

*As seen on  
the Today  
show*

THE  
MATURE  
MIND

THE POSITIVE  
POWER OF THE  
AGING BRAIN

GENE D. COHEN, M.D., Ph.D.

THE  
MATURE  
MIND

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ALSO BY GENE D. COHEN, M.D., PH.D.

*The Creative Age: Awakening Human Potential  
in the Second Half of Life*

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THE  
MATURE  
MIND

*The Positive Power of  
the Aging Brain*

GENE D. COHEN, M.D., PH.D.



A Member of the Perseus Books Group  
New York

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Hardcover first published in 2005 by Basic Books,  
A Member of the Perseus Books Group  
Paperback first published in 2006 by Basic Books

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Designed by Deborah Gayle

Library of Congress Cataloging-in-Publication Data

Cohen, Gene D.

The mature mind : the positive power of the aging brain / by Gene Cohen.

p. cm.

Includes bibliographical references and index.

ISBN-13: 978-0-465-01203-9 (hardcover : alk. paper)

ISBN-10: 0-465-01203-5 (hardcover : alk. paper)

1. Middle age—Psychological aspects. 2. Middle-aged persons—Psychology. 3. Old age—Psychological aspects. 4. Older persons—Psychology. 5. Aging—Psychological aspects. 6. Brain—Aging. I. Title.

BF724.6.C64 2005

155.67'13—dc22

20050225

PBK: ISBN-13: 978-0-465-01204-6; ISBN-10: 0-465-01204-3

10 9 8 7 6 5 4 3 2 1

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*To the elders of my family,  
in deep appreciation  
for the nurturing and wisdom  
they have provided to our family  
and to the community.*

# Contents

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*Acknowledgments*

*Introduction*

- 1 The Power of Older Minds
- 2 Harnessing Developmental Intelligence
- 3 The Second Half of Life: Phases I and II
- 4 The Second Half of Life: Phases III and IV
- 5 Cognition, Memory, and Wisdom
- 6 Cultivating Social Intelligence
- 7 Reinventing Retirement
- 8 Creativity and Aging

*Appendix 1: Notes*

*Appendix 2: Other Useful Resources*

*Index*

# Acknowledgments

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FIRST, I WOULD LIKE TO ACKNOWLEDGE the great support and patience my family provided me while I wrote this book. The fact that for ten months of the process I was recovering from a broken femur and the required two operations made their support all the more precious. My wife, Wendy Miller, and my daughter, Eliana, were simply extraordinary during this time, and my son, Alex, his wife, Kate, and my two granddaughters—Ruby and Lucy—were a fabulous cheering section from their home in Camden, Maine.

I also want to acknowledge the invaluable advice, assistance, and encouragement that Teresa Barker provided in the planning, initial drafting, and development of the book. I am also enormously grateful to Stephen Braun, who collaborated very closely with me in bringing the final draft to fruition, contributing vitally to its quality and timeliness.

Much gratitude goes as well to my agent, Gail Ross, for her successful efforts in connecting me with Basic Books and for her ongoing assistance in keeping things on course. And many thanks to Howard Yoon, who worked so diligently with Gail in this process.

Thanks are due, too, to Jo Ann Miller, my editor at Basic Books, who worked closely with me, and who was always prompt and helpful in answering questions, solving problems, and moving things along.

Deep appreciation goes to the sponsors of the major studies I describe in this book. The Atlantic Philanthropies (USA) Inc. supported the 21st Century Retirement Study. In conjunction with the Helene Bader Foundation, they also supported the development and evaluation of the reading list of children's books described in Appendix 2.

The Creativity and Aging Study was supported by six sponsors led by the National Endowment for the Arts (NEA). The other five supporters were the Center for Mental Health Services of the U.S. Department of Health and Human Services, the National Institute of Mental Health at the National Institutes of Health, AARP, the Stella and Charles Guttman Foundation, and the International Foundation for Music Research. Particular thanks for this study go to Paula Terry, the project officer at NEA. After my book *The Creative Age* came out, Paula, who heads the Accessibility Office Program and coordinates projects on aging at the National Endowment for the Arts, read it and was interested in the summary of research relevant to the impact of creative expression on health in later life. The Arts Endowment has long been committed to making the full spectrum of the arts available to underserved populations, including older adults. Realizing that little data addressed the impact of professional arts programming on older adults, Paula encouraged me to develop guidelines for a study and to submit a proposal to the Endowment.

Thanks go as well to the Small-Alper Family Foundation, Inc., for their contribution to the process of preparing this book.

Finally, I want to express my special appreciation to my colleagues at the three research sites of the Creativity and Aging Study that I directed. Jeanne Kelly, from the Levine School of Music, served as the artistic director for the metropolitan Washington, D.C., part of the study. Jeff Chapline, who heads the Center for Elders and Youth in the Arts (CEYA), directed the San Francisco site. Susan Perlstein, who heads Elders Share the Arts (ESTA), directed the Brooklyn site and shared the important findings of the Creativity and Aging Study with the National Center for Creative Aging (NCCA), which she also directs, to promote dissemination of the research results for practical use by



community-based art programs across the country. Working with these terrific colleagues was like being on a dream team.

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# Introduction

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The greatest obstacle to discovery is not ignorance—  
it is the illusion of knowledge.

—Daniel J. Boorstin

“Over the hill.”

“Out to pasture.”

“Twilight years.”

“Retired.”

These words reflect a stubborn myth—that aging is a negative experience and that “successful aging” amounts to nothing more than slowing the inevitable decline of body and mind. Rubbish. Some of life’s most precious gifts can *only* be acquired with age: wisdom, for example, and mastery in hundreds of different spheres of human experience that requires decades of learning. Growing old can be filled with positive experiences, and “successful” aging means harnessing and manifesting the enormous positive potential that each one of us has for growth, love, and happiness.

