Preface

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One of the most exciting fields in the world is brain research. Keeping pace with the explosion of brain research over the past two decades has proved challenging, but astute educators are applying the findings with growing success. The result is a learning approach that is more aligned with how the brain naturally learns best. This dramatic new paradigm, known as *brain-compatible* or *brain-based* education, has emerged with strong implications for teachers and learners worldwide. Based on research from the disciplines of neuroscience, biology, and psychology, our understanding of the relationship between learning and the brain now encompasses the role of emotions, patterns, meaningfulness, environments, body rhythms, attitudes, stress, trauma, assessment, music, movement, gender, and enrichment. By integrating what we now know about the brain with standard education practices, *Brain-Based Learning* suggests ways that schools can be transformed into complete learning organizations.

As many conventional educational models have been shattered like glass, many are saying, "It's about time." The visionary author-scientist H. G. Wells said, "Civilization is a race between education and catastrophe." Indeed, there is an urgency to our planet that we've never before collectively known. At both the local and global levels, we lack the luxury of being able to weather a continued "Dark Age" in learning. Too much is at risk: We must act on the problems facing us now.

> Present problems cannot be solved with the same level of thinking or with the same tools that created them.

This book calls for the initiation of a fundamental shift in thinking. Shortsighted priorities, outdated teacher-education programs, visionless leaders, "program-of-the-week" mentalities, clumsy systems, budgetary bottlenecks, hierarchical infighting, and professional jealousy all contribute to the problem; and they've got to stop. Furthermore, we need to quit playing the victim and arm ourselves with change strategies that work. We can effect the changes called for if we collectively make it important enough to do so. Each brain-based strategy outlined in this book can be achieved by any one of us at little or no expense.

The first step, however, is to make an important distinction between core problems and symptoms. Whereas solving core problems provides a twenty- to fifty-fold return on our investment of resources, solving mere symptoms creates a net loss. When an organization is antagonistic to the natural and effortless way the brain learns, it faces a mind-boggling array of symptoms that result in ever-greater challenges. This means that for every symptom you "solve," you not only miss the real problem, but you wear down an already overburdened staff and ultimately drain valuable resources. Every new program that has come and gone over the past 30 years was likely to be brain antagonistic. Schools must open their collective doors to the simple and fundamental questions that science is now answering for us: How does the brain learn best? How do we create successful learning organizations with the brain in mind?

Why is now the time for a shift in thinking? The research on what works is both compelling and comprehensive. We are all great natural learners. Failing children and failing schools are indications of a faulty system—not a faulty brain—and our schools have taken enough of a beating! When students are provided with a learning environment that is optimal for learning, graduation rates increase, learning difficulties and discipline problems decrease, a love of learning flourishes, administrators focus on the real issues, and learning organizations thrive. In short, creating an organization around the way the brain naturally learns best may be the simplest and most critical educational reform ever initiated. In fact, of all the reforms, nothing provides a better return on your investment of time, energy, and money than developing a brain-based approach to learning.

Now is the time to expand the research to make it school tested and classroom proven. And that is up to us as educators. It is imperative that we share our knowledge and experiences with others.

Even as you read this, learning organizations across the globe, determined individuals, cooperating teams, and whole communities have successfully implemented brilliant, innovative, low-cost, brain-based learning solutions. Thus, it's no longer a question of "Can we?" We know we can provide learners with brain-compatible environments and curriculums that support their natural learning abilities. The question now is "Will we?"

> As in most change efforts, the first thing we face from others is indifference followed by ridicule and opposition . . . and then, finally, respect.

> Brain-based learning is a way of thinking about the learning process. It is not a panacea, nor is it the solution to all of our problems. It is not a program, dogma, or recipe for teachers. And it is not a trend or gimmick. It is, however, a set of principles and a base of knowledge and skills upon which we can make better decisions about the learning process.

People who teach and train others make a vital contribution to the preservation of humanity. We must become a world of learners and begin to value learning as much as freedom, liberty, justice, shelter, and good health. We are obliged to take this assignment seriously—our collective future, in fact, depends on it. I invite you to start now. If you can't do it by yourself, ask for support: Start a network. Determined people everywhere have done it. They've simply said, "Let's get all of these people talking to each other and see what comes of it." As they shared what works for them, they realized a success rate that exceeded the norm.

You can make a significant difference. You are a once-in-forever biological event. This planet gets only one opportunity to experience your unique and powerful contributions, so share all that you are capable of at this moment. Can you step up to the challenge and accept your historic role? Go on, join the learning revolution; you've got nothing to lose and everything to gain. Find other like-minded people and organize yourselves for greater impact.

As Margaret Mead once said, "Never doubt that a small group of concerned citizens can change the world. It is, indeed, the only thing that ever has."

Are you the exception as an educator or now in the mainstream if you are buying into this new approach? How reputable is brain-based education? Harvard University now offers both master's and doctoral degrees in it through the Mind, Brain, and Education (MBE) program. Every year, the program produces about forty graduates with master's degrees and two to four doctors of education who go on to interdisciplinary positions in research and practice. Its mission is to build a movement in which cognitive science and neuroscience are integrated with education so that we train people to make that integration both in research and in practice. The director, Professor Kurt Fischer, helps oversee this new intersection of biology, cognitive science, and pedagogy. Does this sound like a fad to you? It's not.

For many, like Howard Gardner, brain-based education has become a new focus in education. Interest in Harvard's brain-based degree programs is enthusiastic in Canada, Japan, Australia, South Korea, England, South Africa, New Zealand, Argentina, and other countries. There's also a peer-reviewed scientific journal on brain-based education. The journal, which is published quarterly by the reputable Blackwell Publishers and the International Mind, Brain, and Education Society (IMBES), features research reports, conceptual papers, reviews, debates, and dialogue.

This book is written for those who want to know not only what works but why it works and how to incorporate the methods. I have written it in nontechnical terms for new as well as veteran teachers or trainers. When positive habits are formed early, the job of teaching becomes significantly easier. When what we know intuitively works is validated, we are rewarded with great satisfaction. So everyone will benefit no matter what your level of experience. By picking up this book, you've already taken the first step. Turn the page and take the next. If not now, when? If not you, who? Carpe diem.

2 How Your Student's Brain Learns

CHAPTER OUTLINE

This chapter introduces you to a bit of neurobiology. For the most part, the high-level science behind how we learn is not necessary for any educator. But you should know the basics. For example, how do we learn and what can we do to make it happen more often, even on cue? How do emotions and stress affect the learning? These questions become more illuminated when we explore what goes on in our brains.

At times, educators get a bit overwhelmed by all the biology, particularly if they lack a science background. My promise is to keep it brief and keep it relevant. I am reminded of a true story about a physicist, Richard Feynman, who talked about how he gained his science background. He said he would read a text until he got to something he couldn't understand. Then he would take a break, then back up, and read it again. Each time he restarted, he could get a bit further, and eventually he gained more and more background knowledge. Feynman went on to receive the Nobel Prize for Physics in 1965 for his discoveries in quantum physics. In this chapter, if you need to, just take a break from any paragraph. When you come back to it, you'll be ready for more.

> **The essential understanding here is that** the brain can be characterized many ways. But for our purposes, we can say three key things. First, it is highly connected in that events in one part of the brain affect those in other parts of the brain. Second, it is a learning miracle; it's just that much of what it learns may not be what is intended by a teacher. Finally, it is highly adaptable and designed to respond to environmental input.

HOW THE BRAIN LEARNS

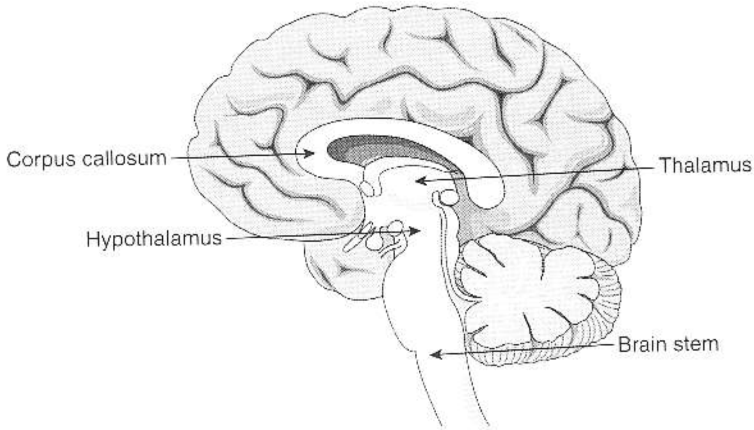
Here's an abbreviated tour of the learning process. In this case, we'll assume that the new learning is overt and explicit, or what we call *classroom learning*. This is critical because the brain processes different types of learning through different pathways. For words, text, and pictures, input to the brain arrives from our senses or it may be generated internally.

Routing Information Through the Brain

This input is initially processed first in the thalamus (see Figure 2.1), the "server" or central switching area of the brain. Simultaneously, it is routed to other specific areas for processing because time is of the essence. Your life is happening in real time, and the moment just might be an emergency! Visual information is routed to the occipital lobe, language to the temporal lobe, and so on. The brain quickly forms a raw, rough sensory impression of the incoming data. If there is any threatening or suspicious data, the amygdala (our "uncertainty activator") is activated. It will jump-start the rest of the sympathetic nervous system for a quick response.

Typically, however, the frontal lobe holds much of the new data in short-term memory for 5 to 20 seconds. This new information is filtered, dismissed, and never gets stored. It may be irrelevant, trivial, or not compelling enough. If it is worth a second consideration, new explicit learning is routed to and held in the hippocampus, two crescent-shaped structures in the midbrain area.

Figure 2.1 Medial view of the brain



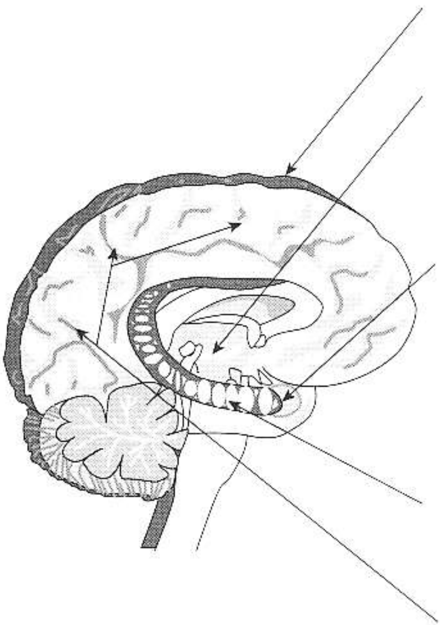
If this new learning is deemed important, it is organized and indexed by the hippocampus and later stored in the cortex. That's the quarter-inch, barklike wrinkle covering the brain. In fact, it is stored in the same lobe that originally processed it—visual information in the occipital lobe, language in the temporal lobe, and so on. The original processing takes place at lightning speeds, but the subsequent stages and storage process can take hours, days, and even weeks. Now, let's dig a bit into the "bit players" in your brain. But first, a reminder: there is no single pathway or process for *all* learning in your brain. Different types of learning (e.g., emotional, the big "aha," spatial, vocabulary, skill learning) each take unique pathways. And although they may share parts of a pathway, we are each unique, and the different input is processed differently. (See Figure 2.2 to review the brain's mapping of content.)

BASIC ANATOMY OF THE BRAIN

The brain is the most complex organ we possess. Cell counts vary widely among humans, but generally speaking, a person's brain contains between 50 billion and 100 billion (100,000,000,000) neurons. For the sake of comparison, consider that a monkey has about 10 percent of that, a mouse has about 5 million brain cells, and a fruit fly has about 100,000. Individual cells don't make us smart; it's the connections that do. When linked together, the number of connections our brain cells can make is estimated to be from 100 trillion to as much as 10 followed by millions of zeroes (more than the estimated number of atoms in the known universe).

Brain size and weight also vary among humans. The average weight is three pounds, and a healthy adult's brain may range from two to four pounds. Albert Einstein, who developed the theory of relativity, had an average-size brain, but the French writer Honoré de Balzac had a brain that was 40 percent larger than

Figure 2.2 How the brain learns new content



average. While the process of learning involves the whole body, the brain acts as a way station for incoming stimuli. All sensory input gets sorted, prioritized, processed, stored, or dumped on a subconscious level as it is processed by the brain. Every second a neuron can register and transmit between 250 and 2,500 impulses. When you multiply this transmission ability by the number of neurons we're estimated to have (approximately 100 billion), you can begin to fathom just how unfathomable human learning potential is.

A normal, living human brain is pink-beige colored and soft enough that it can be cut with a butter knife. Distinguishing the outer surface of the brain, the cerebral cortex (Latin for *bark* or *rind*) appears as folds or wrinkles about the thickness of an orange peel. Rich in brain cells, this tissue covering would be about the size of an unfolded sheet of newspaper if stretched out flat. The cortex's importance is highlighted by the fact that it constitutes about 70 percent of the nervous system: its nerve cells, or neurons, are connected by nearly one million miles of nerve fibers. The human brain has the largest area of uncommitted cortex (no particular required function) of any species on earth, which gives humans extraordinary flexibility and capacity for learning.

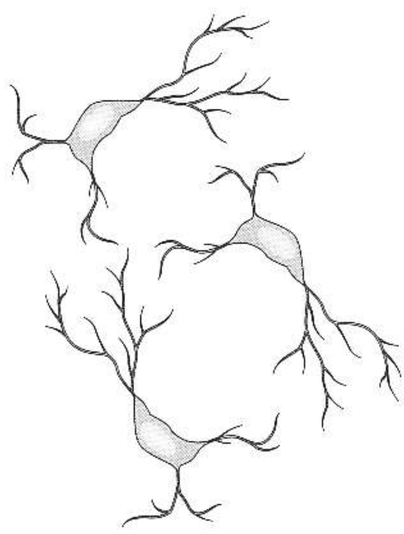
Cells of the Central Nervous System

All of us lose some brain cells all the time as a result of apoptosis (cell death). Scientists estimate that this loss of neurons adds up to about 18 million per year between the ages of roughly 20 and 70. For two reasons, however, this is not a problem. First, even if a person were to lose half a million neurons per day, at this rate, it would still take centuries to "lose" his or her mind. And second, in spite of this naturally occurring pruning process, new research (Eriksson et al., 1998) suggests that we can also grow new brain cells, at least in the hippocampus. Brain cells come in many varieties: chemicals, proteins, fats, and connective tissue. The most commonly known cells are neurons and glia.

Glial Cells

At birth, we have as many as one thousand billion glial cells (see Figure 2.3)—that is, one hundred times the number of known stars in the Milky Way. An autopsy of Einstein's brain revealed that, although it was of average size, it had more than the average number of glial cells. The roles assigned to glial cells seem to be multifaceted and likely include the production of myelin for the axons, structural support for the blood-brain barrier, transportation of nutrients, and regulation of the immune system. There are four primary types of glial cells—astrocytes, oligodendrocytes, microglial cells, and Schwann cells—and each plays a significant role in the learning process. These cells are about 10 times more concentrated in our brains than their neuronal counterparts are. In the past, glial cells were thought of simply as support cells, but this is no longer believed to be true. Today, we know that they are equal to neurons in their capacity, function, and importance. Amazingly, neurons grown with glial cells in a lab culture are not just slightly, but a whopping 10 times more active than neurons grown alone (Allen & Barres, 2005).

Figure 2.3 Glial cells



Neurons

A neuron (Greek for *sinew* or *bowstring*) is a basic structural and processing unit of the nervous system. It has three primary functional areas: the cell body (soma), the outbound projection (axon), and the inbound "feeder systems" (dendrites). Its structure and properties allow it to conduct signals by taking advantage of the electrical charge across its cell membrane. Neurons cannot be seen with the naked eye and come in many sizes and structures.

A normally functioning neuron continuously fires, integrates, and generates information across microscopic gaps called *synapses*, thereby linking one cell to another. No neuron is an end point in itself. Rather, each acts as a conduit for information. Always busy, neurons generate a hotbed of activity. In fact, a single neuron may connect with 1,000 to 10,000 other cells. As a rule, the more connections your cells make, the better.

Adults have about half the number of neurons found in the brain of a two-year-old. A single cubic millimeter (1/16,000th of an inch) of brain tissue has over one million neurons, each about 50 microns in diameter. As you can see, learning begins on a cellular level.

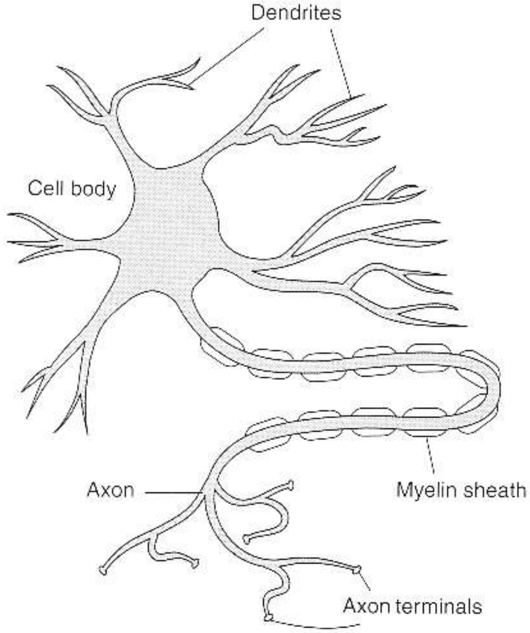
Dendrites. Dendrites are branchlike extensions protruding from a cell body. They are the receivers of the input that gets passed along from neurons to cells (see Figure 2.4). The sum of all the synaptic reactions arriving from the dendrites to the cell body at any given moment determines whether that cell will, in fact, fire. In other words, learning involves groups or networks of neurons. There's a threshold to reach, too; the cell needs enough activation to fire, or it will remain dormant and no memory will be activated.

