C. Sue Carter, Richard J. Davidson, Martha K. McClintock, Bruce S. McEwen, Michael J. Meaney, Daniel L. Schacter, Esther M. Sternberg, Steve S. Suomi, and Shelley E. Taylor. *Foundations in Social Neuroscience*. Cambridge, MA: MIT Press, 2002. This is a veritable encyclopedia of some of the early works on social neuroscience.

Cacioppo, John T., Penny S. Visser, and Cynthia L. Pickett. *Social Neuroscience: People Thinking about Thinking People*. Cambridge, MA: MIT Press, 2006. This contains now classic papers on social neuroscience and is an excellent introduction to the field.

Gazzaniga, Michael S. *The Social Brain: Discovering the Networks of the Mind*. New York: Basic Books, 1985. This is one of the early attempts to relate brain science to social science.

Hassin, Ran R., James S. Uleman, and John A. Bargh. *The New Unconscious*. New York: Oxford University Press, 2005. This contains important papers by Dr. Bargh, one of the pioneers in social neuroscience.

Restak, Richard. *The Naked Brain: How the Emerging Neurosociety Is Changing How We Live, Work, and Love*. New York: Harmony Books, 2006. This is an early book intended to explain social neuroscience to the nonprofessional audience.

———. *The New Brain: How the Modern Age Is Rewiring Your Mind*. Emmaus, PA: Rodale, 2003. This is a story of technology and biology converging and influencing the evolution of the brain.

Consciousness

Baars, Bernard J., and Nicole M. Gage. *Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience*. Burlington, MA: Academic Press, 2010.

Edelman, Gerald. *Wider than the Sky: The Phenomenal Gift of Consciousness*. New Haven, CT: Yale University Press, 2005.

Joseph, R. *The Right Brain and the Unconscious: Discovering the Stranger Within*. New York: Basic Books, 2001.

Laureys, Steven, and Giulio Tononi. *The Neurology of Consciousness: Cognitive Neuroscience and Neuropathology*. Burlington, MA: Academic Press, 2009.

LeDoux, Joseph E. *Synaptic Self: How Our Brains Become Who We Are*. New York: Penguin Group, 2003.

Schwartz, Jeffrey M., and Sharon Begley. *The Mind and the Brain: Neuroplasticity and the Power of Mental Force*. New York: HarperCollins, 2003.

Emotions

Bloom, Floyd, et al. *The DANA Guide to Brain Health*. New York: Simon and Schuster, 2003.

Damasio, Antonio R. *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Penguin, 2005.

Greenleaf, Robert K. *Creating and Changing Mindsets: Movies of the Mind*. Newfield, ME: Greenleaf and Papanek Publications, 2005.

Griffiths, Paul E. *What Emotions Really Are: The Problem of Psychological Categories*. Chicago: University of Chicago Press, 1997.

Kagan, Jerome. *The Temperamental Thread: How Genes, Culture, Time and Luck Make Us Who We Are*. New York: Dana Press, 2010.

LeDoux, Joseph. *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*. New York: Simon and Schuster, 1998.

Luria, Aleksandr R. *The Man with a Shattered World: The History of a Brain Wound*. Cambridge, MA: Harvard University Press, 1987.

Ramachandran, V. S., and Sandra Blakeslee. *Phantoms in the Brain: Probing the Mysteries of the Human Mind*. New York: Harper Perennial, 1999.

Stein, Kathleen. *The Genius Engine: Where Memory, Reason, Passion, Violence, and Creativity Intersect in the Human Brain*. Hoboken, NJ: John Wiley and Sons, 2007.

General Cognition: Learning and Memory

Dehaene, Stanislas. *The Number Sense: How the Mind Creates Mathematics*. New York: Oxford University Press, 1999.

———. *Reading in the Brain: The Science and Evolution of a Human Invention*. New York: Viking, 2009.

Klingberg, Torkel. *The Overflowing Brain: Information Overload and the Limits of Working Memory*. New York: Oxford University Press, 2009.

Nisbett, Richard E. *Intelligence and How to Get It: Why Schools and Cultures Count*. New York: W. W. Norton and Company, 2009.

Restak, Richard. *The Naked Brain: How the Emerging Neurosociety Is Changing How We Live, Work, and Love*. New York: Harmony Books, 2006.

———. *The New Brain: How the Modern Age Is Rewiring Your Mind*. Emmaus, PA: Rodale, 2004.

Schacter, Daniel L. *The Seven Sins of Memory: How the Mind Forgets and Remembers*. New York: Houghton Mifflin Harcourt, 2002.

Tan, Zaldy S. *Age-Proof Your Mind: Detect, Delay, and Prevent Memory Loss—Before It's Too Late*. New York: Warner Wellness, 2006.