Of course, aging brings challenges and losses. As actress Bette Davis once famously quipped, “Getting old isn’t for sissies.” Sight may blur, hearing may dull, friends may die or become disabled. All of this is true, but it’s not the *whole* truth. Historically, both science and culture in Western societies have focused exclusively on the negative sides of aging and ignored the positive. It’s time for a better, truer, and more motivating paradigm—not a rosy, everything-is-wonderful perspective, but a clear-eyed view that acknowledges the hard realities of growing old while at the same time celebrating its benefits, pleasures, and rewards. With this book I want to shatter the illusions of “knowledge” about aging that are based on faulty reasoning, insufficient research, and a preoccupation with disease and pathology. My picture of positive aging is based on cutting-edge scientific research as well as my personal experience as a psychiatrist who has treated older adults and their families for more than thirty-five years.

The latest research findings are encouraging and important. Denying or trivializing the positive potential of aging prevents people from realizing the full spectrum of their talents, intelligence, and emotions. But when we come instead to *expect* positive growth with age, such growth can be nurtured. We are still a long way from fully realizing this shift in perspective, but I hope this book will be a forceful catalyst for change in that direction.

## NEW SCIENCE, NEW HORIZONS

Some of the most exciting research supporting the concept of positive aging comes from recent studies of the brain and mind. Much of aging research conducted during the twentieth century emphasized improving the health of the aging body. As a result of this research, life expectancy and

overall health did in fact improve dramatically. Aging research at the beginning of the twenty-first century, in contrast, has expanded with a strong focus on improving the health of the aging *mind*. Dozens of new findings are overturning the notion that “you can’t teach old dogs new tricks.” It turns out that not only can old dogs learn well, they are actually better at many types of intellectual tasks than young dogs.

The big news is that the brain is far more flexible and adaptable than once thought. Not only do the brain retain its capacity to form new memories, which entails making new connections between brain cells, but it can grow entirely new brain cells—a stunning finding filled with potential. We’ve also learned that older brains can process information in a dramatically different way than younger brains. Older people can use both sides of their brains for tasks that younger people use only one side to accomplish. A great deal of scientific work has also confirmed the “use it or lose it” adage: the mind grows stronger from use and from being challenged in the same way that muscles grow stronger from exercise.

But the brain isn’t the only part of ourselves with more potential than we thought. Our personalities, creativity, and psychological “selves” continue to develop throughout life. This might sound obvious, but for many decades scientists who study human behavior did not share this view. In fact, until late in the twentieth century, psychological development in the second half of life attracted little scientific attention, and when attention was paid, often the wrong conclusions were drawn. For example, Sigmund Freud, whose influence on psychological theory was profound, had this to say about older adults: “About the age of fifty, the elasticity of the mental processes on which treatment depends is, as a rule, lacking. Old people are no longer educable.”

Ironically, Freud wrote this statement in 1907, when he was fifty-one, and he wrote some of his greatest works after the age of sixty-five. Furthermore, Sophocles’s *Oedipus Rex*, the masterpiece on which Freud based his pioneering psychoanalytic theory, was written when the Greek playwright was seventy-one years old.

Freud wasn’t the only pioneer to get things wrong when it came to aging. Jean Piaget, who made an extraordinary contribution to our understanding of cognitive development, ended his description of intellectual development with what he called “formal operations,” the kind of abstract thinking that matures during the teenage years. As far as Piaget was concerned, development stopped in young adulthood and then began a slow erosion.

Even the great developmental psychologist Erik Erikson, one of my teachers at Harvard, gave only limited attention to development in older age. Erikson delineated eight stages of psychosocial development and defined each one in terms of an issue or conflict that must be resolved. Yet only one of his stages refers to development after the onset of adulthood—mature age, which, these days amounts to a single stage that can last fifty years! His classic work *Identity and the Life Cycle* included only one page on each of the two last stages of human life. To his credit, Erikson was one of the first influential thinkers to assert that some kind of psychosocial development continues throughout the life cycle. He acknowledged that his work on aging was incomplete, and he invited his students to continue in this area. This book is, in part, my response to the challenge Erikson made decades ago.

## FOUR PHASES

In this book I present a new account of psychological development in the second half of life. This new

view explains many things about older age and is fundamentally forward-thinking and optimistic about our potential for lifelong growth, creativity, and emotional fulfillment. Based on my studies of more than 3,000 older adults, using in-depth interviews and questionnaires conducted multiple times over the years, I have identified the following four distinct developmental phases of late life: midlife reevaluation, liberation, summing up, and encore.

People enter and pass through these phases under the impelling force of inner drives, desires, and urges that wax and wane throughout life. I call these drives the “Inner Push” and have witnessed it in thousands of older adults who have participated in my research projects and clinical practice. The Inner Push is the fuel motivating development; it works in concert with the changes in the aging brain that I explore in [chapter 1](#). My conception of phases is more fluid and dynamic than Erikson’s stages because I recognize that by later life people vary widely in every conceivable way, and no rigid system will be accurate for everyone. The phases I propose are real—I’ve seen them manifested time after time—but people experience them in different ways and sometimes in a slightly different sequence than the one I present.

The first phase, midlife reevaluation, is a time for exploration and transition. It is not at all the same thing as a “midlife crisis”—which modern research has shown has been overreported and is largely a cultural myth. Only 10 percent of people I interviewed reported having a midlife crisis. What I found, instead, was that in this period, from roughly ages forty through sixty-five, people undergo profound reevaluation, asking themselves: Where have I been? Where am I now? Where am I going? Most people experience this period not as a crisis but as a quest—a desire to break new ground, answer deep questions, and search for what is true and meaningful in their lives.