Axons. Although the cell body has the capacity to move, most adult neurons stay put and simply extend their single axon outward. Some axonal migration is genetically programmed, and some is a result of environmental stimulation. Axons normally only talk to dendrites, and dendrites normally only talk to axons. When an axon (which is a thinner, leglike extension) meets up with a dendrite from a neighboring cell, the eureka moment of the learning process occurs.

To connect with thousands of other cells, the axon repeatedly subdivides itself and branches out. Neurons serve to pass along information, which flows in one direction only. The dendrites receive input from other axons and transmit the information to their cell body. Then the information moves out to the axon, which communicates it to another cell through dendritic branches.

An axon has two essential functions: to conduct information in the form of electrical stimulation and to transport chemical substances. Axons vary in size, with the longer specimens stretching to about one meter. The thicker the axon, the faster it conducts electricity (and information). Myelin, a fatty lipid substance that forms around well-used axons, is present around all axons to some degree. Myelination seems to not only speed the electrical transmission (up to twelvefold) but also reduce interference from other nearby reactions. Along with myelination, nodes along the axons can boost electrical impulses to speeds of 120 meters per

Figure 2.4 Axon and dendrite model



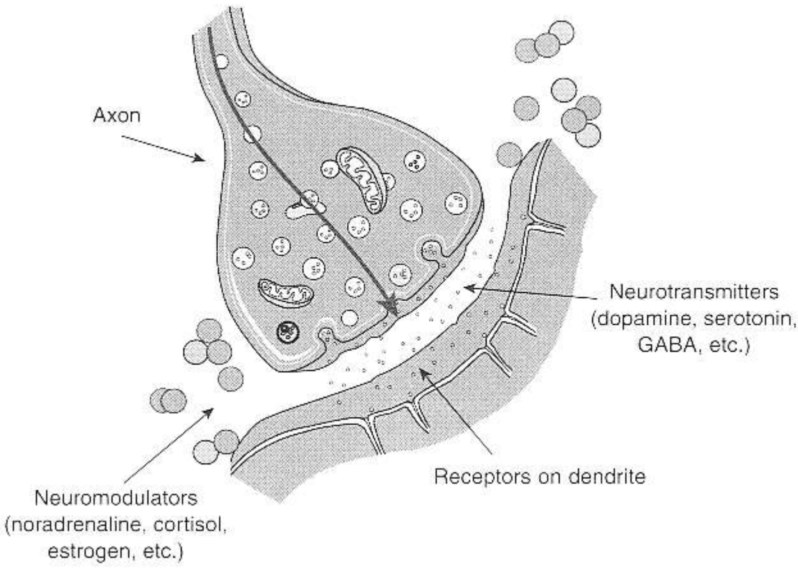
second or 200 miles per hour. The smallest axon probably receives no advantage from myelination.

Figure 2.5 shows the basic physiological process for learning. An electrical impulse travels down the axon, where it triggers the release of neurotransmitters into the synaptic gap. In the span of a microsecond, the chemicals travel across the gap (about 50 microns) and are absorbed into receptor sites on the surface of the receiving dendrite. The neurotransmitters are released, absorbed, and reabsorbed via the thousands of rapid-fire impulses activated every second.

Neurotransmitters influence the synaptic reactions and result in learning impairment, enhancement, or no effect. For example, a low level of the stress hormone cortisol during a learning session has no known effect. Moderate levels, however, enhance synaptic efficiency, and high levels impair learning. On the other hand, the neurotransmitter noradrenaline seems to have the opposite effect. Low levels have no effect, but high levels enhance learning and memory. Progesterone, testosterone, and dozens of other hormones also impact learning. For example, testosterone seems to support spatial learning, but only in moderate levels. A teacher can influence some neurotransmitters (e.g., adrenaline is increased by the type of risk, urgency, and excitement that can happen in a classroom competition), but others are not easily modified (e.g., glutamate seems impervious to our behaviors).

Get it, get it right, and strengthen it. This is the basic learning process that builds intricate neural networks and makes them uniquely our own.

Figure 2.5 Synapse and neurotransmitters



Divisions and Functions of the Brain

The brain comprises four different regions: brainstem, cerebellum, diencephalon, and cerebrum. Together they work as the central command center for the body to move, think, and react.

Brain Stem

The brain stem is the lower part of the brain; it connects the spinal cord to the brain. It houses several loosely defined areas including the pons and the medulla oblongata. This critical area regulates the automatic and nonconscious behaviors essential to life such as breathing and heart rate.

Cerebellum

Our brains need to guide us through life, literally. The area of the brain most associated with balance, posture, and motor control is the cerebellum. It's located in the back of the brain, just under the occipital lobe, and is about the size of a small fist. The cerebellum takes up just one-tenth of the brain by volume, but it contains nearly half of all its neurons (Ivry & Fiez, 2000); the neurons are so compacted that they can form an immense number of connections. This amazing structure may be the most complex part of the brain. In fact, the cerebellum has some 40 million nerve fibers—40 times more than even the highly complex optical tract. Those fibers feed information from the cortex to the cerebellum, and then they feed data back to the cortex. Most of the neural circuits from the cerebellum are "outbound," influencing the rest of the brain (Middleton & Strick, 1994) via a pathway from the cerebellum to the parts of the brain involved in memory, attention, and spatial perception.

Amazingly, this part of the brain, which processes balance, posture, and movement, is the same part that processes much of our learning, too. The reasons for this connection are simple. We learn early on in life to predict (which requires data analysis) each of our movements before we execute them (that's you moving) so that we control them better (Flanagan, Vetter, Johansson, & Wolpert, 2003). This ability suggests that all motor activity is not purely mechanical; it's preceded by quick thought processes that set goals, analyze variables, predict outcomes, and execute movements. Pulling this off requires widespread connections to all sensory areas—a relationship with the cerebellum in such mental processes as predicting, sequencing, ordering, timing, and practicing or rehearsing a task before carrying it out. The cerebellum can make predictive and corrective actions regardless of whether it's dealing with a gross-motor task sequence or a mentally rehearsed task sequence. Recent research suggests a strong relationship between motor and cognitive processes. The cerebellum is the key link between the age-old mind–body link. It's actually the link to how we move and think.

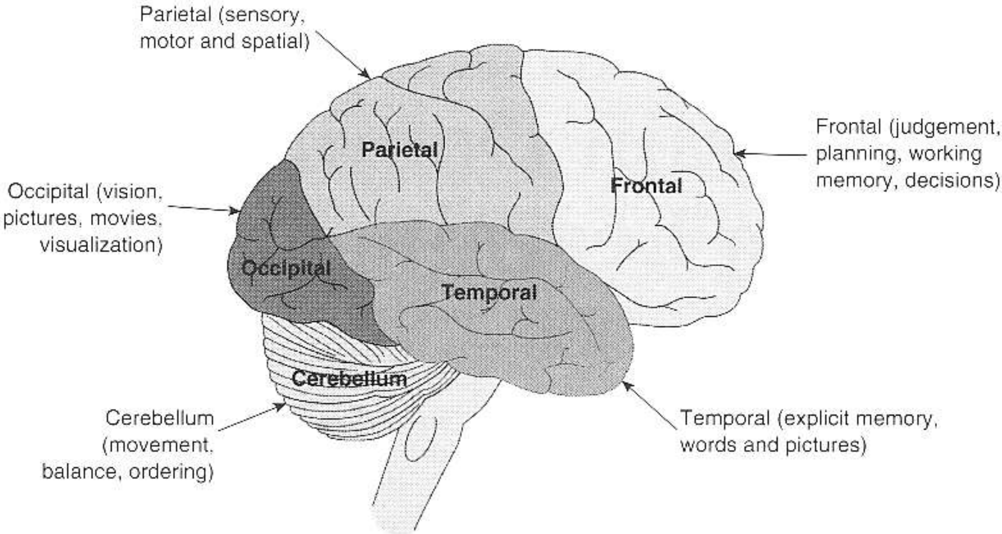
Diencephalon

The diencephalon is the region of the brain that includes the thalamus, hypothalamus, pituitary gland, and other smaller midbrain structures. This region is located at the midline of the brain, above the brain stem. The thalamus serves as the primary incoming relay and sorting station for all sensory information except smell. The hypothalamus performs many vital functions, acting much like a thermostat, sensing environmental input such as temperature, humidity, noise, and stress. At the same time, it signals hunger, thirst, stress, and sex drive. The pituitary gland secretes hormones regulating homeostasis and sexual desires. It is directly next to and functionally connected to the hypothalamus.

Cerebrum

The cerebrum is made up of four primary areas called *lobes*: occipital, frontal, parietal, and temporal (see Figure 2.6). The occipital lobe is located in the middle back of the brain and is primarily responsible for vision. Connect visual areas to language areas, and you can see what you hear and say. That's part of the essence of reading—high visual-auditory connectivity. The frontal lobe is located in the area around your forehead and is involved with purposeful acts like judgment, creativity, problem solving, and planning. The parietal lobe is located at the top back portion of your brain. Its duties include processing higher sensory and language functions. The temporal lobes (left and right) are above and around your ears. They are primarily responsible for hearing, memory, meaning, and language, although there is some overlap in functions between lobes.

Figure 2.6 Lobes of the human brain



THE MICRO LEVEL OF LEARNING

There's more to learning than synaptic focal points firing away in the brain. Most of the communication in the brain takes place outside the axon-to-synapse-to-dendrite connection. In spite of the time we invest in learning about the physical structure of the brain, it is the processes that are the workhorses of communication. Trillions of bits of information are stored in chained protein molecules called *peptides*, which circulate throughout the brain (and body), transmitting their knowledge to available receptor sites on each and every cell in the body.

The development of neural networks of cells that have fired together often enough to "wire together" are activated by complex interactions between genes and our environment, and are modulated by countless biochemicals. Remember that to truly understand new content, we must move from the micro to the macro and back to the micro world. In this process, information may become oversimplified and out of context, but as elaboration occurs, the pieces of the puzzle reunite to form an accurate picture that results in accurate learning. Now that you are armed with the basics of how the brain learns, let's find out how this knowledge informs the teaching profession.

7 Stress and Threat

CHAPTER OUTLINE

Stress is your bodily reaction to a perception, not reality. It occurs when you experience an adverse situation or person in such a way that you perceive you're out of control, or losing control, and your goals are compromised. If your goal is to get home safely and on time to make a dinner appointment, stress occurs in your body when there's a traffic accident up ahead and your goal of getting home on time is threatened. There is no stress in a school, a building, or a job. It's not "out there." There are exceptions, of course; you may be exposed to toxic levels of chemicals or a "sick building" and that may stress out your body by compromising your immune system. But typically, stress is what occurs in your body as a result of your perceptions. Change your perceptions, and you change your stress levels.

TYPES OF STRESS

All of us have experienced *good* stress and *bad* stress. Good stress (*eustress*), occurs in short bursts; it is simply stress that is not chronic or acute. It occurs when we feel moderately challenged and believe we can rise to the occasion. Under these circumstances, the body releases chemicals like cortisol, adrenaline, and norepinephrine, which heighten our perceptions, increase our motivation, and strengthen our bodies—all conditions that enhance learning. Eustress occurs when we have the following:

- actively want to solve a particular problem
- have the ability to resolve the problem
- perceive some sense of control over circumstances
- get sufficient rest between challenges
- can think of a potential solution to the problem

The negative form of stress (*distress*) occurs when we feel threatened by some physical or emotional danger, intimidation, embarrassment, loss of prestige, fear of rejection or failure, unrealistic time constraints, or a perceived lack of choice. Distress occurs when we

- are confronted with a problem we don't want to solve
- don't perceive a solution to the problem
- lack the resources to solve the problem
- feel the risk levels involved are unacceptable
- have little or no control over circumstances
- experience repeated situations of intense prolonged stress

The Brain in Distress

Threats are defined as any stimulus that causes the brain to trigger a sense of fear, mistrust, anxiety, or general helplessness. This state can be a result of physical harm or perceived danger (usually from teachers, parents, or peers), intellectual harm (unrealistic performance expectations or time constraints; lack of resources, support, or positive role models), or emotional harm (embarrassment, humiliation, or isolation). Under any type of perceived threat, the brain does the following:

- loses its ability to correctly interpret subtle clues from the environment
- reverts to familiar, tried-and-true behaviors

- loses some of its ability to index, store, and access information
- becomes more automatic and limited in its responses
- loses some of its ability to perceive relationships and patterns
- is less able to use higher-order thinking skills
- loses some long-term memory capacity
- tends to overreact to stimuli in a phobic-like way

In the brain, a change in conditions (e.g., from comfort to fears, threats, or danger) focuses selective attention and instigates a subsequent reaction. This initial recognition of uncertainty causes the amygdala to send a message to the hypothalamus, which begins the chemical cascade to the adrenals, and soon the glucocorticoids (e.g., cortisol) and amines (e.g., noradrenaline) prepare you for the event. The frontal lobes also monitor the event. Cortisol is a hormone that is a temporary source of energy, and for half an hour or even a few hours, it can be helpful. But over the course of days, weeks, or months, chronically high levels of cortisol wreak havoc on the brain.

The difference between positive or moderate stress and distress or threat is distinct. Positive or moderate stress is good for learning; distress and threat are not. Chronic stress makes students more susceptible to illness. In one study (Johnston-Brooks, Lewis, Evans, & Whalen, 1998), learners examined just prior to test time revealed depressed immune systems and lower levels of an important antibody for fighting infection. Such findings may help explain the vicious academic performance cycle with which most of us have become all too familiar: more test stress means more illness and missed classes, which eventually means lower test scores, and the cycle of failure repeats. In addition to increased cortisol levels, recent studies (e.g., Casolini et al., 1993) link chronic stress to low serotonin levels, which are suspected risk factors for violent and aggressive behavior patterns.

The amygdala is at the center of all our fear and threat responses. It focuses our attention and receives immediate direct inputs from the thalamus, the sensory cortex, the hippocampus, and the frontal lobes. Neural projections (bundles of fibers) from the amygdala then activate the entire sympathetic system. Under duress, the sympathetic system triggers the release of adrenaline, vasopressin, and cortisol—chemicals that immediately change the way we think, feel, and act.

The area of the brain most affected by high stress or threat is the hippocampus, which is very sensitive to cortisol. Over time, cortisol may weaken the brain's local memory and indexing systems and may narrow perceptual mapping. The hippocampus is also the center of the body's immune system, so the chronic release of cortisol weakens the body's ability to fight disease, too.

> Learners in a state of fear or threat experience not only reduced cognitive abilities but also weakened immune systems.

A chronically high cortisol level leads to significant physical changes in the brain. Stanford scientist Robert Sapolsky (1992, 1994, 1996, 1999) found atrophy levels of 8 to 24 percent in the hippocampus of Vietnam War veterans with posttraumatic stress disorder: "We have known for many years that stress can interfere with neuron production in the fetal brain and that it can damage and even kill pre-existing neurons. Now we have evidence, as well, that when there is neuron production in the adult brain, stress can also disrupt it" (2004, p. 137). High levels of distress can cause the death of brain cells in the hippocampus—an area critical to explicit memory formation. And chronic stress impairs students' ability to sort out what's important and what's not.

For the most part, the brain responds to threat exposure in predictable ways. The moment a threat is detected, the brain jumps into high gear, and new research reveals that threatening environments can trigger chemical imbalances. Especially worrisome is the reduced level of serotonin, which is a strong modulator of emotions and subsequent behaviors; when serotonin levels fall, violence often rises. Threats also elevate levels of vasopressin, which has been linked to aggression. These imbalances can trigger impulsive and aggressive behavior that some researchers believe can lead to a lifetime of violence.

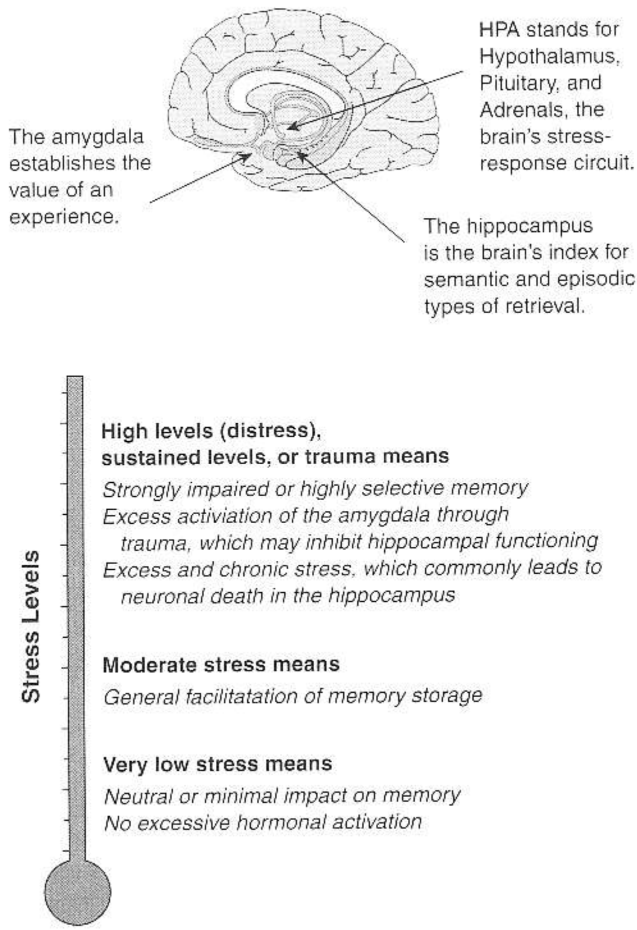
The Distressed Learner

The list of potential threats to learners is endless, and threats can be found anywhere, from one's own home to a neighbor's home, from the hallway outside your classroom to the gang that rules the neighborhood. It could be an overstressed parent; a boyfriend; a rude classmate; an unknowing teacher who threatens a student with humiliation, detention, or embarrassment; or a combination of these stressors. When the brain is put on alert, defense mechanisms and behaviors are activated, which is great for survival but not for learning.