Willingham, Daniel T. *Why Don't Students Like School? A Cognitive Scientist Answers Questions about How the Mind Works and What It Means for the Classroom*. San Francisco: Jossey-Bass, 2010.

Neuroimaging

Logothetis, N. K. “What We Can Do and What We Cannot Do with fMRI.” *Nature* 453 (2008): 869–878.

Poldrack, R. A. “Can Cognitive Processes Be Inferred from Neuroimaging Data?” *Trends in Cognitive Sciences* 10.2 (2006): 59–63.

Poldrack, Russell A. “Neuroimaging: Separating the Promise from the Pipe Dreams.” *Cerebrum 2010: Emerging Ideas in Brain Science*. New York: Dana Press, 2010.

Racine, Eric, Ofek Bar-Ilan, and Judy Illes. “fMRI in the Public Eye.” *Nature Reviews Neuroscience* 6.2 (2005): 159–164.

Plasticity

Nelson, Charles A., Charles H. Zeanah, Nathan A. Fox, Peter J. Marshall, Anna T. Smyke, and Donald Guthrie. "Cognitive Recovery in Socially Deprived Young Children: The Bucharest Early Intervention Project." *Science* 318 (2007): 1937–1940.

Restak, Richard. *Mozart's Brain and the Fighter Pilot: Unleashing Your Brain's Potential*. New York: Harmony Books, 2001.

———. *Think Smart: A Neuroscientist's Prescription for Improving Your Brain's Performance*. New York: Riverhead Books, 2009.

Stress

Sapolsky, Robert M. *Why Zebras Don't Get Ulcers: A Guide to Stress, Stress-Related Diseases and Coping*. New York: W. H. Freeman, 1994. This is one of the early books on stress that still remains timely and relevant.

Technology

Carr, Nicholas. *The Shallows: What the Internet Is Doing to Our Brains*. New York: W. W. Norton and Company, 2010.

Carroll, James. "Silent Reading in Public Life." *Boston Globe*, February 12, 2007.

Connor, Charles E., Howard E. Egeth, and Steven Yantis, "Visual Attention: Bottom-Up versus Top-Down." *Cognitive Biology* 14 (2004): 850–852.

Powers, William. *Hamlet's BlackBerry: A Practical Philosophy for Building a Good Life in the Digital Age*. New York: HarperCollins, 2010.

Rosen, Christine. "People of the Screen." *New Atlantis* 22 (2008): 20–32.

Video Games

Anderson, C. A. “An Update on the Effects of Playing Violent Video Games.” *Journal of Adolescence* 27 (2004): 113–122.

Anderson, C. A., A. Sakamoto, D. A. Gentile, N. Ihori, A. Shibuya, S. Yukawa, M. Naito, and K. Kobayashi. “Longitudinal Effects of Violent Video Games on Aggression in Japan and the United States.” *Pediatrics* 122 (2008): 1067–1072.

Chatfield, Tom. *Fun Inc.: Why Play is the 21st Century’s Most Serious Business*. London: Virgin Books Limited, 2010.

Gentile, D. A., and J. R. Gentile. “Violent Video Games as Exemplary Teachers: A Conceptual Analysis.” *Journal of Youth and Adolescence* 9 (2008): 127–141.

Green, C. S., and D. Bavelier. “Action Video Game Modifies Visual Selective Attention.” *Nature* 423 (2003): 534–537.

Jaeggi, S. M., M. Buschkuhl, J. Jonides, and W. J. Perrig. “Improving Fluid Intelligence with Training on Working Memory.” *Proceedings of the National Academy of Sciences* 105 (2008): 6829–6833.

Koepp, M. J., R. N. Gunn, A. D. Lawrence, V. J. Cunningham, A. Dagher, T. Jones, D. J. Brooks, C. J. Bench, and P. M. Grasby. “Evidence for Striatal Dopamine Release during a Video Game.” *Nature* 393 (1998): 266–268.

Li, R., U. Polat, W. Makous, and D. Bavelier. “Enhancing the Contrast Sensitivity Function through Action Video Game Training.” *Nature Neuroscience* 12 (2009): 549–555.

Murphy, R. F., and W. R. Penuel. *A Review of Recent Evidence on the Effectiveness of Discrete Educational Software*. Washington, DC: Planning and Evaluation Service, U.S. Department of Education, 2002.

Rosser Jr., J. C., P. J. Lynch, L. Cuddihy, D. A. Gentile, J. Klonsky, and R. Merrell. "The Impact of Video Games on Training Surgeons in the 21st Century." *Archives of Surgery* 142 (2007): 181–186.