The midlife reevaluation phase is followed by what I call the liberation phase: a time when we feel a desire to experiment, innovate, and free ourselves from earlier inhibitions or limitations. This desire often overlaps with midlife reevaluation and then comes on strong throughout the late fifties and sixties and into the seventies. As this shift is happening, our brains undergo significant physiological changes, including the sprouting of new connections between brain cells and a more balanced use of the two brain hemispheres. This is a time when people express the sense of “If not now, when?”

The summing up phase, from the late sixties through the seventies and eighties, can be a time of recapitulation, resolution, and review. One of the common outcomes of this autobiographic summing up process is a desire to give back—to family, friends, and society. Volunteerism and philanthropy, prominent among older people well into their eighties, are two tangible manifestations of this phase.

For the final phase I use “encore” in the French sense of “again,” “still,” and “continuing.” This phase is not a swan song, but a variation on a theme: the desire to go on, even in the face of adversity or loss. This need to remain vital can lead to new manifestations of creativity and social engagement that make this period full of surprises.

When people come to understand these phases of later life and the mechanisms at work behind them, I have seen them become powerfully motivated and energized. Released from overly negative illusions about aging, people are often stirred by new energy, direction, or purpose.

## DEVELOPMENTAL INTELLIGENCE

In this book I introduce a novel concept, developmental intelligence, which I see as the greatest

benefit of the aging brain/mind. Developmental intelligence is the degree to which a person has manifested his or her unique neurological, emotional, intellectual, and psychological capacities. It is also the process by which these elements become optimally integrated in the mature brain. More specifically, developmental intelligence reflects the maturing synergy of cognition, emotion, intelligence, judgment, social skills, life experience, and consciousness. We are all developmentally intelligent to one degree or another, and, as with all intelligence, we can actively promote its growth. As we mature, developmental intelligence is expressed in deepening wisdom, judgment, perspective, and vision. Advanced developmental intelligence is characterized by three types of thinking and reasoning that develop later than Piaget's "formal operations" and hence are referred to as "postformal operations": relativistic thinking (recognizing that knowledge may be relative and not absolute); dialectic thinking (the ability to uncover and resolve contradictions in opposing and seemingly incompatible views); and systematic thinking (being able to see the larger picture, to distinguish between the forest and the trees).

These three types of thinking are "advanced" in the sense that they do not come naturally to youth; we prefer our answers black or white, right or wrong. And we usually prefer *any* answer to none at all. It takes time, experience, and effort to develop more flexible and subtle thinking. Our capacity to accept uncertainty, to admit that answers *are* often relative, and to suspend judgment for a more careful evaluation of opposing claims is a true measure of our developmental intelligence. In this book I'll show you how you can cultivate your developmental intelligence and thereby reap its rewards.

## TWO NEW STUDIES

I've had the privilege of directing two groundbreaking studies of older age since 2000, one looking at the new face of retirement and the other at the positive benefits of creativity in older adults. Both studies have generated surprising—and encouraging—results. My retirement study shows just how outmoded the word "retirement" really is. For most people these days, the years after age sixty-five are anything but "retiring." It's not that everyone is a dervish or that people don't relax and enjoy themselves, but most people I interview see this life stage as a great opportunity to pursue activities and interests for which they previously didn't have time. Far from being a time of social and cultural withdrawal (as was postulated by early influential research), "retirement" can usher in *great* engagement, more satisfying relationships, new intellectual growth, and more fun.

My other study explores the mental, physical, and emotional effects of participating in a community arts program. Again, my colleagues and I have made surprising discoveries. Contrary to societal myths, creativity is hardly the exclusive province of youth. It can blossom at any age—and in fact it can bloom with more depth and richness in older adults because it is informed by their vast stores of knowledge and experience. As I will explain more fully later, taking part in any kind of arts program, including the nonvisual arts of music, dance, and theater, can improve your health, your outlook, and your resilience.

Important implications flow from these two studies, both for private citizens and for those responsible for supporting the health and well-being of older adults. Outcomes from our creativity study, for example, should be invaluable for program directors of senior centers. Similarly, the findings from the retirement study that many older people are seeking part-time work should interest human resources directors in corporations and nonprofit institutions. In reporting the findings from my

research, I hope to provide a road map for improving the social supports and educational opportunities for all older adults.

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## MY HOPE

In 1971, when I entered the field of gerontology, it was a relatively new area of study, underfunded and hobbled by stereotypes and misconceptions. As recently as the 1960s and 1970s, many experts still viewed old age as a disease: the mind and body, they believed, naturally fell apart, like a car after many years of use.

By the mid-1970s, these views began to change as evidence accumulated about the realities of aging and as the population of older adults began to surge. The federal government started spending millions of dollars on new research through two major programs: the National Institute on Aging and the Center for Studies of the Mental Health of the Aging, the latter of which I was fortunate enough to be the first director. Researchers began to understand that aging is not a medical condition in and of itself; it is simply a time of life in which many medical conditions become manifest—the so-called age-associated problems. This new focus fueled the field of geriatrics and provided a more balanced view of old age. Healthy adults, researchers found, retain sound mental and emotional faculties and typically decline only gradually in their physical resources.

Over the next thirty years, funding for aging research grew from \$50 million a year to more than \$1 billion today. Yet despite this infusion of time and money, studies still tend to focus on the problems of older age. Even the recent and important book *Successful Aging*, by John Rowe and Robert Kahn, presents the goal as minimizing decline rather than recognizing the huge potential for positive growth in later life. Although Rowe and Kahn rightly emphasize the importance of maintaining health, mental functioning, and active engagement in life, they don't present the possibilities for *improving* these areas with age.