Many learners who are underperforming may be simply overstressed. At the elementary level, students may not even be cognizant of the problem. To some learners, achieving at a higher level may simply feel like an impossibility. If all you've ever known is poverty, for example, it's difficult to realize an alternative—a necessary step in the resolution process. Identifying the core stress, then creating an awareness of alternatives, and ultimately working toward a desirable change are the cornerstones of empowerment. And it is this foundation that is critical to optimal learning. Remember, if the brain is in survival mode, it won't effectively process and recall even simple semantic facts like a basic math calculation. You can bet, however, that it will remember information such as "Today is Daddy's payday, which means he'll come home drunk. I better stay away from him tonight." Children who happen to be in such a state likely won't complete their homework because their emotions (and therefore attention) are drawn to more immediate matters.

Distressed children typically experience constricted breathing, which can alter how they focus and blink. Distress can impact learners in other ways, too. Figure 7.1 shows how various levels of distress, including a traumatic event, can impact memory. A stressful physical environment adds to the problem. Crowded conditions, fear of violence or peer retaliation, and even fluorescent lighting can impact learner stress. All of these stress factors contribute to the low achievement/low self-esteem cycle of failure that can occur in spite of a child's high IQ or natural intelligence.

Figure 7.1 Stress, trauma, and memory



What This Means to You

Ensure that learners have the necessary resources and support to complete the assignments you give them and, ultimately, to resolve high-stress issues that may be harming them outside of class. Keep in mind that learners will experience undue stress if they do not (1) perceive that a solution is possible, (2) have the necessary resources to solve a problem, (3) have a sense of control over a bad situation, (4) have sufficient time to learn, or (5) have the ability or awareness to manage their stress. Seek help if you suspect that a learner is facing threat and high stress outside the classroom. Routinely incorporate brief stretching, breathing exercises, and purposeful play in the classroom. Introduce activities and games that add an element of moderate challenge, fun, and stress-free learning to your classroom environment.

Quite a few stressors, many of which cannot be avoided, influence our emotional environment. For an adult, it's the noise, erratic drivers, mean-spirited customers, hardheaded colleagues, selfish bosses, broken-down copy machines, insensitive family members, financial worries, and screaming children that provide the emotional stress. For youth, it's fundamentally no different. A typical school day is full of broken promises, hurt feelings, and fear of the unknown. The project that flopped, the low math score, the bully's mean remarks, the insensitive teacher, the pressure to conform, the pressure to perform, the popularity contest, decisions about values and choices, and concerns about money—all of these can be sources of stress that the brain responds to as threats. Accepting our different roles in various social situations can be difficult for adults, let alone youngsters just beginning to grapple with self-identity issues. But if we have a lot of support, we can manage the stress more effectively. Support can come from many places and does not necessarily have to originate at home to positively influence learners.

According to a study by Reis and Diaz (1999), despite lack of parental involvement in the academic pursuits of nine ethnically diverse and economically disadvantaged high school females, the students continued to perform well on achievement tests and in other academic endeavors. The students attributed their success to interaction with other high-achieving students, teachers, and mentors—all of whom helped deepen a strong belief in self. Thus, student achievement may be less related to the parental support factor than to the enrichment factor of the educational setting.

What This Means to You

Social status or popularity, especially among teens, represents a key source of stress for students. For example, a student who may be the top dog at home, but is just one of many in a classroom of 30, may feel stressed out at school. However, such a student may shine if given a leadership role. Since the brain's chemistry can actually change in response to one's perception of social status, it makes good sense to shift leadership roles often to ensure that all students have a chance to lead as well as to follow. Providing an enriched learning environment at school can contribute a great deal to a student's support system. The less support a child receives at home, the more he or she needs to be enriched and supported at school. A simple step you can take to offset the many stressors learners face is to provide more predictability in the form of school and classroom rituals. Predictable events, like a graded paper returned when promised or a peer cheer for completing a project on time, helps put the unsettled brain at ease.

The good news is that moderate levels of stress seem to facilitate storage and retrieval of memories. Moderate stress, such as that caused by an approaching deadline, may also provide the impetus or motivation necessary to accomplish a challenging task. If learners feel capable of overcoming the challenge before them and have the support to persevere through difficult times, the stress state can help establish an optimal learning environment. On the other hand, some studies suggest that low-stress environments increase student receptivity to complex and novel learning.

What This Means to You

Incorporate stretching and breathing sessions, quiet walks, support groups, music, and art therapy in your own life. Give your students and yourself downtime or reflection time to get in touch with your stress levels. Reducing sugar and caffeine intake can help moderate the effects of stress. Only when you are effectively managing your own stress levels can you be at your best for others.

Reactions to Threats

Students often swing or swat at each other to establish rank and control. Such territorialism can be heard in comments such as, "Don't look at me that way!" For the sake of survival, the brain's receptor sites have adapted to the dangers in the normal environment. But misreading danger cues is common for learners who are stressed out. What may be perceived as a friendly gesture by someone who is emotionally well adjusted may be experienced as a threat by one who has lived with chronic threat. While this behavior frustrates teachers, it makes perfect sense to the student whose life seems to depend on it.

There are other costs to threats as well, such as induced or learned helplessness. Because survival always overrides pattern detection and complex problem solving, stressed students are less able to understand subtle connections, patterns, and implications. Under threat, the brain uses less of the reflective higher-order thinking skills of the frontal lobes and resorts to using more of the reflexive nature of the amygdala. In addition, only immediate consequences are likely to be considered in the decision-making process. These results have tremendous implications for learning. Nonstressed learners will exhibit better thinking, understanding, attention, concentration, and recall. Consider, for example, that when you are taking a test (and feeling stressed because of it), an answer can be on the tip of your tongue but not quite accessible. But the moment you turn in the test, the answer pops into your head.

The residue of threat lingers in the body for up to 48 hours. The student who was abused at home on Saturday night is bringing his or her body's stress imprint to school on Monday morning.

Changes in blood flow to the brain also negatively impact the threatened learner. According to Drevets and Raichle (1998), of the University of Pittsburgh, when faced with threat, we experience an increased blood flow to the lower (ventral) area frontal lobes and a decreased flow to the upper (dorsal) area of the frontal lobes. This means that the area of the brain that processes emotions is getting the lion's share of the blood, creating the feeling of being overwhelmed, while the area used for critical thinking, judgment, and creativity doesn't receive enough.

What This Means to You

Avoid calling on learners unless they volunteer. Eliminate discipline policies that are based on fear or threats. Avoid scorekeeping, overt comparisons, or situations that cause embarrassment to students. Never threaten students by saying you'll send them to a higher authority, kick them out, or call their parents. Provide an enriched environment with many opportunities for interactions with caring adults and other learners. Reduce testing and grade stress by providing more frequent reviews, feedback, and remedial support. Make assessments more genuine and meaningful by recognizing the personal challenges of individual students and acknowledging even slight progress.

Putting an End to Threats

High stress or threats have no place in schools. This is a given. The military, which purposely creates a stressful environment for accelerated learning, is a well-known departure from the rule. The very essence of boot camp is to create a stressful environment that resembles a war environment. Thus, threats and punishment are commonplace. However, even the military's teaching approach changes when a soldier is being trained for a technical job or a leadership position that requires critical recall and strategic thinking rather than pure obedience. Teaching soldiers to obey commands at all costs is, in fact, a very different learning task from teaching them to show good judgment and be critical thinkers.

Students who have experienced early chronic exposure to threats and high stress, particularly those who come from violent backgrounds, usually have attention difficulties. Survival behaviors, such as consistent and constant shifting of eyes, voice, and attention, are the norm as these students unconsciously scan the room for potential predators or prey.

What This Means to You

Here are four ways you can reduce the impact of threat on your learners:

1. Increase their sense of safety at school. Encourage discussions about their fears, worries, and causes of stress. Sometimes just the opportunity to talk about these issues helps reduce the burden. Incorporate small-group activities, and model effective communication and problem solving. Increase use of teams and other strategies for developing group identity and support. When necessary, seek outside help and support.
2. Encourage positive relationships among learners. Give them time to relate to each other in ways that go beyond the superficial. Allow for personal choice in the process of creating teams. Once teams are formed, allow learners to remain with the group long enough to develop strong interpersonal relations. Help learners resolve conflicts by being available to offer support, but not enforcing your influence too strongly. Help them with their decision-making and problem-solving

(Continued)

(Continued)

skills, but don't solve problems or make decisions for them. Initiate team cheers, applause, and other affirming rituals that make students feel good.

3. Provide numerous opportunities for learners to express themselves. This can be initiated through the use of art, dance, poetry, singing, sharing, journal reflection, sports, debate, and small-group activities. Give students the opportunity to set their own ground rules and classroom standards. What they help create, they will buy into and adhere to with less resistance.

4. Activate prior learning by reviewing the previous lesson(s). Offer generous feedback, and establish mechanisms for self-evaluation and peer review. If nothing else, this simple strategy will reduce learner stress and increase confidence immensely.

When you create a safe and relaxed learning environment with an absence of threats and high stress, many learners will surprise you. They'll very quickly exhibit improved thinking and problem-solving skills and fewer disruptions and behavioral problems. Although no one can be expected to provide the perfect environment (there is no such thing), providing an emotionally and physically safe environment with plenty of opportunity for enrichment will go a long way toward offsetting life's little (and sometimes big) imperfections.

HOW RELAXATION AFFECTS LEARNING

In a study of 39 older adults conducted at Stanford University's School of Medicine, researchers determined that a memory training course was more effective when students were relaxed. The study compared two groups. The first was taught to relax every muscle in their body, from head to toe, prior to the memory training. The other group was simply given a lecture on positive attitudes. Both groups then attended a three-hour memory training course and were ultimately tested on what they learned. The overall score of the group that received the relaxation instruction was 25 percent higher than that of the control group.

What This Means to You

Physical relaxation may be more important to learning than previously realized. Teach your students about the benefits of relaxation. Better yet, make it part of the daily routine.

The Importance of Rest

The brain may become more easily fatigued when conditions for learning are less than optimal. To get the brain's best performance, deep physiological rest is necessary.

How much sleep is enough? This varies from individual to individual; however, we do know that it is the REM period (the dream state) of sleep that is most crucial. While some adults require eight to ten hours of sleep per night, others seem to function perfectly well on four to six hours. Learners who are short on sleep may perform well on short quizzes requiring rote memorization but not as well on extended performance testing that requires stamina, creativity, and higher-level problem solving.

Learners who live under stress, anxiety, or constant threats of some kind don't receive the all-important brain rest needed for optimal functioning. Without it, learning and thinking are impaired.

Energizer Ideas

- Use the body to measure things around the room and report the results: "This cabinet is 99 knuckles long."
- Play a Simon Says game with content built into the game: "Simon says point to the South" or "Simon says point to five different sources of information in this room." Ensure that's it's a win-win activity with no risk and no embarrassment.
- Do a giant class mind map, or break into teams and do group mind maps.
- Have students move around the room, for example, for a scavenger hunt: "Get up and touch seven objects around the room that represent the visible spectrum or colors of the rainbow."
- Relate locations to new learning: "Move to the side of the room where you first learned about the food chain related to our pet snake."
- Conduct thinking games and values exercises that require learners to move: "Move to the left side of the room if you feel more like an ant or to the right side of the room if you feel more like an elephant."
- Even simple games we learned as children are great. Have learners jump rope and sing rhymes that reflect new learning.
- Spell difficult words to the tune of "B-I-N-G-O" while clapping out each letter until the whole word has been spelled.
- Wake up the class with a silly stint of Hokey-Pokey, Ring Around the Rosie, or London Bridge. Even adults can benefit from these childhood favorites.
- Conduct a ball-toss game, incorporating content from prior learning. This is great for reviews, vocabulary reinforcement, storytelling, or self-disclosure.
- Have students rewrite lyrics to familiar songs, substituting new words.
- Play verbal Tug of War, in which dyads choose a topic from a list and each must devise an argument. After the verbal competition, the whole class engages in a traditional game of Tug of War with dyad partners on opposite sides.
- Use cross-laterals, such as arm and leg crossovers. Cross-lateral movements activate both brain hemispheres for greater integration of learning. "Pat your head and rub your belly" or "Touch your left shoulder with your right hand" are examples of cross-laterals. Others include marching in place

while patting opposite knees, touching opposite eyes, knees, elbows, heels, and so on.

- Facilitate stretching and breathing exercises. Rotate leaders.
- Provide frequent breaks for water or walking around, or provide this option to learners anytime they need it.
- Ask students to plan and lead a class session, or break into teams and have each present an activity to the rest of the class.

8 The Role of Sight in Learning

CHAPTER OUTLINE

All of us in education know that the facilitator–learner relationship is of critical importance to the training and learning environment. Unless this relationship is characterized by trust, safety, and mutual respect, the learning process will be stilted. Walk into any classroom or training facility, and you can very quickly sense the impact of the emotional, intellectual, and social climate. Yet there's much more to the puzzle of learning. How important is the effect of physical environments on our students? You may be surprised!

In San Diego, California, at the recent national convention for the 18,000 members of the American Institute of Architects, the keynote speaker was not an architect; he was Fred Gage, an internationally known award-winning neuroscientist from the Salk Institute. He provoked the audience by suggesting that our environments have a powerful effect on our brains. He asked the audience to investigate the extent to which architects take this into consideration when they design buildings. Out of this intellectual groundbreaking, a new academy, the Academy of Neuroscience for Architecture, was launched. Times have truly changed.

> **The essential understanding here is that** we have a whole new discipline, one that shapes our brains. Our buildings influence not just how we feel but the physical structure of the brain. This chapter begins to break down how the senses influence people and what that means for educators.

SIGHT'S IMPACT ON THE LEARNING PROCESS

How does your brain know what specifically to pay attention to in the moment? Our eyes are capable of registering 36,000 visual messages per hour. Between 80 and 90 percent of all information that is absorbed by our brains is visual. In fact, the retina accounts for 40 percent of all nerve fibers connected to the brain. That enormous capacity is why it is important to be aware of the environmental factors that influence how we see and process information.

Information flows both ways, back and forth, from our eyes to the thalamus to the visual cortex and back again. This feedback is the mechanism that shapes our attention so that we can focus on one particular thing, like a teacher or a book. Amazingly, our "attention headquarters" gets feedback from the cortex at nearly six times the amount that originated from the retina. Somehow, the brain corrects incoming images to help you stay attentive, but once it reaches its immediate capacity, it demands the filtering-out of incoming stimuli. In other words, the brain has an intrinsic mechanism for shutting down input when it needs to.

The essential elements enabling our eyes to compose meaning from our visual field are contrast, tilt, curvature, line ends, color, and size. These elements, perceived even before learners consciously understand what they've seen, can inform teaching practice and provide a framework for attracting learner attention. While optimal learning involves far more than getting and keeping students' attention, the principles of piquing the brain's interest are useful.

> Attract the brain with movement, contrast, and color changes. Our visual system is designed to pay close attention to those elements because they each have the potential to signal danger.

Color in the Environment

In television commercials, one of the big trends in getting our attention is retro; advertisers use black-and-white ads. Does this get our attention? Yes, but momentarily. The brain is wired to pay attention to novelty, movement, intensity, contrast, and saturation. Black-and-white ads can work, but color is a truly powerful medium, and one that is generally underestimated. A recent study (Vuontela, Rämä, Raninen, Aronen, & Carlson, 1999) measured the relative value of verbal cues versus color cues in learning and memory. In testing memory for verbs and memory for colors, learners better recalled color. And when objects were tested against color, once again, color memory was stronger. Even an intention to remember did not affect the outcome of the experiment.

How a color affects you depends on your personality and state of mind at the moment. If you are highly anxious and stressed, for example, red can trigger more aggressiveness. But if you are relaxed, the same color can trigger engagement and positive emotions.

Our color preferences may say a great deal about us, and they may be innate. For example, you might walk into a room and immediately feel uncomfortable, while another room makes you feel happy and inspired and another makes you feel drained and depressed. It is very possible that the prevailing colors of the rooms are impacting your mood more than you realize. Even in everyday language, it is obvious how strongly color influences us. We often identify people by the color of their skin or the color of their clothing. In general, we remember colors first and content second.

What This Means to You

Use color handouts, and vary color widely on your PowerPoint presentations instead of having the same constant blue background. Consciously choose the colors you use in the classroom; hang colorful posters; and encourage the use of bold color in mind maps, painting, projects, and posters, and softer colors for background.

Concrete Vivid Images

What is the best way to convey information? Is it through discussion, reading material, or computers? No, say Fiske and Taylor (1984). Concrete vivid images are most influential. Neuroscientists theorize that this is because (1) the brain has an attentional bias for high contrast and novelty; (2) 90 percent of the brain's sensory input is from visual sources; and (3) the brain has an immediate and primitive response to symbols, icons, and other simple images.

The brain is wired to identify objects more quickly when they differ from a group of similar objects. These differences are analyzed in parallel by the brain so that while the learner may be observing location, the brain may also be processing property differences, such as color, form, and weight. This evolutionary tendency of the brain provides us with an edge that has ensured our survival. Thus, in the learning environment, working models, project-based assignments, a variety of information media (e.g., computers, videos, books, cameras, writing equipment), and an array of art supplies make for productive learning and a happy brain. We remember best the concrete visuals that we can touch and manipulate.