*The Mature Mind* presents a new paradigm of aging, one that I hope will eventually displace today's negative views and assumptions. It recognizes the potential beyond the problems associated with aging. It reframes the aging process as a set of developmental phases that support real growth, opposed to the view of aging as an inevitable decline. This book shows how we can support and cultivate our natural capacity for positive change. I sincerely hope it will help redirect public dialogue on this topic by delivering a promising message about the value and capacities of the maturing mind.

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## The Power of Older Minds

Your brain never stops developing and changing.  
It's been doing it from the time you were an embryo,  
and will keep on doing it all your life.  
And this ability, perhaps, represents its greatest strength.

—James Trefil, physicist and author

MY IN-LAWS, HOWARD AND GISELE MILLER, both in their seventies, were stuck. They had just emerged from the Washington, D.C., subway system into a driving snowstorm. They were coming to our house for dinner and needed to catch a cab because it was too far to walk—but it was rush hour, and no cabs stopped. Howard tried calling us to get a lift, but my wife and I were both tied up in traffic and weren't home yet.

As his fingers began to turn numb from the cold, Howard noticed the steamy windows of a pizza shop across the street. He and Gisele marched through the slush, entered the shop, stepped up to the counter, and ordered a large pizza for delivery. When the cashier asked where to deliver it, Howard gave him our address, and added, "Oh, there's one more thing."

"What's that?" the cashier asked.

"We want you to deliver us with it," Howard said.

And that's how they arrived—pizza in hand—for dinner that night.

This favorite family story perfectly illustrates the sort of agile creativity that the aging mind can produce. Would a younger person have thought of this solution? Possibly. Creativity knows no age limits. But in my experience, this kind of out-of-the-box thinking is a learned trait that improves with age. Sherry Willis, of the Human Development and Family Studies program at Pennsylvania State University, calls it pragmatic creativity in everyday problem solving, a capacity that her research has found to be very strong in later life. Age allows our brains to accumulate a repertoire of strategies developed from a lifetime of experience—part of what has been referred to by other researchers as crystallized intelligence. Howard hadn't done the pizza parlor routine before, but the accumulated experience of other successful strategies helped stimulate the thinking that produced his creative solution.

Howard's solution reflects not only the experience of years and a certain agility of thought but also a mature psychological development that is prevalent among people in their sixties and seventies. With age can come a new feeling of inner freedom, self-confidence, and liberation from social constraints that allows for novel or bold behavior. Howard wasn't afraid to make an unusual request of perfect strangers, and that was a key part of his success that night.

In Howard's story we have a picture of a healthy aging mind at work: clear, creative, resourceful.

and powerful. But how does such a mind develop? On what does it depend for its existence? The short answer is the brain.

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It's been said that the mind is what the brain does. The mind is often described as "software" running on the "hardware" of the brain. But this analogy is too simple. The brain is far more malleable and flexible than any computer chip. And the mind, although it seems almost ghostlike, can powerfully influence the brain and, by extension, the body. Mind and brain are really two sides of a single coin—mind/brain. This chapter explores the brain side of this equation and looks at recent discoveries in brain science that illuminate the positive potential of the aging mind.

You may have learned the following "facts" about the brain:

- The brain cannot grow new brain cells.
- Older adults can't learn as well as young people.
- Connections between neurons are relatively fixed throughout life.
- Intelligence is a matter of how many neurons you have and how fast those neurons work.

All these "facts" are wrong, as we will see. And that's good news for all of us. The brain is more resilient, adaptable, and capable than we long thought. Research in the past two decades has established four key attributes of the brain that lay the foundation for an optimistic view of human potential in the second half of life:

- The brain is continually resculpting itself in response to experience and learning.
- New brain cells *do* form throughout life.
- The brain's emotional circuitry matures and becomes more balanced with age.
- The brain's two hemispheres are more equally used by older adults.

Now, let's be clear. I am not suggesting that the brain is immune to age-related changes. The brain is made of cells, like every other part of the body, and cells can and do "wear out" with age. Certain aspects of brain function do decline with age, such as the raw speed with which complicated mathematical problems are solved, reaction times, and the efficiency of short-term memory storage. But the "negatives" are by no means the whole—or even the most important—story about the aging brain. Unfortunately, because much brain research has focused on age-related *problems*, negative aspects of aging have been emphasized and the positive implications of research have been overlooked. Indeed, one of the most important findings of all is still not widely known; namely, that much of the decline in mental abilities formerly associated with aging is *not* caused by aging per se but by specific diseases such as "microstrokes," Alzheimer's disease, and mental illnesses such as depression. Healthy old brains are often as good as or better than younger brains in a wide variety of tasks.

Understanding more about how your brain works is important because understanding can spark motivation. If you learn how memory works and see the connections between the health of your neurons and the choices you make in diet, exercise, sleep, social activity, and how you challenge your mind, you'll be more likely to harness your brain's latent potential.

## THE POTENTIAL OF OLDER BRAINS

The most important difference between older brains and younger brains is also the easiest to overlook.



older brains have learned more than younger brains. Many aspects of life are simply too complicated and subtle to learn quickly, which is why experience counts in so many spheres of life. Human relationships, for example, are notoriously complicated, and it can take decades to acquire the deep knowledge and understanding it takes to be a truly effective therapist, pastor, manager, or politician. There is simply no substitute for acquired learning in such fields as editing, law, medicine, coaching, and many areas of science. In these and many other fields, age generally trumps youth. Of course, age alone is no guarantee of excellence, but excellence in many fields can be achieved only after many years of hard work and experience.

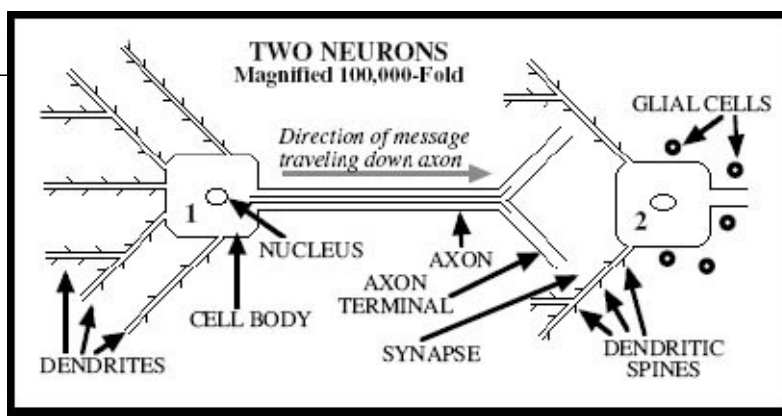
We now know that learning actually causes physical changes in the brain. An older adult's brain, magnified tremendously, would look distinctly different from a young person's brain. The brain cells (called neurons) in the parts of the brain that an older person has used continuously would look like a dense forest of thickly branched trees, compared with the thinner and less dense forest of a young person's brain. This neural density is the physical basis for the skills of accomplished older adults.

Let's take a closer look at learning and how it sculpts the brain.

To learn, we must remember. Memories, in turn, are created when clusters of hundreds or thousands of neurons fire in a unique pattern. Whenever you perceive anything, whether it's a whiff of cinnamon, a catchy song, or a visual image, a flood of signals lights up particular constellations of neurons in certain parts of your brain. If conditions are right (that is, if you are paying attention), the connections between these neurons are automatically strengthened. If this particular pattern of neurons is stimulated later in exactly the same way—say, by another whiff of cinnamon—the network “lights up” more easily than it did previously and you “remember” the smell. The original sensation is stored in these discrete patterns of primed connections. The more often a particular pattern is stimulated, the more sensitive and permanent are the connections between the neurons in the pattern. This process of memory formation is summarized by the phrase “neurons that fire together, wire together.”

Not only does learning link neurons in new patterns, it also stimulates neurons to grow new connections (known as synapses) through tiny branchlike extensions called dendrites.

The idea that the brain physically changes as a result of learning—a phenomenon called plasticity—emerged in the mid-1960s from animal studies conducted by Marion Diamond, a professor of anatomy at the University of California, Berkeley. Diamond found that when rats were placed in a more stimulating environment, their neurons sprouted new dendrites and produced higher levels of an important brain chemical called acetylcholine. The age of the rats made no difference. The brains of older rats showed the same kind of robust response to a stimulating environment as the brains of younger rats. A great deal of research conducted since those pioneering experiments has proven that the same phenomenon occurs in all animals, including human beings. In short, the brain actively grows and rewires itself in response to stimulation and learning.



Two neurons magnified 100,000-fold showing dendrites, cell body, axon, and synapse(s) with postsynaptic neuron(s). Regardless of age, a stimulating environment with challenging activities prompts an increased production of dendrites, dendritic spines, glial cells, and synapses (contact points between different neurons), enhancing brain capacity and communication among neurons.

For example, brain imaging studies have found that London taxi drivers have an enlarged region in the hippocampus—the part of the brain used for navigating in three-dimensional space. The driver's experience of negotiating the complex London streets “exercised” that part of their brains, which grew as a result. (And the oldest drivers in the study showed no hippocampal decline compared with the younger drivers.) Similar findings were reported in a study of musicians, who were found to have significantly increased functioning in the parts of the brain associated with hearing and the discrimination of tone and pitch.

I suspect that a brain scan of my neighbor, Lorraine Kennedy, would reveal similar kinds of robust growth in certain parts of her brain. Kennedy, who just turned ninety, is legendary for her knowledge of local history. She is an infallible resource on who lived where, and when, in the Victorian houses lining our street. Whenever some clarification is needed about a historical fact, people turn to her, and, without a computer, digital assistant, or notes, she retrieves the information from memory—sometimes along with plenty of additional detail. The part of her brain where all this knowledge resides would look far richer and more complicated than the corresponding part in the brain of a young person.

The complex neural architecture of older brains, built over years of experience, practice, and daily living, is a fundamental strength of older adults. And the more complex the architecture, the more it resists degradation by injury or disease.

Of course, the brain and its architecture are not static. Our brains are a bit like Monticello, the home that Thomas Jefferson built and then proceeded to modify during the many years he lived there. By continuing to learn and have new experiences, we can actively maintain, build, and remodel our brains for more effective and creative tasks. Doing so involves avoiding certain things as well. Stress, excessive alcohol and drug use, inactivity, smoking, obesity, malnourishment, and social isolation all can weaken the brain's neural superstructure. In fact, these are some of the real culprits behind age-related mental decline, not aging itself.

One aspect of brain development is frequently misunderstood, to the detriment of people's views about their own mental capacities. Some people have the false belief that mental ability is “all in the genes” and that anything that has a genetically determined component, such as eye color or the shape of one's nose, can't be changed. Genes, of course, are very powerful, and, broadly speaking, the genes we inherit do set some limits on what we can achieve mentally or physically. No matter how hard some people train, they'll simply never be Olympic runners, for example. But genes are not all that powerful—not by a long shot. Rather than constituting an immutable blueprint for our bodies and behavior, genes, it turns out, are highly sensitive to our environment, what we are exposed to, what we

perceive, the emotions we feel, the stress we are under, and a host of other factors in our lives. Many genes include “switches” for their activity—they can be turned on or off, or their activity levels can be dialed up or down like a volume control.