What This Means to You

Visuals are an important key to remembering content. Make lectures or presentations more compelling to the brain by using objects, photographs, graphics, charts, graphs, slides, video segments, bulletin board displays, and color. For maximum impact, change media frequently—from inspiring videos and vivid posters to mind maps, drawings, and symbols. Challenge students to generate evocative images, either through visualization or in the form of artwork, posters, or murals.

The Impact of Peripherals

The brain absorbs information from surrounding peripherals on both conscious and unconscious levels. Many people commonly use peripherals (or items of visual interest in the environment), but they may support learning even more than we realize. Since the brain prioritizes stimuli like colors, decorative elements, sounds, and smells, the importance of these elements should be considered in the planning of optimal learning environments. Peripherals in the form of positive affirmations, learner-generated work, and images depicting change, growth, and beauty can be powerful vehicles of expression. With direct instruction only (lecture), audience recall drops quickly, but with the addition of peripherals, effortless, subject-specific, longer-lasting recall is generated.

What This Means to You

Assess what factors may be currently influencing your learning space. Consider influences like posters on the wall, room color, concrete visuals, and bulletin board items. A passive approach to surroundings can actually detract from the learning. Make an effort to enhance your visual environment. Add interesting collections, photos, objects, and bulletin boards.

Light in the Environment

Lighting strongly influences vision, which strongly influences learning. Thus, anything we can do to make our eyes more comfortable in the classroom contributes to optimal learning. Although we are rarely consciously aware of it, fluorescent lights have a flickering quality and a barely audible hum, which can have a very powerful impact on our central nervous system. Apparently the brain reacts to this visual-auditory stimulus by raising cortisol levels (an indication of stress) and causing the eyes to blink excessively.

In a study of 160,000 school-age children, Harmon (1951) found that lighting was a major contributor to student health and learning. By the time the children in his study were in sixth grade, more than 50 percent had developed deficiencies related to classroom lighting. Subsequent changes to lighting in the learning environment reversed the results. Six months later, the same children experienced a 65 percent reduction in visual problems, a 55 percent reduction in fatigue, a 43 percent reduction in infections, and a 25 percent reduction in posture problems. In addition, they exhibited an increase in academic achievement.

A more recent study conducted by the Heschong Mahone Consulting Group (2007) focused on 21,000 students from three districts in three states. After reviewing school facilities, architectural plans, aerial photographs, and maintenance plans, each classroom was assigned a code indicating the amount of sunlight it received during particular times of the day and year. Controlling for variables, the study found that students with the most sunlight in their classrooms progressed 20 percent faster on math tests and 26 percent faster on reading tests compared to students with the least lighting. These gains are astonishing considering how hard school districts work to raise reading and math scores. Most districts would be overwhelmed with a 5 percent gain in test scores; a 20 percent gain is unheard of. But that's the disparity between classrooms with the lowest and brightest light.

In the follow-up study, the Heschong Mahone Group (2007) found how sources of glare can negatively impact learning. Classrooms that face the morning sun (east) and have no blinds or tinted windows will underperform compared to classrooms facing north. In subjects with more visual dependency, such as math, students did better when whiteboards were used (versus overhead projectors) since the lighting was better. Schools would do well to heed lighting and student performance research in an environmental context when designing buildings.

The positive impact of a quality learning environment with strong natural lighting is both dramatic and lasting.

What This Means to You

Soft, natural lighting is best for learning. Provide a variety of lighting types in your room, and give learners a choice in determining where they sit.

Seasons Can Impact Learning

Can sunlight affect learning? Definitely, says Orlock (1993). The length and brightness of daylight affects the body's melatonin and hormone levels and influences the release of neurotransmitters. A portion of the hypothalamus (located in the diencephalon region) gets direct information from the eyes and sets the body's time clock. This affects concentration, energy, and moods. And anything that affects our mental state, in turn, impacts our learning.

A specific condition known as Seasonal Affective Disorder (SAD) was recorded in 1987 by the American Psychiatric Association. This officially recognized biomedical problem, which seems to affect women more than men, is caused by a lack of exposure to sunlight during the winter months. It results in depression and, therefore, negatively impacts learning. Residents who live closer to the equator face less than a 2 percent chance of being affected by SAD, but those farthest from the equator face up to a 25 percent chance. The best time for learning is when the hours of the day are longest—from June to August in the Northern Hemisphere and December to February in the Southern Hemisphere (Liberman, 1991). However, these are the times when most schools break for the summer vacation and the holidays.

A small amount of artificial light or sunlight therapy can alleviate the symptoms of SAD if the dosage of light is strong enough, says Liberman (1991). Phototherapy treatment sessions can last from 30 minutes to 4 hours a day. The good news is that 85 percent of SAD sufferers who participate in light therapy are relieved of the symptoms of anxiety and depression.

What This Means to You

We may be able to improve learning simply by improving the lighting during the darker winter months. Explore your options for improving the lighting in your environment during periods of low sunlight. Ask other teachers if they have witnessed symptoms of SAD among their students. And seek the help of your medical provider if you think you may be suffering from the condition yourself.

13 Teacher Communication

CHAPTER OUTLINE

There's quite a bit of irony in teaching. One of the ironies stems from the fact that most teachers go into the profession because they want to help others. The result of helping others is that you feel needed and valued. But if you're not very skillful or experienced, you may not feel that you make much of a difference yet. Or if you're very experienced and have not upgraded your skill set or attitudes lately, you may struggle in your class. What does this have to do with you? The better you get as a teacher, the stronger you'll see, feel, and know that you make a profound difference in the lives of your students. This chapter focuses on the "how" of making a difference. When students are treated well, their brains produce feel-good chemicals and commonly make decisive statements such as "I like learning." It's a given that quality teaching makes a difference. But what are the intangibles and less measured qualities that also affect student outcomes?

The essential understanding here is that teachers are a huge part of the environment. The 30 or so other brains in the room filter what the teacher says and how he or she acts. It may not be fair to put all of this on a teacher, but it's true. Teachers are the mobile, shifting environment for learning. If you had to send your child to a school and the choice was either a great classroom and an average teacher or an average (even run-down) classroom and a great teacher, it's an easy call. Take the great teacher!

A TEACHER'S INFLUENCE ON A CLASSROOM

Teachers are not merely influenced by the overall school climate; they create their own microclimates in the classroom. Learners in a positive, joyful environment are likely to experience enhanced learning, memory, and self-esteem. How does this happen? What is it about the brains of students that makes them so susceptible to teacher actions, emotions, and beliefs?

The primary way in which teachers affect students is through student observation of the teacher. This activates the brain's *mirror neuron* system. Two Italian researchers named Iaccomo Rizzolati and Vittorio Gallasse discovered these amazing subsets of brain cells by accident. They found that neurons in the ventral premotor area of a macaque will fire anytime the monkey performs a complex action, such as reaching for a treat, pulling a handle, or pushing a small door (different neurons fire for different actions). Amazingly, however, a small subset of neurons will fire even when the monkey watches another monkey perform the same action, but it has to be an action that interests the monkey (Iacoboni, Molnar-Szakacs, Gallese, Buccino, & Mazziotta, 2005). In essence, the mirror neuron is part of a network that allows you to see the world from another person's point of view, hence the name. All of us have these mirror neurons, though there is evidence that they are significantly impaired in people with autism (Iacoboni & Dapretto, 2006).

The significance of this system is profound. It is likely the basis for imitation learning, contagious yawning, social learning, mob behaviors, copycat crimes, and why kids pick up on the teacher's emotions. In short, it helps us understand why we are affected by the behaviors of people around us. But are these mirror neurons always on and working? Assuming that they are healthy, they are always on. But our frontal lobes, as they mature, can dampen down the effects of the mirror neurons. So instead of copying another person's negative or dumb behavior, you might say to yourself that the action is crazy, irrelevant, or dangerous and choose to avoid it. However, many younger kids, and even teens, have not yet reached this point and thus will still copy the bad behavior. In fact, many adults with compromised frontal lobes (e.g., from brain injury, drugs, or depression) still make poor choices based on seeing others in action.

In a classroom, because of the mirror neuron system, students may, to some degree, pick up on the teacher's mood, facial expressions, and actions far more than previously thought. When teachers are happy, some of it can rub off on students (and vice versa), and a teacher's frown, scowl, or sarcastic comment may be more hurtful than we might think. But how do teacher attitudes impact learning? Learners pick up on the emotional state of the instructor, which either enhances or interferes with cognition. Teachers who smile, use humor, have a joyful demeanor, and take genuine pleasure in their work generally have high-performing learners. This may help explain why when you're in a good mood, your learners seem to mirror it back to you.

> The fact that negative comments may pose a health risk to students is stunning new evidence that speaks to the importance of positive teacher attitude.

We know that teacher expectations influence student learning. But how? Expectations increase the likelihood of certain behaviors, which in turn may influence the outcome. Beliefs can and do lead to specific outcomes. An experiment carried out by Rosenthal and Jacobson (1968) at an elementary school tested the hypothesis that in any given classroom there is a correlation between teachers' expectations and students' achievement. All students at the school were given an intelligence test at the beginning of the school year. Then the researchers randomly selected 20 percent of the students—without any relation to their test results—and reported to the teachers that these students showed "unusual potential for intellectual growth" (p. 181) and could be expected to bloom in their academic performance by the end of the year.

Eight months later, at the end of the academic year, all the students were retested. Those previously labeled as "intelligent" showed significantly greater increases in scores on the new tests than the children who had not been singled out for teachers' attention. Because the teachers' expectations about the intellectual performance of the so-called special children had changed, so had the intellectual performance of these students (Rosenthal, 1991). For ethical reasons, Rosenthal and Jacobson's experiment focused only on favorable or positive expectations and their impact on intellectual competence, but it is reasonable to infer that unfavorable expectations could also lead to a corresponding decrease in performance. In fact, nearly half of the teachers in Zohar and Vaaknin's (2001) study considered higher-order thinking inappropriate for poor or low-achieving students. Yes, expectations do matter, but how much?

A good deal of research has been devoted to this topic, which is surprisingly controversial. The questions revolve around three core issues:

1. Is this effect genuine and has it been reliably reproduced? (yes)
2. To the extent that there is an effect, how great is it? (2–10 percent)
3. Is the effect size significant? (depends on what you compare it to)

Historically, the quoted estimate of the significance of teachers' *expectancy effects* on student achievement was about 5–10 percent (Brophy, 1983). More recently, average expectancy-effect sizes from 0.1 to 0.3 have been reported, although it is "likely that under certain conditions expectancy effects may be larger or smaller" (Jussim, Madon, & Chatman, 1994, p. 324). An effect size of 1.0 means that there is a 100 percent correlation between the action taken and the behavior produced.

Yet a small EE can result in larger cumulative effects over time, particularly for more vulnerable and at-risk students (Jussim et al., 1994). A small act, a choice word, a choice affirmation, and a positive act—and now the effect is snowballing. If the effect size seems small to you, use the following examples for comparison: Reducing the risk of dying from a heart attack by taking aspirin is 0.02 (not 0.2, but 0.02!), and the impact of chemotherapy on breast cancer survival is 0.03. That's far less than the expectancy effect. While there is some controversy about the size of the effects, there is an effect—and it's free to teachers!

Learners in positive, joyful environments are likely to experience enhanced learning, memory, and self-esteem.

Our beliefs and attitudes as teachers, are inextricably intertwined with how we teach. Moment by moment, we offer suggestions about learning through our unconscious attitudes. We may, for example, suggest that learning is hard or easy, homework is valuable or not, schools are happy places that we enjoy or merely places we have to go. We may also suggest that a student might find a subject easy, fun, and challenging or hard, boring, and frustrating. Our smiles, or lack thereof, communicates more to students than the words we verbalize. The tone of our conversations, appearance, organization, and effort all contribute to the collective whole.

What This Means to You

Your attitude each day is as important to learning as the material you present. Take the time to get centered and positive. Do whatever ritual or activity is necessary for you to be at your best. More important than *how* a positive attitude works is that we know it works. Teachers who are happier and more pleasant to be around bring out the best in their learners. Take a few minutes each day to destress and regroup. Listen to music that enhances your mood, eat well, exercise if that grounds you, and post affirming or humorous reminders around your home and teaching area. Making the conscious effort to get into a good teaching state before you start the day will go a long way toward creating a successful learning environment.

Teacher Authority and Credibility

Some schools have lost the magic middle ground between being an authority and being authoritarian. Some of the defining characteristics of a strong educational leader are strength of character, integrity, purpose, presence, charisma, confidence, and competency. Teachers should be authority figures, not because of their job title but because of their words and actions in the classroom. Traditional authority based on using a heavy hand may have worked in the past, but the more appropriate approach for today's students involves recognizing their rights, offering them some choices, and instilling in them the desire to cooperate. The defining question educational leaders of today are asking is, "Is my approach to teaching worthy of respect?"

As a teacher, you often don't have the luxury of gaining immediate respect by virtue of donning a uniform. Rather, your credibility is determined by your ability to win learners' respect. They will judge your actions as well as your content message. If you're successful, they will want to do what you ask of them because they believe and trust you.

What This Means to You

Become more aware of the things you do, or can do, to increase your credibility. Here are some specific examples:

- Model respect. Respect your learners, and they will be more respectful of you.
- Share your experience. How long have you been in the profession? How did you develop your specialty knowledge or area of expertise? What are some personal experiences that have been instrumental in your growth?
- Talk about your mentors and role models.
- Volunteer to work on district, state, or national projects or committees.
- Become known as your organization's spokesperson on a particular subject—preferably your area of expertise.
- Attend continuing education courses, conferences, and workshops. Present at them if possible.
- Keep your promises and commitments.
- Use positive language—never vulgarity or profanity. Interrupt all racist or sexist remarks made by anyone in your presence.
- Contribute articles to periodicals, anthologies, or scholarly journals for publication consideration.

Teacher Congruency

Although we are only able to consciously process one incoming sensory message at a time, the subconscious works overtime translating all the other sensory data. For example, while you watch a movie, what you hear is being registered on a subconscious level, and while you listen to a concert, what you see takes a back seat to the music. Thus, it is critical to ensure that what you're saying is congruent with your body language. Your learners are aware of both your verbal and nonverbal communication. They are influenced by messages that you may not even be aware you are sending.

Let's say, for example, that you verbalize to your students the following: "I'm very happy to be here today." But actually, your head is shaking from side to side as if to say, "I'd rather be elsewhere." Although both messages are received, the second one has the most impact.

What This Means to You

We all convey mixed messages at times, which can undermine the goal of our communication and reduce our credibility. You may want to practice your nonverbals. Videotape yourself for review. Identify two or three areas in which you might improve your congruency and delivery. Seek feedback from others. And be sure that what you're trying to convey is accurate and true to your real position on the matter.

Teacher Appearance

As we learned from the Pygmalion experiment (Rosenthal & Jacobsen, 1968), teacher expectations of a learner's ability affect learning outcomes, but does this theory work in reverse? Do students' expectations of teachers affect performance? According to clothing consultant John Molloy (1988), yes. He conducted a study to determine the impact of teacher dress on student learning. Malloy reports that better-dressed teachers experienced fewer student discipline problems and better work habits. He also found that socioeconomic background influenced the type of clothing students best responded to. Some critics attribute the results of Malloy's study to the placebo effect—that is, teacher credibility positively influences believability, which positively influences the treatment results. Once again though, expectations, beliefs, and results are all connected.

Let's say, for example, that you attend a conference and the presenter is wearing something very outdated or sloppy. Your first impression will be different from what it would be if he or she is wearing a suit or other business apparel. Like the patient who believes the doctor knows best, the student who believes the teacher knows best will likely have better results. Whatever credibility edge one can obtain by dressing presentably is one that should not be overlooked.

What This Means to You

Your clothing conveys powerful messages about your attitude, values, and personality. Make the effort to dress professionally. Take pride in your appearance, as you would want your students to do. We may not like it, but human nature is to judge others—whether unconsciously or consciously—based on their appearance. When it comes to credibility, image plays a key role.

Tight Teacher Control

Excessive control by teachers may reduce learning by increasing the stress or threat level. If students are to be predominantly self-motivated, they must be given the opportunity to focus on their own areas of interest and to participate in activities they find interesting. Unless learners are stakeholders in the learning process (i.e., they have some influence over it), the learning will be forced, rote, mechanical, short-lived, and eventually distasteful. As Glasser (1999) notes, the more learners feel controlled, the more resentful they get. And resentment, whether expressed (and manifested as frustration, rebellion, and anger) or suppressed (and manifested as detachment, sabotage, and apathy), detracts from learning. Students who lack perceived control on an assigned task will hold back and give less than their best efforts. It makes sense: if you feel that you lack control over your own destiny, why would you want to invest in someone else's?

The brain's most important work is thinking and problem solving. Learning is an interactive process that occurs on many levels. The learning has to be input, filtered, associated, processed, evaluated, and stored to be useful. Learning to think is an evolutionary process. The more learning is generalized, contextualized, and reframed, the more the learner owns it. Deep learning requires usage and feedback. Over time, the meaning of the material expands, and eventually the learner develops a level of expertise. The new model of teaching, analogous to offering substance for the learner to fill his or her own container, reframes the teacher as more of a learning coach.

> Highly controlling motivational strategies such as real or implied threats, strong punishments, compelling rewards, and forced competition are sometimes effective. However, they are likely to produce negative developmental consequences if they are repeated across many different behavioral episodes.

Although teachers have a tendency to establish conformity when dealing with a large group, this approach almost always backfires. By consistently using controlling means on your learners, you'll undermine their overall success. People lose interest in activities when they feel coerced or manipulated to engage in those activities, even when the motivational strategies used are intended to be positive and motivating.

In most cases, school starts off being fun and motivating with high initial interest. But that enthusiasm is typically replaced with resentment, complacency, and avoidance as controlling strategies are used, creativity is discouraged, choice is reduced, and parental pressure intensifies. Sadly, intrinsic motivation is sidelined for another year.

What This Means to You

We may have much more to do with the behaviors of our learners than we previously thought. Hold a staff meeting. Get everyone aligned on this issue. Develop a policy that everyone can buy into. Eliminate rewards; replace them with the alternatives of choice, creativity, enthusiasm, multicontext learning, and celebration.

LEARNER EXPECTATIONS

The results of Chang's (2001) study suggest that an important factor in processing new data is whether learners think the material is going to be useful to them. The key determiner of how successfully learners responded was their expectation about the information's relative utility.

Just as we don't conduct research in a vacuum, we don't learn or teach in a vacuum either. Rather, our expectancy of the future must be acknowledged as a factor if we are to move toward the goal of objectivity. Philosopher Karl Popper points out that the supposed science of scientific reasoning is staged against a backdrop of prior beliefs, presuppositions, and prejudices, which can certainly influence what is, or is not, discovered. In lectures, he made the point beautifully by asking the audience to please "observe." Their reply was typically, "Observe what?" To which he said, "Exactly my point." Observation does not occur in a vacuum; it is strongly influenced by what we are looking for. Perhaps the teaching tip here is to acknowledge that our predictions and projections indeed influence results.

What This Means to You

Because your so-called top learners often expect to get the most out of a class, they usually do. The proverbial snowball effect seems to apply here: the more often students practice learning, the more they learn. You can positively influence your learners' expectations regarding your class by consciously embedding positive suggestions into materials, your presentation, and the learning environment. How much learners get may be affected profoundly by how motivated they become, how much relevance the material has for them, and how much they think they will learn. Some suggestions for generating positive expectancy include sending home positive notes about the course content; asking students to describe their hopes, expectations, and desires for the class; encouraging excitement and celebration over new learning; and providing learners with a time for "showing off" to peers and parents.

Altering Learner Behavior

Teachers can affect student behaviors in many ways. One powerful way is in the words that teachers choose. Overall, there are seven primary forms that are universally used to alter a learner's behavior. Your role as a teacher is to determine which is the best approach for particular learners as a means of motivating without manipulating or controlling them.

Generally More Effective Communication Methods

Suggest. Make a request that illuminates the preferred options. For example, "You might like to use your colored pens for taking notes." This approach provides a strong perceived choice. If students like the options, they're likely to choose one.

Ask. Make the request in a way that encourages students to follow. For example, "Would you please use your colored pens for taking notes?" This approach provides some perceived choice.

Tell. This option is primarily used to provide instructional directions. Simply give learners a directed statement in an expectant tone. For example, "Using your colored pens, please write this down . . . ." This approach provides minimal perceived choice.

Generally Less Effective Communication Methods

Hope. This request is not verbalized; rather it is simply assumed that learners will comply. The thought is actually outside their awareness. Since the learners don't know about it, there is no perceived choice.

Imply. This request is never made; rather it is talked around in the hope that learners will infer from the implication. Because no overt recommendation is made, there is minimal perceived choice.

Demand/Threaten. This is an order, delivered in a way that learners have minimal or no perceived choice. This method should be reserved for occasions when a person's safety is in danger.

Force. This approach is to be used only in an emergency. Learners have no perceived choice; no other option is available to them. This is unacceptable unless lives or property are at stake.

Forced Silence and Class Inactivity

Teachers who believe that a controlled and quiet environment is best for learning ask learners to remain in their seats and stay quiet. But research by Valle (1990) suggests that this may not be a good idea. Among adolescents studied, 50 percent needed extensive mobility while learning. Of the remaining 50 percent, half (25 percent of the total) needed occasional mobility and the remaining subjects needed minimal movement opportunities. We've all been in the situation of addressing a group and some of the listeners appear to be tired, drowsy, or listless. Is this your fault or the audience's? It doesn't matter; let them get up and move around!

What This Means to You

If learners seem lacking in attention, energy, or curiosity, they may need more permission to move around. Provide more active-learning opportunities and kinesthetic/tactile stimulation. What may seem like a boring topic or a bad time of day may simply be a product of learners who are restless and need some activity. Schedule a stand-up-and-stretch break every 20 minutes or so. Include cross-lateral movements and deep breathing. Provide a diversity of activities so that learners can choose what appeals to them. Offer team and partner learning, excursions outside the classroom, frequent water breaks, and simple movement activities that get the circulation going and keep active learners happy.

The Climate Can Be Highly Active

To millions of teachers around the world who plead with students to please sit down and be quiet, James Asher is a rebel. A pioneer in second language learning and the developer of the Total Physical Response (TPR) approach, Asher maintains that learning on an immediate, physical, and gut level speeds acquisition dramatically. Asher's (1966) hypothesis is still true today: teach the body; it learns as well as the mind. This approach to learning reminds us that actions and movement can play a powerful role in the learning and recall of new information.

While it's true that much learning can occur without anyone's ever leaving a seat, it's also true that most of what you think is important in your life that you "really know," you have learned through experience, from doing something, not from a chalkboard or textbook. In addition, the research on the power of physiological states is conclusive: the body remembers as well as the mind. In many cases, it remembers better. To use the TPR approach successfully, the following conditions are recommended:

- The teacher creates strong rapport and a relationship with students.
- The learning climate is cooperative, playful, active, and fun.
- The teacher establishes an environment of mutual respect.
- The teacher gives imperative instructions to students in a commanding but gentle manner.
- The students respond rapidly without analyzing the input.

The TPR approach associates a body movement with new learning. In teaching Spanish, for example, you might simply stand up and verbalize the Spanish word for *stand*. Then you might touch your knee and say the word for it in Spanish, or tell students to follow you in walking around the room and repeat the Spanish word for *walk*. The approach is very natural, much like how a parent teaches an infant. Although Asher created the approach for teaching languages, it is transferable to other subjects as well. For example, it can help learners remember vocabulary words, spelling, geography, science concepts, social studies, collaboration skills, and math formulas.

What This Means to You

Associate new learning with various physical movements. Draw from the dramatic arts, fine arts, music/band, and sports. Engage your class in regular role-playing, charades, games, and movement activities. Students can organize extemporaneous pantomimes to dramatize a key point. Incorporate overviews of future learning or reviews of past learning in one-minute commercials adapted from popular television advertisements.

15 Motivation and Rewards

CHAPTER OUTLINE

A common question asked by teachers is "How do I motivate my students?" It's a legitimate question, yet there's a better one to ask. Since the brain is designed to learn, you could ask, "What am I accidentally doing that is demotivating my students?" or "How can I undo the damage that was done to this student in his or her past?"

The human brain loves to learn. Our very survival, in fact, is dependent upon learning. If you believe your job is to be a learning catalyst (one who lights a fire for learning), rather than someone who simply delivers information once you have students' attention, then motivating your learners will likely be a nonissue. After all, in a brain-based learning environment, the learners are already motivated (just the way they were, ideally, when they walked in your door).

LEARNED HELPLESSNESS

Under ordinary circumstances, most good learning environments encourage active student learning. Healthy brains usually make good choices, but unhealthy brains often make poor choices. Learners who have acquired a condition called *learned helplessness* generally fall into the second category. The good news is that you can do something about it, but you have to be informed so that you can recognize and act on your awareness.

Helplessness can devastate even the brightest learners. Since being active is our natural state, what causes a student to feel helpless? What causes learners to sit in class like a lump on a log and not participate? Temporary helplessness is one thing; what we're talking about here is a chronic condition or disorder that develops over time. The symptoms in Figure 15.1 often accompany learned helplessness.

Students who suffer from learned helplessness are not necessarily hostile or argumentative. They simply don't want to take action because they truly believe there is no dependable cause-and-effect relationship between their efforts and the outcome. When you believe you don't have any control over

Figure 15.1 Symptoms of learned helplessness

- not caring what happens
- giving up before starting, or sabotaging positive outcomes
- motivational and emotional deficits; depression, anxiety
- not acting on a request, or not following directions
- increased attraction to hostile humor
- cognitive impairment
- belief that the outcome of an event is independent of input
- passivity instead of activity
- self-imposed limitations that exacerbate passivity

your environment, why try? The following are some of the probable causes of learned helplessness:

- It can be developed over time from repeated exposure to trauma and high stress. It is most likely to occur when one feels both out of control and lacking influence.
- It can be influenced by society. In many cultures, the prevailing attitude is that whatever happens, good or bad, "it is God's will." This is a different point of view from "God gave us the power to choose our destiny."
- It can be learned in a specific context through repeated uncontrollable experiences. For example, one might be otherwise capable but feel helpless in math class due to multiple prior failures.
- It can come about through observation of others who encounter uncontrollable events. For example, viewing global disasters on television day after day may be a contributing factor, as may growing up in a welfare-supported family in which a vicious cycle of poverty prevails over a long period of time.
- It can be strengthened by well-intended but overly controlling relationships. Parents who do their children's homework, or teachers who take over when students seek help, can both be culprits.

Changes in the Brain

There can be no change in student behavior without a corresponding change in the brain. Body-mind, mind-body: There is no separation. Depending on the population sample, only 5–25 percent of kids may have learned helplessness. Here are some of the changes we see in the brain when a robust condition of learned helplessness is evident:

- decreased amounts of norepinephrine—an important compound that contributes to the arousal system
- lowered amounts of GABA (a common neurotransmitter), with links to anxiety
- decreased amounts of available serotonin and dopamine—the "feel-good" neurotransmitter
- increased activation in the amygdala—the structure that is involved in intense emotions
- increases in both the autonomic nervous system and the sympathetic nervous system—both of which are involved in stimulation of the stress-related hormone cortisol

Conditions and Constraints

Although the characteristics listed above are not causal, these biological markers are evident in many cases of learned helplessness. In other words, a decreased amount of serotonin or dopamine does not cause learned helplessness, but those who experience learned helplessness exhibit lower levels of these neurotransmitters in general.

There are varying levels of susceptibility to learned helplessness. It turns out that only about two-thirds of students are likely candidates. This is because many individuals are "immunized" against it by previous successful experiences in which they had a certain amount of control over their environment. There is greater susceptibility among those who are aggressive or dominant in a group. This is counterintuitive: those who seem to be the most social, outgoing, assertive, strong, and in control are, in fact, the most likely to be victims of learned helplessness.

In addition, some links with depression have been identified. One of the few distinctions between learned helplessness and depression, in fact, is that depression triggers a generalized belief that responding will be ineffective, whereas those with learned helplessness believe that responding is independent of the outcome. This is a subtle but important difference.

Typically, the criterion for learned helplessness status is an inappropriate passivity, via mental or behavioral actions, to meet the demands of the situation. Can it be contextual? Yes, and an example would be students who are active in all classes but math. Perhaps these students learned through prior failures that there is no causal relationship between their behaviors and the outcome of their math studies. Learned helplessness can be evoked or triggered by a location, person, or event, and this transient quality makes it even more difficult to diagnose and treat.

Unlearning Learned Helplessness

It should be noted that most of the time when we see an unmotivated student, it is not a case of learned helplessness. It is more likely a temporary motivation deficit due to lack of clear goals, underarousal, malnutrition, value conflicts, inactivity, conflicting learning styles, prejudice, or lack of resources. Genuine learned helplessness is a serious and chronic condition. It is not treated by a few compliments and a smile. Teachers who have students who fit the description should know that they are in for a challenging test of their patience and skill. The good news is that there are steps you can take to facilitate hope and contribute to healing. All of these steps have one important thing in common: they increase the students' perception of their ability to control the outcome of an event. You'll see improvement from the following types of experiences:

- teaching *Learned Optimism* (Seligman, 1998)
- extending positive emotional states and redirecting negative states in class
- engaging in community service (e.g., scouts, Red Cross, cross-age tutoring)
- taking activist roles (e.g., changing school or community policies)
- planning classroom activities with some choice involved (e.g., field trips, teamwork, ball toss)
- enhancing personal skills (e.g., CPR, martial arts, academic competitions)
- engaging in physical immersion events (e.g., Outward Bound, camping, SuperCamp, boot camp)
- taking part in active hobbies (e.g., caring for animals, skating, sports)
- making family contributions (e.g., meals, cleanup, yard work, car work)
- enjoying sports, theater, and music programs

Giving learners more control over their environment is the first step toward boosting confidence. In *Choice Theory*, Glasser (1999) says that confidence increases whether the control is real or illusory. In an experiment on noise and control, two groups were put into a noisy room. One group had no control over the noise, and the other had a placebo control knob that they thought gave them control over the noise; neither group actually had control. The subjects reported their moods before and after each equally administered 100-decibel session. After the group that knew it had no control ended its sessions, the subjects reported increases in depression, anxiety, helplessness, stress, and tension, while the other group reported being affected very little by these factors.

Helplessness is a common state for students who do poorly in school. It is common for students in schools where the administration or teaching staff is controlling, manipulative, and coercive. Since the natural state of the brain is curiosity and motivation, schools and staff have to ask themselves hard questions such as "What are we doing that makes learners feel powerless?" and "In what ways might our behavior create helplessness, and how can we change this?"

What This Means to You

Participation and motivation are boosted by inclusion, ownership, and choice and are impaired by autocratic insistence and tight control. Make a list of choices you provide to learners. Do they have control of their environment? For example, who maintains the temperature, volume, lights, and other physical elements in your room? Do students feel free to get up and walk around when they need to move? Can they get water when they are thirsty? Can they take a break from one type of learning if they feel the need to so? As you provide more learner control, you will find that participation and motivation increase quite naturally.

Excessive Praise Is Detrimental

According to Kohn (1993), children can become negatively dependent on praise, just as they can on any other external reward. This dependency can lead to lower self-confidence, loss of intrinsic joy in the learning process, and decreased self-esteem. When the reward is withdrawn, learners feel let down. Praise is also interpreted by some as manipulative, and relying on it can easily backfire. Learners may feel controlled and resent the scrutiny, or they may feel self-conscious and inadequate if they sense any insincerity on the part of the praiser.

Overly heavy praise given to a learner can be detrimental to learning. While intermittent praise can be positive, too much praise from authority figures can increase the pressure to perform and result in performance anxiety. Subjects who were given praise right before a skills test consistently performed worse than those who did not receive praise. Students who were heavily praised became more tentative in their answers and gave up on their own ideas more quickly than those who were not.

If a teacher continually praises students for doing their homework or for sitting quietly in class, soon they discover that it is the praise that they seek, not the behavior that the teacher is attempting to reinforce. The following are characteristics of ideal feedback:

Frequent is better than infrequent.

Both positive and negative can be effective.

Task oriented (not personal) is more effective.

Localized negative ("Put the A function on the left side of the equation, not on the right.") is most effective.

Global negative ("You're not trying.") is the least effective.

Positive feedback ("Great job!") falls in the middle.

Personal positive specific is effective ("Your choice of descriptive words was highly effective in establishing the emotional tone.").

What This Means to You

The most striking and permanent aspect of a positive judgment is that it's still a judgment. Reduce your praise, and increase peer feedback and support, which is more motivating to the learner. Encourage rather than praise. Say, "You're on the right track" or "Give it your best effort." Give praise that is not contingent on performance. Encourage learners to take risks. Provide affirmation, not back slapping. When the task is completed, ask learners what their assessment is. In this way, learners begin to develop a sense of quality about the learning, instead of feeling pressure to perform the right way. Teach learners how to provide supportive feedback to each other.

MOTIVATION AND REWARDS

All of us have two different sources of motivation acting upon us: that which arises from within (intrinsic) and that which is externally reinforced (extrinsic). The intrinsic source for learning motivation is ideal for many reasons, the most obvious of which is that even without the artificial controls of a classroom environment, students will continue to achieve.

Remember, all human beings are born with intrinsic motivation; we don't need someone to monitor it unless a brain-antagonistic environment has been set up. Yet if you are operating under the assumption that more teacher control is better, learner motivation is always going to be a problem. Why? Control creates resentment, which undermines natural curiosity and intrinsic motivation. The more fundamental question is, what is your responsibility as a teacher? The answer is both simple and complex: create environments in which learning is as natural as breathing.

The essential understanding here is that we are all biologically driven to seek out new learning. The human brain loves to learn; our very survival, in fact, is dependent on learning. Usually our motivation looks as if it is the pursuit of curiosity, novelty, social contact, food sources, shelter, and enjoyment. Learners have a built-in motivation mechanism that does not require a teacher's input or manipulation to work. Our brains have hungrily absorbed information, integrated it, made meaning out of it, remembered it, and used it at the appropriate times for eons. At school, if we use our natural motivations and curiosity, we can expect students to learn better and enjoy more.

We've all seen apathetic students. But if they made it to school, there's hope. Either the specific classroom environment demotivated them or they brought negative baggage from prior school experiences. In either case, "the unmotivated learner" is a myth. The root of the problem is not so much the learner as the conditions for learning that are less than ideal in most school contexts. A great number of kids have been labeled "underachievers," yet when we stop to consider the amount of motivation it takes for some undersupported children to simply get to school, we tend to rethink our labels. Once learners are in their seats, the teacher's role is to elicit their natural motivation. If learners are severely stressed, they may not be able to process information as efficiently as other learners can, but you can bet their motivation to solve problems is strong. Negative behaviors are commonly reinforced in the artificial and unresponsive school environment. And the problem is perpetuated when we identify, classify, group, label, evaluate, compare, and assess learners.

> There is no such thing as an unmotivated learner. There are, however, temporary unmotivated states in which learners are either reinforced and supported or neglected and labeled.