Thousands of genes are involved in the growth and maintenance of the brain. In fact, the brain uses up a larger portion of the human genome than any other organ. Many of these genes respond to the neural stimulation of learning. By challenging our brains, we not only actively shape existing neurons and stimulate their growth, we also switch on the key genes for making the cellular raw materials needed for mental development. The relationship between us and our genes is much more like a dance than most people think, which is a hopeful situation indeed.

## ESTELLE’S STORY

The potential of the healthy older brain is beautifully epitomized in Estelle Jansen, age seventy-one, a participant in my study of retirement-age adults. Estelle lives independently in a retirement community, where she moved after her husband’s death.

Estelle’s life has been rich and full. Her husband, to whom she was married for forty-one years, was a foreign service officer, and his career took them to many countries around the world. Estelle loved the experience of living abroad and always tried to learn the local language wherever they landed.

After recovering from her husband’s death, Estelle began again to feel the desire for fresh, challenging experiences. She decided to earn a master’s degree in history, despite some reservations about not having computer skills and fears about whether she could keep up with classmates in their twenties. But she dove into the challenge, starting off by taking a computer course for older adults who were new to the technology. She said it was “like learning a foreign language,” and she quickly learned what she needed for her course work.

In her history courses, she found that her younger colleagues enjoyed her contributions to class discussions. And because of her focus on the work—including her habit of spending more time on assignments by choice, rather than need—she was very successful in her classes. When I met her, she had just completed her first semester and earned solid grades. “I kept up just fine after all, thank you,” she said.

You might think that Estelle’s brain, so able and open to learning at seventy, is exceptional. But in fact all older adults, unless they are afflicted with injury or disease, have the same capacity to learn, grow, and derive satisfaction and pleasure from new accomplishments. Indeed, the fastest-growing group of graduate students are those over age fifty, a trend that supports an optimistic view of the potential of the aging brain.

## NEW BRAIN CELLS, NEW POTENTIAL

For decades, one of the most unshakable axioms of neuroscience was that nerve cells cannot regenerate and the brain does not create new neurons. Then, in the early 1960s, Joseph Altman, at the Massachusetts Institute of Technology, made the startling discovery that new neurons *can* form—at least in rats. Specifically, he found new cells growing in the hippocampus of adult rats, a part of the brain that is critical for new memory formation. In 1998, scientists showed that the adult human brain produces new neurons as well, a process called neurogenesis. It turns out that many regions of the

brain have primitive cells that, under certain conditions, can mature into either fully functioning neurons or brain cells called glia, which provide mechanical and nutritional support for the neurons. (It's probably not coincidental that, at autopsy, Einstein's brain was found to have significantly more glial cells than average.)

These remarkable findings were rich with implications, not only for the treatment of brain-decaying diseases such as Parkinson's disease and Alzheimer's disease, but for anyone interested in preserving or improving their mental capacity. The findings threw open the possibility that we can actually build (or rebuild) our brains.

We now know that new brain cells can form in other important regions of the brain. In 1999, a team of scientists at Princeton University led by psychologist Elizabeth Gould found that, in monkey brains, new neurons can grow in several regions of the cerebral cortex, the region responsible in humans for many of our "higher" functions, such as reflection, planning, decision-making, and emotional control.

Researchers are beginning to home in on what triggers new neuronal growth, although much about the process remains unknown. Challenging mental activity certainly stimulates neuronal growth, but so does another activity that few would have suspected: vigorous physical exercise. Exercise seems to "juice" the brain by stimulating the production of chemicals called brain growth factors. These compounds, in turn, provoke the primitive brain cells to mature into neurons. Prolonged stress, on the other hand, seems to dramatically suppress new neuron production. Studies have shown that both physical and psychological stress reduce the growth of new cells in the hippocampus. Patients with depression or posttraumatic stress disorder also show reduced hippocampal volume, while treatment reverses this trend.

The discovery that new brain cell growth can occur in adulthood has transformed views of the aging brain and the potential for enhancing brain functioning in older adults. For example, Greg Kempermann, of the Department of Experimental Neurology at Humboldt University in Berlin, says that studies conducted in his department suggest that neurogenesis enables the aging brain "to accommodate continued bouts of novelty." In other words, neurogenesis may have played a role in my father-in-law's pizza delivery inspiration and Estelle Jansen's success in a graduate program at age seventy.

Fred Gage, at the Laboratory of Genetics at the Salk Institute, who is one of the co-discoverers of neurogenesis in the mature brain, notes that "the stage has now been set for a new understanding of the adult brain" and emphasizes that even a damaged adult brain very likely retains some capacity to heal and recover. Of course, since memories are stored in patterns of connection between existing neurons, new neurons will not mean the recovery of memories lost to disease or injury. But the brain's ability to grow new neurons is one of the most exciting discoveries in neuroscience and a dramatic reason for optimism about the brain's potential in the second half of life.

## EMOTIONS IN BALANCE

George Barker was a smart, scrappy son of a housepainter. When World War II broke out, he enlisted in the Air Force and became a bomber pilot. Like many veterans, the experience of war and the real possibility of being killed affected him deeply—although in the decades following his combat experience he rarely talked about it. He returned from the front, began a career in journalism, married, and raised a family. Then, when he was in his sixties, he was diagnosed with leukemia, a cancer of

white blood cells that weakens the immune system.

His doctors advised him to avoid travel and any interactions that would expose him to pathogens such as playing with his grandchildren. He rejected the advice.

“I went through a war being shot at every day,” he says. “I’m not going to start living in fear now because I might catch a cold.”

Taking some appropriate cautions, he continued to travel, see his family, and engage in a full and loving life. A disease that might have caused a younger person to become depressed or withdrawn became a challenge, but not an obstacle.

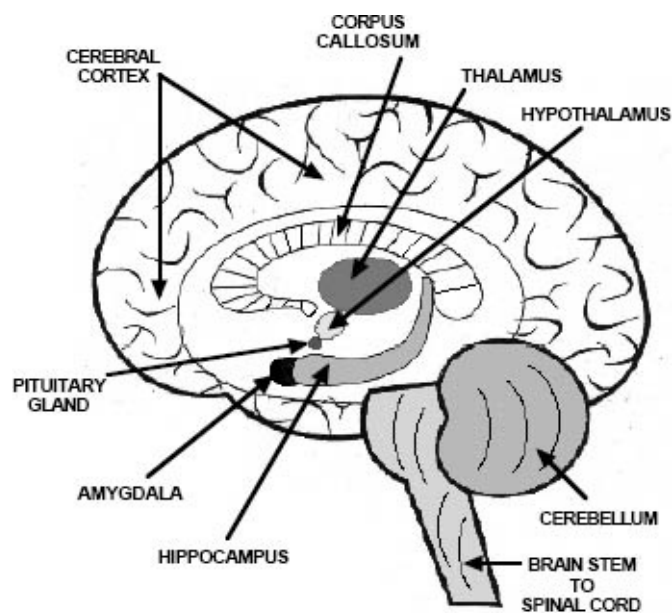
Among the myriad negative stereotypes and myths about aging is the view that many older people are depressed by the physical ills that, admittedly, become more common with age. In fact, however, research shows that the incidence of depression in later life is no higher than in early adulthood. Many studies have reported high morale in older adults, even among those who are frail. The positive outlook of people like Estelle Jansen and George Barker isn’t the exception—it’s the rule. I recall one day saying, “Have a lovely day!” to a seventy-four-year-old woman participating in one of my studies.

“I’ll *make* it a lovely day!” she shot back with a smile.

Many factors play into the high morale and positive outlook of so many older persons, including such things as a greater acceptance of life’s realities, a greater sense of self, and a long-term perspective that makes it easier to accept the inevitable slings and arrows of daily life. In addition to such psychological factors, however, new evidence shows that changes in the older brain itself play an important role in the emotional aplomb and equanimity of many older adults.

Human emotional responses are produced and regulated by a set of structures deep in the brain called the limbic system. These structures have been shaped by millions of years of natural selection to provide both a carrot and a stick to guide behavior in ways that favor survival and reproduction. Positive emotions such as feelings of affection, bonding, love, pleasure, and happiness arise from electrical and chemical activity in the limbic system in response to external cues such as the proximity of potential mates; success in obtaining food, status, and security; and, in human beings, the satisfaction of higher drives such as curiosity and artistic or musical expression.

#### SIDE VIEW OF THE INNER BRAIN AND THE LIMBIC SYSTEM



Side view of the inner brain and the limbic system. The limbic system is a group of anatomical structures, including the hippocampus.

amygdala, parts of the cortex, and parts of the hypothalamus, that functions as the motivation and emotional center of the brain.

Negative emotions such as fear, anger, envy, disgust, and depression arise in response to events or situations that threaten our survival, well-being, or sense of fair play. Some negative emotions are inborn. Anger, for example, is a nearly universal response to the perception of unfairness against us. And some fears, such as fear of snakes, spiders, and heights, have a genetic component to them. But fear, anger, and other negative emotions can also be learned, such as when a hypochondriac mother engenders a constant fear of illness in her children, or when a chronically angry father unconsciously transmits the message that anger is an expected or appropriate reaction to life's difficulties.

A particularly important aspect of the human emotional system is how these systems are connected to the neocortex, the thick layer of brain tissue overlaying the limbic system. The neocortex performs many functions, among them giving us our sense of self-awareness as well as "higher" attributes of consciousness such as morals, beliefs, intentions, goals, and aspirations.

Many more nerve fibers run from the limbic system up to the cortex than run from the cortex back down to the limbic system. If neural activity were water, the limbic system would have a firehose connection to the cortex and a straw from the cortex. This fundamental imbalance in connectivity means that emotions can easily overwhelm and overrule the thinking, deliberating parts of our brain. From an evolutionary standpoint, this makes perfect sense: animals that respond quickly and unthinkingly to perceived threats have a much better chance of survival than animals that ponder the situation before reacting.

For human beings, however, this basic brain imbalance between our reason and our emotions leads to all sorts of trouble. Indeed, our universal tendency to be pulled between what we know is right and what we want to do is at the core of much great art and literature. Our frequent inability to control our emotions and cravings is one of the defining features of our species. Our ability to control our emotions and modulate our behavior appropriately, however, is a hallmark of maturity.

The capacity to ride out emotional storms more flexibly and resiliently is one of the great fruits of aging. This is partly due to learning, experience, and practice, which stimulate the growth of new dendrites and sometimes entirely new neurons. This may mean that we can actually begin to equalize the out-of-balance connections between the limbic system and the cortex. In a real sense, we can build more control wires connecting our "higher" selves to our emotional centers.

But that's not all. The limbic system itself appears to grow calmer with age. One focus of current research is the amygdalae, two almond-shaped structures in the limbic system that generate some of our most intense emotions. The amygdalae are positioned to intercept sensory information streaming in from our eyes, ears, and noses; if that information contains a potential threat, the amygdalae immediately fire off volleys of impulses that can change our behavior even before the signals have been fully processed and interpreted by our neocortex. That's why your heart starts pounding at the vague shape of two men approaching you on a dark sidewalk. The men may or may not be a threat, but your amygdalae don't care and are preparing you for the worst.