The following techniques demotivate learners and drive away intrinsic motivation:

- coercion, control, and manipulation
- weak, critical, or negatively competitive relationships
- infrequent or vague feedback
- racism, sexism, or prejudice of any kind
- outcome-based education (unless learners help generate the outcomes)
- inconsistent policies and rules
- top-down management and policy making
- repetitive, rote learning
- inappropriate or limited learning styles
- sarcasm, put-downs, and criticism
- perception of irrelevant content
- boring, single-medium presentation
- reward systems of any kind
- teaching in just one or two of the multiple intelligences
- systems that limit achievement of personal goals
- responsibility without authority

Rewards and the Human Brain

To the brain, a reward is simply a strong positive feeling. It is generated by the release of the neurotransmitter dopamine, which can be triggered by many experiences. To an educator, a reward is a compensation or consequence that (1) is predictable by students and (2) has market value, meaning that it is valued by most students.

In a never-ending effort to control, manipulate, manage, and influence learners, some educators have become accustomed to using rewards; however, considering the brain's natural operational principles, this technique is not productive. To understand this irony, first let's define *reward*.

If it is only predictable but has no market value (e.g., smile, hug, compliment, random gift or token, awards assembly, public approval), then it is simply an acknowledgment, not a reward. If it has market value but absolutely no predictability (e.g., spontaneous party, pizza, cookies, gift certificates, small gifts, trips, tickets), then it is a celebration, not a reward. However, if students know that by behaving a certain way they might get a prize, that's enough predictability to be called a *reward*. The determining criterion is simple:

Did the learners change their behavior in the hopes of getting the favor?

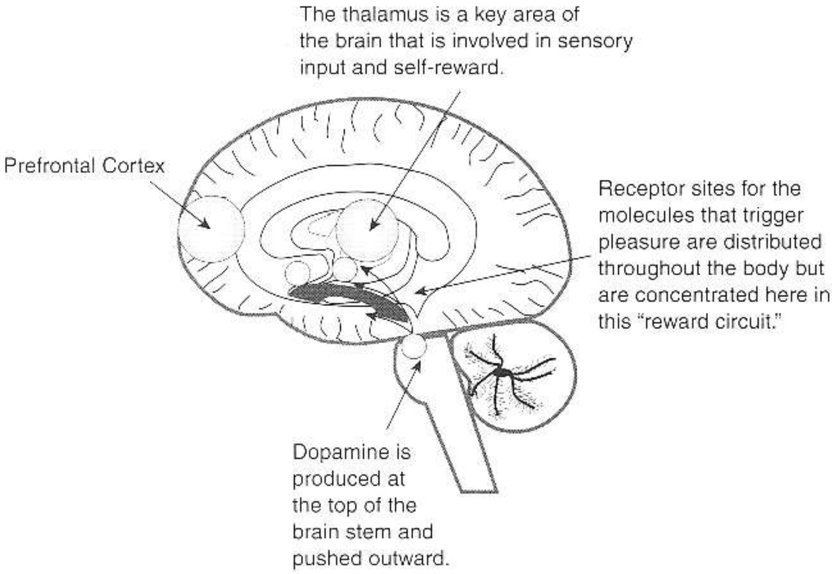
If you offer learners something that meets this criterion, you are, in fact, bribing the learner. A reward system, regardless of what you call it, carries an implicit and covert threat: if learners don't meet the criteria, they will not receive the reward or some opportunities will be withdrawn. As you can tell, the issue has a great deal to do with intent, which can sometimes be tough to read.

What do rewards do to the brain? The brain, which has its own built-in reward system (see Figure 15.2), is highly customized to each individual. This system can be tracked and observed with tracers injected into the blood that measure the release of the chemical dopamine—the "feel-good" neurotransmitter.

This customized reward system develops over time based on each person's unique experiences and perceptions. And each person's system responds to rewards differently. What is a reward to one person may not be much of a reward to another. Events and thoughts can change the system by altering the receptivity of the receptor sites to the brain's endogenous opiates.

The reward system habituates easily, which means that although a reward may be motivational at first, soon thereafter the ante must be increased for the pleasure to remain stable, much as an addict who needs ever-greater amounts of a drug to get the same high. The first time a person uses cocaine, the rush of pleasure may be 500 times that of his or her normal experience, but by the second time, it may drop to 200 times, and by the third, the brain may release only 100 times the amount of dopamine in response. You can imagine what a predicament this puts the brain in. The promise of pleasure entices, but each time the drug is used, the pleasure is less. The brain has habituated. In school, this means that what worked the first time might be insufficient the next time, and the need for an ever-increasing value of reward is sought. The gold stars that worked for first graders become

Figure 15.2 The brain's internal reward system



cookies for third graders and pizza for fifth graders. Before you know it, you can't provide what the students desire. It's a vicious cycle! Thus, rewards in the learning process must be used judiciously, if at all, to accomplish increased learning.

The Detrimental Effects of Rewards

A student's ability to be creative appears to be linked to intrinsic motivation, since it gives the brain greater freedom of intellectual expression, which in turn seems to inspire even more creativity. A reward system prevents the establishment of intrinsic motivation because there's rarely an incentive to be creative—only to exhibit the requested behavior. Creativity is rarely measured in relation to a reward system; in fact, the two are usually at opposite ends of the spectrum. You either get intrinsically motivated creative thinking or extrinsically motivated repetitive, rote, predictable behaviors. Amabile (1989) found that reward systems lower the quality of the work produced. She conducted more than a dozen studies over nearly 20 years with the same results: in the long run, rewards didn't work. Among artists, creativity (as judged by their peers) dropped subsequent to signing a contract to sell their work upon completion. The fact that financial rewards were pending lessened their fullest expression.

> A system of rewards and punishments can be selectively demotivating in the long term, especially when others have control over the system.
>
> —Geoffrey and Renate Caine

Most behavior-oriented threats and anxiety, coupled with a lack of learner input and control, will shut down learner thinking and cause learners to prefer repeated, predictable responses to lower their anxiety. This may make teachers think the reward system is working, but initiating changes within this system becomes more difficult because any change increases threat and anxiety to students and teachers alike. Learners who have been bribed for either good work or good behavior find that soon the previous reward wasn't good enough. They want a bigger and better one. Soon, all intrinsic motivation has been killed off, and learners are labeled "unmotivated." Like a rat in a cage pushing a food bar, the learner behavior becomes just good enough to get the reward.

Rewards conflict with learners' goals under the following circumstances:

1. **The learner feels manipulated by the reward.** "You just want me to dress your way."
2. **The reward interferes with the real reason for the learning.** "Now that I'm getting rewarded for receiving good grades, I care only about what's on the test."
3. **The reward devalues the task, and the learner feels bribed.** "This class must be pretty bad if they're giving us a bribe just to attend."

Consider, for example, a school that is having problems with truancy and low attendance. The administrative staff decides, as an incentive, to reward those who come every day. Now each student gets a reward for having 100 percent attendance during the month. The school has worked out an arrangement with local businesses so that the reward is a free meal at McDonald's or Pizza Hut. Students immediately feel bribed for coming to school. They think, "The situation must be really bad for them to bribe us." But learners still respond to the rewarded behavior. "It's stupid, but we'll play the game," they say. Now school is about working the system instead of learning.

Strategies for Eliciting Intrinsic Motivation

1. **Meet learners' needs and goals.** The brain is designed biologically to survive: it will learn what it needs to learn in order to survive. Make it a top priority to discover your learners' needs, and engage those needs. If students need what you have, they're interested. If the content relates to the students' personal lives, they're interested. For example, 6-year-olds have a greater need for security, predictability, and teacher acceptance than 14-year-olds do; the teens' needs are more likely to be about peer acceptance, a sense of importance, and hope for the future. And an 18-year-old is likely more interested in autonomy and independence. Use what's appropriate for the age level of your students.
2. **Provide a sense of control and choice.** Creativity and choice allow learners to express themselves and feel valued. The opposite of this is manipulation, coercion, and control.

3. **Encourage and provide for positive social bonding.** This can come in many forms—a likable teacher, classmate, situation, or group. Encourage teamwork, collaboration, and group activities.

4. **Support a sense of curiosity.** Inquiring minds want to know; this is the nature of the human brain. Keep engaging curiosity—it works! Newspaper tabloids and electronic tabloids have played off our curiosity for years. Just witness all the stories about Elvis, aliens, Princess Diana, Hollywood celebrities, and UFOs.

5. **Engage strong emotions.** Engage emotions productively with compelling stories, games, personal examples, celebration, role-plays, debates, rituals, and music. We are driven to act on our emotions because they are compelling decision makers.

6. **Encourage adequate nutrition.** Better nutrition means more mental alertness. Learn about how diet influences the thinking and learning process. Write up a list of suggestions to give to your students and their parents. Suggest specific brain foods—eggs, fish, nuts, leafy dark green vegetables, apples, bananas, and others known to increase mental alertness.

7. **Incorporate multiple intelligences.** Draw learners in through their strengths, which may range from spatial, bodily-kinesthetic, interpersonal, and verbal-linguistic to intrapersonal, musical-rhythmic, and mathematical-logical. We are particularly motivated when we can demonstrate our strengths and proclivities.

8. **Share success stories.** Tell inspiring stories about other learners who have surmounted obstacles in order to succeed. Develop a mythology and a culture of success. Consider how just walking on a college campus can elicit feelings of motivation.

9. **Provide acknowledgments.** These include assemblies, certificates, group notices, team reports, compliments, and appropriate praise. Positive associations fuel further action.

10. **Increase frequency of feedback.** Make it your part-time job to see that learners get a lot of feedback during each class. Use charts, discussion, peer teaching, projects, and role-plays. Feedback needs to be nonjudgmental and immediate.

11. **Manage physiological states.** Learn to read and manage states. There is no such thing as an unmotivated learner, only unmotivated states. Elicit anticipation and challenge states in your learners and in yourself.

12. **Provide the hope of success.** Learners need to know that it's possible for them to succeed. Regardless of the obstacles or how far behind they may be, hope is essential. Frank (1985) strongly believes that hope works like a powerful drug and is essential to restoring demoralization. Every learning context must provide some kind of hope.

13. **Model the joy of learning.** Since more than 99 percent of all learning is nonconscious, the more excited you are about learning, the more motivated your learners will likely be.
14. **Mark successes and achievements with celebrations.** These include peer acknowledgment, parties, food, high-fives, and cheers. These create the atmosphere of success and can trigger the release of endorphins that further boost learning and motivation.
15. **Maintain a physically and emotionally safe learning environment.** An environment in which it is safe to make mistakes, ask questions, and offer contributions is essential. Meet learners' physical needs for adequate lighting, water, food, movement, and comfortable seating. Also ensure that learners are physically safe from building hazards. Make sure they know you are always available to discuss any concerns about their safety, including concerns about other students.
16. **Incorporate learners' individual learning styles.** Provide both choice in how students learn and diversity in what they learn so that they can use their preferred learning styles.
17. **Instill positive beliefs about capability and context.** Reinforce learners as they meet difficult challenges. Tell them that you know they can succeed and accomplish their goals. Discover what beliefs individual may hold about themselves that might be holding them back, and work to affect them positively.

None of these strategies cost anything (no rewards or bribes are necessary), and they work. They certainly involve more initial preparation and work to create a climate of intrinsic motivation, but it pays off in the long run. Teachers who rely on extrinsic motivation may be vastly underestimating three things: (1) the power and limitations of their influence, (2) learners' desire to be intrinsically motivated, and (3) the long-term ease of reinforcing intrinsic rewards.

Rewards . . .

reduce the learner's ability to solve complex problems without extrinsic motivators
reduce learner responsiveness to the environment
result in increased stereotypical, low-risk, low-creativity behavior
increase learner attentiveness to, and reliance on, external systems of rewards and punishments

Deci and Ryan (1987) say there is evidence linking extrinsic motivation to positive outcomes in work involving noncreative tasks, memorized skills, and repetitive tasks. However, in order to get learners to be creative and have greater subject interest, higher self-esteem, and the ability to be reflective, there must be intrinsic motivation. Reward systems prevent this, but make no mistake about it, some learners will respond to rewards in the short term.

Paradoxically, the more demotivating the environment is, the more learners seek rewards. Stressed and anxious learners are more likely to look to others for safe, predictable role modeling; to listen to others for goals; and to increase their own stereotyped, lower-order thinking. But this creates a catch-22. At a low level, rewards work. The teacher continues their usage, and learners are now victims of the glass ceiling principle: they learn to perform to the lowest level needed to get the reward. I often have teachers say to me, "My students seem to like the reward system. They complain when it is dropped, and their performance goes down." Teachers use this as evidence to say, "I know I shouldn't bribe them, but the system works!"

> Learners who experience stress and anxiety in their environment will prefer external motivation, meaning a system of reliable rewards.

The problem is that the system does work—too well. Rewards lead to learners who become preoccupied with "playing the game" and not really doing quality learning. Why? Quite simply, the ability to alter perceptual maps, to do higher-order thinking, and to create complex thematic relationships with the subject is not available to the brain when it experiences the anxiety of a reward system.

> In the long run, rewards do more damage than good toward motivating the so-called underachiever.

The more you use a reward system, the more you evoke the two-headed dichotomous dragon: (1) the psychological anxiety of performance increases, and (2) every reward carries with it an implied certainty of success or failure. But which will learners achieve: success or failure? They want to reduce the uncertainty, so they pick tasks that have a high degree of predictability (often boring, repetitive skills). Learners are also more likely to pick goals set by others instead of themselves (even the goals they do pick are often the basic, overworked, media-reinforced, cliché types).

What This Means to You

Replace rewards with positive alternatives, including meeting learner goals, peer support, positive rituals, self-assessment, acknowledgments, love of learning, enthusiasm, privileges, increased feedback, more options for creativity, and more student control. Rewards do more harm than good; they encourage results other than those originally intended. Phase out reward systems. It makes more sense to make school or work a worthwhile place to be, rather than trying to bribe people to attend or perform. When you incorporate the brain-based strategies in this book, rewards will become unnecessary.

Rewarded Actions Lose Appeal

Following a decade of postreward analysis, Kazdin (1977) concluded that when the goodies stop, the behavior stops, too. At first, he was excited about the behavior changes. In an earlier publication, Kazdin (1976) talked about how much patient behavior had changed. And that's what people remembered the most. Once a proponent of rewards, he set up a token economy system in a health care institution. But by 1977 he had determined that although the rewards worked temporarily, they did not maintain the desirable outcomes.

> Removal of token reinforcement results in decrements in desirable responses and a return to baseline or near-baseline levels of performance.
>
> —Alfie Kohn

All learners have their own biases that they bring to a particular context. The biases constitute personal beliefs, hopes, expectations, fears, values, and emotions. These are what hold a behavior in place. Rewards are designed to change the behavior, not the biases. Hence, any reward-driven activity is likely to fail in the long run.

We all know teachers often offer rewards for attendance, homework, or good behavior. Pizza Hut had a program designed to reward students for reading by offering pizzas. The follow-up, however, would likely confirm that those who read the most were those who had been reading already; they just decided to play the game. And learners who had not ordinarily read before the promotion likely returned to their prior habits afterward. If that program was as successful in the long run as it was in the short run, we would have a nation of ravenous readers right now.

What This Means to You

Many learners would become more intrinsically motivated if given a chance, but as long as a reward system is in place, they'll play the game and undermine their own progress in the long term. Reduce or eliminate all rewards. Phase out slowly any rewards you are now using. Incorporate positive alternatives: celebrations, variety, novelty, and feedback.

Should You Ever Use Rewards?

According to Kohn (1993), "if your objective is to get people to obey an order, to show up on time and do what they're told" (p. 41), rewards can work. But, he adds emphatically, rewards simply change the specific, in-the-moment behavior and not the person. If your objective is to help learners authentically achieve, rewards simply don't work.

Rewards don't help learners . . .

achieve long-term quality performance
become self-directed learners
develop values of caring, respect, and friendliness
develop creativity and higher-order thinking skills
increase integrity and self-confidence
develop inner drive and intrinsic motivation

Here's an example of when a reward might be used: You have a bunch of chairs to move to another room. It's the end of the day; you're tired and hungry. You ask a couple of students if they'd be willing to help you move them after class. They say, "No, not really." But you're desperate, so you say, "How about if I get you both a Coke?" They change their minds and decide it's worth it. The chairs get moved. Everybody's happy. The reward was appropriate.

ALTERNATIVES FOR BRIBERY AND REWARDS

There are many positive alternatives to bribing students for better behaviors. The first and most powerful one is to make school more meaningful, relevant, and fun. Then you won't have to bribe students. If you are using any kind of reward system, let it run its course and end it as soon as you reasonably can. If you stop it abruptly, you may get a rebellion. The learners will need to detox from the reward drug. Remember, the research says that learners who have been on a reward system will become conditioned to prefer it over free choice.

But replacing rewards with alternatives gets a bit tricky for two reasons. First, the entire system of marking and grading is a reward-and-punishment system. The rewards are good grades, which lead to teacher approval, scholarships, and university entry. How can an instructional leader work properly (without bribes and rewards) within a system that is so thoroughly entrenched? What if other teachers use rewards but you don't? You will have your work cut out for you, but if you provide learners with the reasoning behind your approach, they will eventually prefer your methods. Be patient.

Second, there are many gray areas. A certificate may be just an acknowledgment when you give it to students, but what if parents reward learners with money when it is taken home? Then it becomes a reward in spite of your best intentions. The solution is to try to make parents aware of the destructive effects of rewards at an open house night or by letter. You don't have to bribe learners to learn. The human brain loves to learn! Simply follow the "rules" for brain-compatible learning, and learners' thirst and hunger to learn will return.