People vary widely in the vigor with which their amygdalae respond. Brains are as unique as faces, and that goes for specific brain structures as well. Some people have very reactive, sensitive amygdalae—they startle easily, are "hot tempered," or feel intense bodily reactions to frightening situations. Others have relatively quiet amygdalae and are therefore more apt to be "cool," rational, unreactive, and unemotional. But for almost everyone, the amygdalae are notoriously difficult to control—and the younger you are, the harder they are to rein in.

This is where some recent research on the aging brain comes into play. Studies using brain

imaging techniques such as positron-emission tomography (PET) scanning find that activity in the amygdalae decreases with age, specifically in response to negative emotions such as fear, anger, and hatred.

A study by Mather Canli and his colleagues in the psychology department at the University of California, Santa Cruz, found that as adults age, they:

- Experience less intense negative emotions
- Pay less attention to negative than to positive emotional stimuli
- Are less likely to remember negative than positive emotional materials

As the study's authors summed it up, "This profile of findings suggests that, with age, the amygdalae may show decreased reactivity to negative information while maintaining or increasing their reactivity to positive information."

In short, older people are usually calmer in the face of life's challenges. As one of the subjects in my retirement study put it, "I'm less uptight about things and less of a perfectionist. Minor things don't upset me, and I make better judgments about things." We now know that this positive aspect of aging is the result not just of experience and learning but also of fundamental changes in brain function.

## EXTREME MAKEOVER OF THE AGING BRAIN

As human beings evolved and developed the capacity to devise new strategies for survival, such as tool use and language, the human brain increased in size. But Nature had a problem: the head couldn't simply keep getting larger, because eventually it wouldn't fit through the birth canal. The female pelvis could only enlarge so far without the entire body becoming unstable. What to do?

Conveniently, the brain, like some other organs such as eyes, ears, lungs, and kidneys, is a dual structure. We actually have two brains, left and right, connected by a kind of broadband neural link called the corpus callosum. Nature's solution to the problem of ever-increasing demands for specialized brain processing areas was to use a division of labor: some capacities would be handled primarily by the left hemisphere, others by the right. Hence, in most people (there are some interesting exceptions) speech, language, and mathematical and logical reasoning are handled by the left hemisphere. The right hemisphere tends to specialize in such functions as face recognition, visual spatial comprehension, and intuitive/holistic operations, such as those underlying artistic creativity.

Much has been made of these differences in hemispheric function, not all of it well grounded in science. Some talk of "left-brained people" and "right-brained people" or of women being more "right-brained" and men being more "left-brained." This is mostly metaphor, however. Healthy men and women need both sides of their brains and use both sides fluidly and continuously throughout life. Although people certainly vary in the relative strength of the activity of their hemispheres, to ascribe things like career choices to one side of the brain or the other is a misrepresentation of current knowledge.

At the level of specific brain functions, however, we can correctly speak of right/left differences. It turns out that throughout early life the brain typically uses predominantly only one side at a time for things like decoding written language, generating speech, or recognizing patterns. Use of one side of the brain is referred to as unilateral hemisphere involvement; use of both sides is referred to as

bilateral hemisphere involvement.

In the course of conducting studies with PET scans and magnetic resonance imaging, scientists noticed something unexpected going on in the brains of older adults. When, for example, young adults retrieve a specific word from memory, they usually use mostly the left side of their brain. Older adults doing the same task, however, often use both hemispheres. This phenomenon has been found with other tasks too, such as face recognition, working memory, and certain types of perception. The part of the brain examined in these studies is the prefrontal cortex in both hemispheres, a region that lies just behind the forehead. Much of this work has been described by Roberto Cabeza, of the Center for Cognitive Neuroscience at Duke University. He calls the phenomenon “hemispheric asymmetry reduction in older adults”—dubbed HAROLD for short.

These findings were puzzling. Did the bilateral hemisphere involvement in older people reflect some kind of impairment? Was it a desperate attempt by an aging brain to draw on greater brain power to solve problems? Or was it something positive—perhaps a way for the brain to create more “redundancy”—a backup system, so to speak?

To compare these two hypotheses, Cabeza measured brain activity during a set of memory tasks being performed by three groups: younger adults, low-performing older adults, and high-performing older adults. He found that the low-performing older adults used right prefrontal cortex regions similar to those used by the young adults, but the high-performing older adults used both hemispheres. These findings suggest that although the low-performing older adults and the young adults recruited similar networks of brain cells, the older subjects used them inefficiently (hence their low performance), whereas the high-performing older adults counteracted age-related neural decline by reorganizing their neural networks.

This is stunning news. Although we don’t yet understand exactly how the brains of older adults remodel themselves in this more efficient and powerful way, they clearly do. This phenomenon may be related to another one of older age: an interest in making sense of one’s life by writing and talking about it.

## CHARLES’S STORY

Charles Pugh, now ninety-two, was seventy-two when he retired from a long career as an IRS agent. He moved easily into a less pressured life that included a lot of the things he’d loved but never had time for: fishing, reading, bowling with friends, and more relaxed time with his wife. One day in the kitchen, his wife remarked that she was frustrated because she had loaned a roaster oven to someone but couldn’t remember to whom. Charles excused himself for a moment, disappeared into his study, and soon returned with the name of the friend who had borrowed the roaster—and the date.

Amazed, his wife asked how he could possibly know. Charles took her into his study and pointed to the bottom shelf of a bookcase that ran the length of the room. There, in a neat row of identical volumes, were Charles’s accumulated diaries covering the years since his retirement. With the increased free time of retirement, Charles had decided to keep a diary. He began by noting details of life as minute and mundane as the roaster’s migration. But he eventually expanded his notes to include more thoughtful observations and reflections on life. What had begun as a simple accounting—which for Charles was a familiar way to relate to the world—had evolved into a more textured account of his life, colorful, and with meticulous (and often helpful) detail.

Autobiographical writing and storytelling among older adults is common, and it stems from



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