What the Reward Proponents Say

Behaviorists treat learners as empty vessels that need to be filled. In this paradigm, the way you get learners to learn is to first gain control, then control what and how they learn; if they aren't interested, you simply bribe them. Those who are steadfast in their insistence on rewards usually defend themselves on the following grounds:

Proponents of reward systems often claim that . . .

rewards are necessary ("After all, what's the intrinsic reward for computing the problem 4 + 4?")
the studies on intrinsic rewards are theoretical only
rewards are harmless
the real world uses rewards
rewards are effective

Those who have discovered the power of alternatives know the answers already. But for the others, here are some comments about the five points raised above:

1. **"Rewards are necessary."** This is false. In the control paradigm, students have been so conditioned that even simple learning begs for a motivating cue. This is because their natural love of learning has been manipulated out of them. Millions of students learn based on curiosity, joy, and their natural love of learning. Learners who say they want rewards have simply been conditioned to want them.

2. **"The studies on intrinsic rewards are theoretical only."** This is false. Hundreds of studies on the follies of rewards have been done with real people in everyday situations. One of the most innovative programs for almost 30 years, SuperCamp, uses no rewards, and its results have been reported worldwide. It has more than 50,000,000 graduates, and one-, five-, and ten-year studies demonstrate that its methods work.

3. **"Rewards are harmless."** Once again, false. Consistent studies have documented that, under the context of a reward, the brain operates differently. Behaviors become more predictable, stereotyped, rigid, and narrow. You can get a desired behavior with rewards, but you won't get intrinsically motivated students with a passion for learning.

4. **"The real world uses rewards."** In some cases, yes; in many other cases, no. Critics say that everyone gets rewards for their work, but that's not true. Many people work because they love what they do. The majority of teachers went into their profession because they liked the satisfaction of helping others grow and succeed, even though other jobs pay better.

5. **"Rewards are effective."** For rote, repetitive tasks, yes, rewards enhance performance for a while. But then the novelty of the reward wears off, and the performance drops. Someone can hold a gun to your head and get you to do almost anything. It's effective, isn't it? But this doesn't make it right. Rewarded behaviors rarely continue after the rewards are removed, unless the learner did not depend on the rewards to begin with.

Replacing Rewards With Learning

When you begin to remove rewards from your learning environment, don't expect a standing ovation. Research has shown that many learners prefer rewards even though they are counterproductive to their learning. Why? It's predictable. Take your time phasing out rewards. Allow existing programs to expire on their own. Then ask students for their partnership in replacing extrinsic rewards with intrinsic rewards. Teachers who make unilateral decisions about classroom operations while ignoring student input reinforce a sense of powerlessness. Rather, engage students in active discussion about the real cost of rewards and the real rewards of learning.

If you replace rewards with more student choice, feedback, and empowerment, learners begin to choose to learn for their own reasons. This transition to learning for learning's sake will not happen overnight. Students will need time and support in directing their focus inward—on their own needs, values, goals, belief systems, and emotions. Thus, the removal of external rewards is only the first step. Next, students need to be supported while their locus of control shifts from external to internal. When you stop hearing "Is this going to be on the test?" you'll know you have achieved the goal. What this question tells you about learners is that they've had the love of learning bribed out of them by unknowing teachers. Since they don't think learning is any fun, they need a bribe for their effort. The goal of brain-based teaching is to let the brain reward itself for its own growth, just as it is naturally equipped to do.

GOAL SETTING INCREASES PERFORMANCE

Teachers maintain many types of goals for their students. Some are directed by a governmental entity (e.g., standards for outcome-based learning). Others may be your own goals (e.g., "I want them to develop a real love of learning"). And yet others may be determined by a particular learner's situation (e.g., "Johnny's going to learn to read this year"). But most critical to a brain-based learning approach are the learners' goals for themselves. The best goals are student-generated goals.

Locke and Latham (1990) reviewed 400 studies examining goals for motivation, and the results were definitive. They found that specific, difficult goals lead to better performance than easy, vague ones. The results, based on studies conducted in the United States and seven other countries, included more than 40,000 subjects, 88 different tasks, time spans ranging from one minute to three years, and numerous performance criteria, including behavior change, quantity and quality outcomes, and costs.

A few other criteria are also important for effective goal setting (Ford, 1992). The target has to be at an optimal level of difficulty—challenging, but attainable. In addition, learners need to have (1) ample feedback to make corrections, (2) capability beliefs to help them persevere in the face of negative feedback, (3) the actual skills needed to complete the task, and (4) an environment conducive to success. The three keys to learner goal acquisition, says Ford, are the learners' beliefs, the emotions, and goals.

But if goals are given too much attention, they can be counterproductive. When the pressure is too great, learners report feelings of self-consciousness and the tendency to make simple mistakes and "choke" on material they know that they know but can't remember in the pressure of the moment.

Personal Agency Beliefs

Personal agency beliefs (PABs) is a term used to describe people's capability beliefs about themselves. These are activated once a goal is set and are influenced by the context of the moment. For example, a student's belief upon being accepted to a university might be, "Wow, I think I can do well and graduate from this university in four years." However, once the student is attending classes, he or she may begin thinking, "Gee, with a full load at school and working part time, getting good grades is harder than I thought."

In a long-term study of 250 students, ages 12 to 15, Meece, Wigfield, and Eccles (1990) found that the single best predictor of success in mathematics was the students' expectancy of future math success. Once these students were in the classes, the best predictor of their likelihood of continuing in math classes was its importance to them.

Although an instructional leader isn't always privy to learners' ever-evolving PABs, when it is obvious that students lack strong capability beliefs, there is a solution. With significant student input, establish controllable short-term goals (Barden & Ford, 1990). If you do that, the long-term outcomes may still be in doubt, but the short-term successes can positively impact the PABs of underconfident learners.

Goals are best when they . . .

are created by the learner
are concrete and specific
have a specific due date
can be measured through self-assessment
are reviewed and adjusted periodically by the learner

The beliefs or PABs that teachers have about their students—both individually and collectively—impact the learners in powerful ways as well. Rosenthal (1991) and Rosenthal and Jacobsen (1968, 1996) present a compelling argument for why teachers and trainers should maintain high expectations of learners. As previously mentioned, results of their study suggest that students will perform (not coincidentally) as well as you expect them to. Some learners may get sufficiently engaged with simple goals, such as "Here's what we can get done today," while others may require more challenging goals, such as "Let's design a better health care system and see if we can get it picked up by the local news."

What This Means to You

Goal setting is an important aspect of the learning process. Let students generate their own goals. Let them discover whether their own beliefs can support these goals. Ask them about the learning environment: Do they feel it supports them in achieving their goals? Do they have the resources they need to reach their goals? Most learners who want to succeed are capable of succeeding, though they often lack the beliefs necessary to do so. Ask learners to set immediate short-term goals for the day in addition to longer-term goals. Make sure the goals are positive, measurable, and obtainable. For example, a goal could be as simple as wanting to learn two new interesting things today. You then need to provide the necessary resources, learning climate, and feedback to help learners reach their goals. Hold them accountable. Check back later to assess results and celebrate, if appropriate. If necessary, help learners reassess their goals or their approach to achieving them. Celebrate each step on the road to success.

Previsualization Boosts Learning

A study at Oxford University found that visualization before a learning activity improved learning (Drake, 1996). A group of elementary school children were asked to practice visualization, imagery, and make-believe before being tested, whereas the control group simply took the test. The group that did the visualization first scored higher on the test.

Before you went to your last job interview, chances are you rehearsed the interview in your mind a few times over. This kind of practicing help you access important information and, in a sense, pre-exposes your mind to pertinent data.

What This Means to You

In some cases, learners may not be unmotivated; they may just need mental warm-ups. A few minutes invested early in the class can produce a big payoff later. Create a daily routine for learners. Before you start, have them do some physical stretching and mental warm-ups, such as role-playing, generating questions, visualizing a scene, solving a problem, or brainstorming.

Inspiring Optimal Motivation

Ford (1992) researched optimal environments for motivation and found that four factors were critical to what he calls *context beliefs,* the functional elements that are in vitro, or embedded within a learner's situation:

- The environment must be consistent with each individual's personal goals. This means that the learning environment must be a place in which learners can reach their own personal goals.
- The environment must be congruent with learners' biosocial and cognitive styles. If abstract learning is taking place in a crowded, competitive room with fluorescent lighting, it will be a problem for a concrete learner who needs space and prefers to work cooperatively.
- The environment must offer learners the resources they need. In addition to materials, advice, tools, transportation, and supplies, learners need to have adequate time, support, and access.
- The environment must provide a supportive and positive emotional climate. A sense of trust, warmth, safety, and peer acceptance is critical.

As a child, did you find yourself naturally and effortlessly engaged in learning? Why or why not? Were the qualities described above inherent in your learning environment? How inherent are they in the learning environment you provide for your learners today?

What This Means to You

Many students you consider to be unmotivated may be very motivated under the right conditions. Make a big poster featuring the conditions for optimal learning, and post it in your classroom and/or office. Let it be your guide for how to motivate learners and yourself.

16 Attention and Survival Value

CHAPTER OUTLINE

The wording in the phrase *to pay attention* is appropriate. We are giving to another person a precious commodity: our attentional resources. Strong attention requires that we orient, engage, and maintain each appropriate neural network. In addition, we must exclude or suppress both external and internal distracters. And although not every type of learning requires attention and engagement, explicit learning (of facts, names, and faces) actually does require attention. Even when we go for a walk, our brain "learns" a great deal. But it's not an in-depth type of learning; it's known as *priming*. In the typical word-based, semantic-style classroom learning, more focused and engaged attention is better than less of it. That's no news flash to most teachers, yet most struggle to maintain attention. Why?

Biologically relevant school stimuli include opportunities to make friends, quench thirst or hunger, and learn safety considerations such as a change in weather or bullying. The student's brain is also concerned with avoiding danger of embarrassment, failure, or harm. Yet some teachers ask students to orient and sustain attention until instructed otherwise (even if it means listening, reading, or focusing for up to an hour) and to do so daily in a gossip-ridden, physically inactive, and emotionally insensitive environment. It rarely works out the way the teachers would like.

The level of attention we are able to apply to a learning situation is limited by our perception of the value of doing so. Remember that our brains are most alert to information that helps ensure our survival. This is the state that elicits maximum attention—a state that thankfully isn't often experienced in a classroom or training environment. Since the survival state is reserved for issues of life and limb, we as teachers can't hope for our students' complete attention in the classroom; nor would it even be healthy. We can, however, create an environment where learners have the flexibility to focus on aspects of learning that are personally meaningful to them. This chapter explores the mechanisms and boundaries of the brain's attentional system and how we can best manage students' attention for optimal learning.

MAKING MEANING

Humans are natural meaning-seeking organisms. But while the search is innate, the end result is not automatic. Since meaning is generated internally, excessive input can conflict with the process. An important principle to remember is that either you can have your learners' attention or they can be making meaning, but never both at the same time. Facilitate a small-group discussion after new material is introduced to sort it out, generate questions, and play "what if" scenarios. Encourage learners to find personal meaning in their new learning. Explain to them how the brain naturally prioritizes information moment by moment.

During this necessary period of incubation, the brain filters out new incoming stimuli. It begins to sift through its full plate of information, looking for links, associations, uses, and procedures as it sorts and stores. This is a process that can occur only during downtime. Some kind of reflection time—writing in journals or having small-group discussion—makes good sense for the brain after new material is presented.

What This Means to You

Provide settling time. Just as a cake needs to settle after baking, the brain's neural connections need time to solidify and settle after learning. The best type of settling time is not doing seatwork or homework, but rather taking a walk, stretching, performing rote classroom chores (e.g., clearing the bulletin board, hanging art), doodling, or merely resting. Breaks, recess, lunch, and going home can also be considered downtime. Ideally, "brain breaks" ought to be built into your lesson plans every 20 minutes or so. The more intense the new learning, the more reflection time is necessary.

Attention Shifts

The brain's E-I (external-internal) shift is frequent and automatic. This shifting of focus seems to be a critical element in (1) maintaining understanding, (2) updating long-term memories, and (3) strengthening our neural networks. The brain needs time to "go inside" and link up the present with the past and the future. Without it, learning drops dramatically.

> When we consider current findings in brain research, it becomes clear that the whole concept of on task or off task is irrelevant.

The two critical factors for determining the amount of processing time a person needs are the learner's background in the subject or how much prior knowledge and skill the learner has, and the intensity or complexity of the new material. High novelty and complexity with low learner background means more processing time will be necessary. The reverse is also true: high learner background with low novelty and complexity (e.g., a review) means less learner settling time is necessary.

Some students need equal external and internal time, while others may need a 5-to-1 ratio—meaning they have a longer attention span. When you see good students in class who are not paying attention, it is a mistake to automatically assume they are goofing around. It may be that something has triggered their memory or shifted their focus inward.

What This Means to You

It may be that our notion of staying on task is really inappropriate and, in fact, a counterproductive way to measure learning. Keeping students' attention 100 percent of the time is a bad idea. The learner who you are assuming is not focused may simply be rethinking things in light of new information. Build into each day sufficient reflection time and group or partner processing time. Avoid long lectures, give frequent breaks, and pay attention to the individual and collective states of learners.

Optimal State for Learning

Very little learning happens when students are stressed out, despondent, or otherwise distracted. But when they are prompted into a positive state for learning, they naturally do better. Csikszentmihalyi (1990) reports in his book *Flow: The Psychology of Optimal Experience* that a state of consciousness (flow) is the primary criterion for optimal learning. Although it is impossible to merely will this uninterrupted state of concentration into existence, it happens when people lose themselves in an activity. That is, all self-consciousness and awareness of time fades, and what is left is a pure pleasure-producing absorption into the experience. Children, teenagers, and athletes find themselves in this state more often than the average adult.

Intelligence-Building States

Intelligence building is enhanced by maximizing complexity of states
↓
Continuity
(strength and persistence of previous states)
Flexibility
(capacity for variability and the responsiveness to context demands)

Csikszentmihalyi (1990) defines *flow* as a pattern of activity in which individual or group goals emerge (as opposed to being mandated) as a result of a pleasurable activity and interaction with the environment. When your skills, attention, environment, and will are aligned, flow is more likely to occur. Creativity and learning emerge in an accelerated fashion when learners are encouraged to go with the flow while enjoying themselves and defining and refining their own learning challenges. This philosophy allows learners to take responsibility for their learning in a relaxed state.

Flow is most likely to emerge when the balance of challenge and mastery is equal. Let's say, for example, that you've decided to learn to play the saxophone (or speak a foreign language, ice skate, golf, jog, surf the Web, etc.). At first, the practice takes a lot of effort, but over time it mysteriously gets easier, and before you know it, you're actually having fun! Time passes without your awareness, your skills improve, and you seem to be improving without struggle. You have reached the perfect balance. Your skill level matches the challenge.

The Best State for Learning

- intrinsically challenged with material that is not too easy, not too hard (best if the learner chooses it, so that it is personally relevant)
- low-to-moderate stress, general relaxation (this does not mean no stress)
- immersed flow state in which attention is focused on learning and doing (rather than being self-conscious or evaluative)
- curiosity and anticipation (when a learner discovers an interest in a particular subject, build on it)
- confusion (can be a motivator if it's brief and doesn't continue)

Matching Challenge and Mastery

As viewed by sophisticated imaging devices, brain activity increases when mental tasks are increased in complexity and difficulty. Even when learners are unsuccessful at very challenging experiments, their brains continue to be actively engaged. You play much better tennis, for example, when your opponent provides a good challenge for you. If, however, your opponent is at a different skill level than you (either better or worse), you will likely lose interest quite quickly.

Csikszentmihalyi (1990) further contends that we can get into the magical state of flow every day. When the challenge is greater than your skills, that's anxiety; when your skills exceed the challenge, that's boredom. But when the challenge and skill level are matched up, whammo! You've hit the jackpot! It is fairly easy to get learners into optimal learning states if you remember what gets you into that state.

What This Means to You

Teaching in a way that encourages students to reach the flow state may be one of the most important roles you have. In this state, learners are highly internally motivated, and learning becomes enjoyable. Help learners reach flow by setting up favorable conditions for it. Mandated, step-by-step instruction can work well in the initial stages of learning (by instilling focus, confidence, and motivation), but once you're beyond this, learners will likely be stifled by a rigid structure. Keep challenge high but stress low. Let learners set the pace while you provide the support. Have them design a complex project that is personally relevant, and then vary the resources to keep the task appropriate to their ability levels. Make it exciting; use teams, simulations, technology, and deadlines while maintaining appropriate levels of guidance and control.

What Brain Waves Can Tell Us

Another way to view states is by considering brain-wave patterns. EEG readings provide a measure of brain activity for identified categories by observing chemical reactions, which produce electrical fields that have a quantifiable number of cycles per second. Brain-wave patterns are defined by the following categories:

Delta	0 to 4Hz	Deep sleep/no outer awareness
Theta	4 to 8Hz	Twilight/light sleep/meditative
Alpha	8 to 12Hz	Aware/relaxed/calm/attentive
Beta	12 to 16Hz	Normal waking consciousness
High Beta	16 to 30Hz	Intense outer-directed focus
K Complex	30 to 35Hz	The "Aha!" experience
Super Beta	35 to 150Hz	Extreme states (e.g., psychic, out of body)

So which state is best for learning? It all depends on what type of learning and for how long, but here's a general synopsis: Delta is useless for any type of learning, as far as researchers know. Theta is the state that we all go into and out of right before falling asleep and waking up. It can be great for sleep learning and free association of creative ideas; however, it's too passive for direct instruction. Alpha is an alert state for listening and watching, but it is still fairly passive. Beta is great for typical thinking, asking questions, and problem solving, but High Beta is ideal for intense states such as debating and performing. K Complex is difficult to orchestrate, but you can set up the circumstances for it, and if it happens, great. And finally, Super Beta is such an intense state that it isn't appropriate for schools, classrooms, and formal education. Obviously, you can't use an EEG to measure brain-wave activity in the classroom, but some simple observations about states can still be made. Here are a few examples of corresponding emotions and body language that may reflect a learner's state:

What the Learner Feels	*What You Might See*
Fear	Restricted breathing, tightened muscles, and closed body posture
Anticipation	Eyes wide open, body leaning forward, and breath held
Curiosity	Hand to head, bright facial expression, and head turned or tilted
Apathy	Relaxed shoulders/posture, slow breathing, and no eye contact
Frustration	Fidgeting and anxious movements, tightened muscles, and shortened breaths
Self-convincer	Breathing shifts, and body rocks, tilts, or rolls

If you observe a student struggling with an unproductive learning state, you have a decision to make: Either let it go or facilitate a change. Since all behaviors are dependent on a state, if you help move the learner into an optimal state, you'll get optimal results. But if you allow the learner to linger in an unproductive state, a negative association may develop and eventually impact learning on a very deep level.

For example, if a learner's state is curiosity but the task at hand is overly challenging, the learner can quickly move into confusion. At this point, if the confusion is not resolved, frustration is likely to follow. An aware educator may catch the confusion before it turns to frustration or, worse, anger or apathy. The stages of confusion and frustration last only a short time, so timing is important. You may have only a few minutes to observe the problem and react. If you ignore it, a bigger problem is sure to follow.

Most Common Student States

Fear
Anxiety
Boredom
Apathy
Frustration
Confusion

Most Desirable Student States

Anticipation
Self-convincer
Excitement
Curiosity
Celebration
Enlightenment

Students go in and out of countless states every day, just as you do. Learning is not all in our heads: it's a mind-body experience. How you feel and how they feel is important. It influences every single learning experience. Here are some strategies for managing learning states:

1. **Activities.** Facilitate a change from one to another, intensify learner involvement, lead a stretching session or an energizing game, shift from individual to group work, move locations, or do something novel.

2. **Environment.** Create an energy shift with a lighting, seating, or temperature change; use aromas, sound, ionizers, plants, or color. Provide an emotionally safe environment.

3. **Multimedia sources.** Incorporate a video, a computer program, an overhead projection system, music, or slides.

4. **People.** Change speakers, or shift learners' visual focus; have the students teach each other. Shift to groups or buddy-study.

5. **Tone.** Provide a shift in theme, schedule, time frame, goals, resources, rules, or opinions.

6. **Focusing.** Facilitate breathing exercises (inhale and exhale slowly through the nose); incorporate visualization and imagery.

7. Choice. Provide learners with choices; ask for their input. Student motivation increases as you increase their control and accountability. Provide a safe environment, frequent feedback, positive social bonding opportunities, and adequate nutrition and water. Engage multiple learning styles.

Every day, you'll get more adept at reading states and managing them productively. Always ask yourself: What's the target state for this learning activity? If the answer is a reflective state, facilitate a stress-reducing exercise; then play some slow music. If the activity calls for an active state, have students stand up and take a few deep breaths; then play some fast music. In any case, be respectful of your learners' processes. Sometimes a student's state may be reflective of a deep-seated problem that shouldn't be dismissed. If a problematic state continues for more than a couple of days with an individual student, it may be a good idea to seek additional help from a school psychologist or another mental health professional.

What This Means to You

The most effective instructional leaders know how to recognize and manage learning states and ultimately teach others how to do this for themselves. As learners begin to recognize their own attentional rhythms, the reward is fewer classroom disturbances and more empowered learners. To move learners from nonproductive states to productive learning states, provide them with some choice, suggest a change of activities, shift your voice or your approach to a problem, provide a change of location, alter lighting, facilitate a movement game or activity, play some music, or construct a class art project. Hundreds of other possibilities exist, of course; the bottom line is to give learners some control over their environment and facilitate a shift from a mental or cognitive activity to a physical, creative, or reflection activity.

17 Teaching How to Think

CHAPTER OUTLINE

The brain is a natural at many things. It creates simple association effortlessly, without any conscious thinking processes. If we always have a good time in a restaurant with a certain friend or family member, we associate that restaurant with good feelings, even though there are no feelings in the physical building.

We also generalize without any conscious thought. If we are wronged several times in one week by red-haired people, we tend to generalize that to all red-haired people (false assumption!). But aside from a few exceptions, we as teachers have to actively teach thinking skills to our students.

Examples of the types of skills that must be taught explicitly include logic, cause and effect, correlations, the use of analogies, risk analysis, prediction skills, decision making, and a host of others. While in a perfect world each of these and others would be included or embedded in an everyday lesson at school, this doesn't happen very often. We have to choose the types of critical-thinking programs we use and be rigorous about implementing them.

WHAT EXACTLY IS THINKING, ANYWAY?

When we say, "I am thinking," what we are really saying is, "I am trying to manipulate internal symbols in a meaningful way." Thinking is a process whereby the brain accesses prior representations for understanding or creates a new model if one does not exist. The following categories represent some of these modes of representational thinking.

1. **Symbolic language.** Includes pictures, symbols, sounds, words, or "internal movies." This also includes verbal expression, music, or technological communications, such as computer-programming languages.
2. **Indirect knowledge.** Includes mental models, procedural thinking, physical patterns, and other implicit knowledge, such as feelings. How you feel about something or whether you have a sense about something plays a large role in the decision-making process.
3. **Direct sensations.** Includes touch, natural sounds, scenes, and the experience of nature.

When we break thinking down into the above three categories, we see how difficult it is to measure it. The mind, body, and feelings are all involved; there is no separation. Knowing this, it should be no surprise to hear that how we are thinking can be discerned by observing the body. When we are tense or happy, nothing necessarily has to be said for another person to interpret our thinking.

Factors That Influence Thinking

Critical thinking means that effective and reliable mental processes are used in the pursuit of relevant and correct knowledge about the world. Reasonable, reflective, and responsible mental processes help us decide what to believe or do. A person who thinks critically can ask appropriate questions, gather relevant information, efficiently and creatively sort through this information, reason logically from this information, and come to reliable and trustworthy conclusions about the world that enable one to live and act successfully in it.

Critical thinking is, in fact, a survival imperative in the twenty-first century. Children are not born with the power to think critically, nor do they develop this ability naturally beyond survival-level thinking, which is more innate. Throughout history, those most skilled in thinking and problem solving flourished, while the less skilled perished. Teachers can capitalize on this natural aptitude to survive by explicitly focusing on the related attributes of good problem solvers—primarily, critical-thinking skills. Fortunately, nature does some of the work for us, but there is still a great deal we can do in the classroom to ensure that learners develop high-level thinking skills. Let's start with a review of some of the primary factors that influence thinking or cognition (see Figure 17.1).

Environment

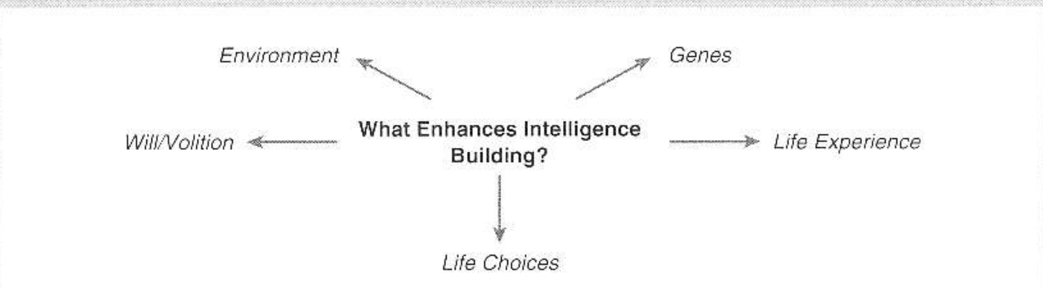
A challenging environment forces the brain to flex its thinking muscles. Intrinsic motivation kicks in to reverse the uncomfortable biochemical state called *stress*. On the other hand, when the body reaches the biochemical state of balance called *homeostasis*, motivation classically drops. When an environment provides an equal amount of challenge and stress with empowerment and support, you get an ideal learning situation whereby progress proceeds most rapidly.

The underchallenged learner may relieve boredom with disruptive behavior, while the overly challenged learner is likely to feel defeated and withdraw unless some resolution or success is achieved. Resting precariously between these two critical points is the magic learning moment. Teachers who provide a safe and challenging environment, while staying attuned to learner states and responding appropriately to them, facilitate a great number of teachable moments.

Will/Volition

Riding closely on the heels of the environment factor is the motivation factor, also known as *will* or *volition*. In fact, the two are inseparable. When an environment is conducive to learning, positive motivation naturally follows. However, when daily life is unchallenging (or dysfunctional in some other way), even the brightest learners can end up squandering their intellectual potential. Until learners get motivated to use and enhance their cognitive skills, they are likely to remain ensconced and stagnant in their relative comfort. The best way to

Figure 17.1 What enhances intelligence building?



strengthen learner motivation is to provide meaningfulness, learner choices, and emotional support while affirming the individual.

Life Experience

Emerging brain research provides good evidence that the brain is biologically molded by life experiences—especially in infancy. At birth we immediately begin experiencing basic needs (or problems), which are either met or not. For example, the baby who wails with hunger and is promptly satisfied with feeding experiences a deep sense of success. The ignored baby, on the other hand, experiences a poignant sense of failure. Multiplied a thousand times in a few years, we soon start behaving in ways that reflect this fundamental programming. Influenced strongly by a sense of personal power or (all too often) a sense of powerlessness, our life experiences build on one another, usually reinforcing our early programming.

Genes

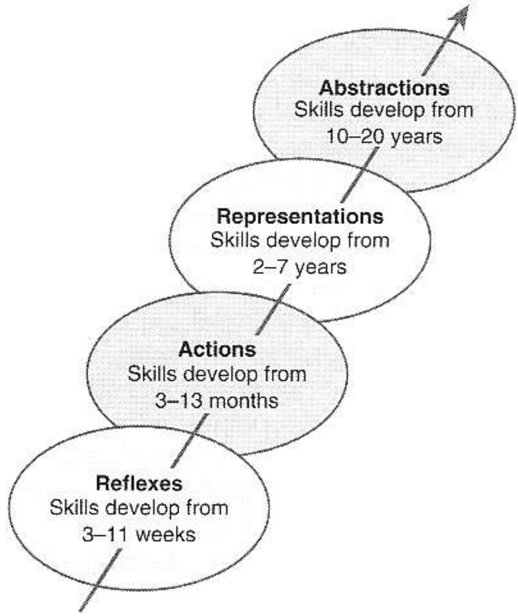
Although the nature-versus-nurture debate has reigned for years, the current cognitive science and neuroscience research suggests that both positions are correct. Although life experiences most certainly impact cognitive responses, genes influence such things as alertness, memory, and sensory acuity as well—all significant intelligence factors. Consider, for example, how rare it is for parents with very low IQs to produce offspring with very high IQs. Nevertheless, genes alone do not account for genius-level IQs. Thus, we begin to see the interrelated nature of these influences.

Life Choices

Cognitive-enrichment possibilities are ever inherent in our daily decisions, from the foods we eat and people we socialize with to the amount of physical and mental exercise and sleep we get. The brain, like the body, is either nurtured or neglected by our actions. Factors such as poor nutrition, lack of mental or physical challenge, abuse of drugs and alcohol, repeated blows to the head, and extreme stress kill you cognitively. Although we lose brain cells every day, recent brain research suggests that we also generate new cells throughout our lives.

Although the developmental stages highlighted in Figure 17.2 vary from individual to individual depending on the related factors previously mentioned, in general our cognitive development proceeds along a predictable time line. At birth, we possess only reflexes, but babies are quick learners. The development of basic reflexes generally takes place within 3 to 11 weeks, and in 3 to 13 months, infants become capable of basic actions, such as putting food in their mouths or taking a blanket off of themselves. Until this time, however, babies have only the basic cognitive capabilities exhibited by nonhuman primates.

Figure 17.2 Cognitive-development time line



The toddler soon develops the basic representational framework that accompanies language development and sets humans apart in the primate world. Skills accompanying this stage include identifying objects and locations, consciously using body language to make a point, drawing cause-and-effect conclusions, imagining scenarios, and verbalizing needs and feelings with words.

The peak of the cognitive path—abstract thinking—is not reached until the later elementary to high school grade levels. Abstract thinking is reflected in such tasks as identifying universal truths, beauty, ethical dilemmas, and cultural frameworks. By adulthood most of us possess fully matured frontal lobes, the area of the brain thought to be largely responsible for this highest form of cognition.

Being especially good at problem solving does not guarantee success in life, but being especially poor at it practically guarantees failure.

TEACHING THINKING

Can intelligent thinking be taught? Absolutely. Not only can it be taught, but it is also a fundamental part of the essential skills package necessary for success in today's world. A primary focus on creativity, life skills, and problem solving makes the teaching of thinking meaningful and productive for learners. These aspects of intelligence, though long undervalued in the traditional school setting, play an important role in intelligence. The following are some of the skills that ought to be emphasized at the abstractions level of development in the teaching of problem solving and critical thinking:

- gathering information and utilizing resources
- developing flexibility in form and style
- predicting
- asking high-quality questions
- weighing evidence before drawing conclusions
- using metaphors and models
- analyzing and predicting information
- conceptualizing strategies (e.g., mind mapping, lists of pros and cons, outlines)
- dealing productively with ambiguity, differences, and novelty
- generating possibilities and probabilities (e.g., brainstorming, formulas, surveys, cause and effect)
- developing debate and discussion skills
- identifying mistakes, discrepancies, and illogic
- examining alternative approaches (e.g., shifting frame of reference, thinking out of the box)
- developing hypothesis-testing strategies
- analyzing risks
- developing objectivity
- detecting generalizations and patterns (e.g., identifying and organizing information, translating information, crossover applications)
- sequencing events

It would be extraordinary if we could get all school-age kids to strengthen their own skills from this list. But realistically, it won't happen unless thinking skills are a full-time pursuit. The four skills most critical for achievement (if you had to choose just four) would be (1) memory capacity, (2) attentional capacity, (3) processing speed, and (4) sequencing. The good news is that critical thinking can be taught, and it can be taught within the context of other processes in a classroom, such as the following:

Summary and term papers. The best way to teach critical thinking is to require that students write. Writing forces students to organize their thoughts, contemplate their topic, evaluate their data in a logical fashion, and present their conclusions in a persuasive manner. Good writing is the epitome of good critical thinking.

Direct instruction. Teaching critical thinking during lecture is done by questioning students in ways that require that they not only understand the material but can analyze it and apply it to new situations as well.

Quantitative exercises. Mathematical exercises and quantitative word problems teach problem-solving skills that can be used in everyday life. This obviously enhances critical thinking.

Hands-on learning. Students inevitably practice critical thinking during lab activities in science class because they are learning the scientific method.

Homework. Both traditional reading homework and special written problem sets or questions can be used to enhance critical thinking. Homework presents many opportunities to encourage critical thinking.

Quizzes and tests. Exam questions can be devised to promote critical thinking rather than rote memorization. This is true for both essay and multiple-choice questions.

> The intellect asks, "Is it possible?" Only intelligence asks the question, "Is it appropriate?"

If you are already using some of these techniques, then you don't have to change a thing.

What This Means to You

From a brain-based perspective, the most effective way to teach thinking skills is to incorporate real-world problems under authentic (or simulated) conditions. With young children, simple games can produce a suitable environment for teaching thinking. With adolescents, sharing our own thinking processes, working through personal challenges with them, assigning complex group-oriented projects, and analyzing case studies are excellent ways to instill thinking skills. Most important, at any level, model high-level thinking. That is, verbalize your own thinking process as you weigh evidence, consider ramifications, and make decisions.

Brain Activated by Problem Solving

Some research suggests that problem solving is to the brain what aerobic exercise is to the body. It creates a virtual explosion of activity, causing synapses to form, neurotransmitters to activate, and blood flow to increase. A brain that is worked out with mental weights remains younger, smarter, and more creative longer in life. Especially good for the brain are challenging, novel, and complex tasks that require intense thinking and multitasking (i.e., doing more than one type of thinking at a time).

Boredom is a serious problem for the brain because the brain adapts from experience. If the experience is not stimulating, the brain reduces the connections, the strength of the connections, and expectations about learning. Diamond and

Hopson (1998) have shown in studies with rats that boredom does more harm to the brain than enrichment does good. Withdrawal from the world and reduction of stimulation most certainly contribute to senility and depression, while activity and challenge promote health and well-being.

What This Means to You

Our traditional educational system does not teach learners to think. Learners who spend all their free time "doing nothing" can get out of shape—not just physically, but mentally. Television is not exercise; active thinking and problem solving are. We, as instructional leaders, have to set the example and provide the climate that reinforces critical thinking and problem solving. There are many resources currently on the market that provide various types of mental workouts—from brainteasers to crossword puzzles. Make sure that you are not just teaching or training but that you are "growing" better brains. Use visualization, problem solving, debates, projects, and drama. Reduce lecture time, seatwork, and other rote activities. Challenge your students' brains, and be sure to give them the resources to meet the challenge.

Eye Movements and Thinking

As illustrated in Figure 17.3, there are six basic eye movements that relate to thinking. Determine the particular eye (and thinking) pattern for a learner by observing him or her in a real-life, no-stress situation. Controlled laboratory testing has yielded inconsistent results, but the real-world relationship between eye movements and cognitive functioning has been well documented. Cognitive activity occurring in one hemisphere triggers eye movements in the opposite hemisphere.

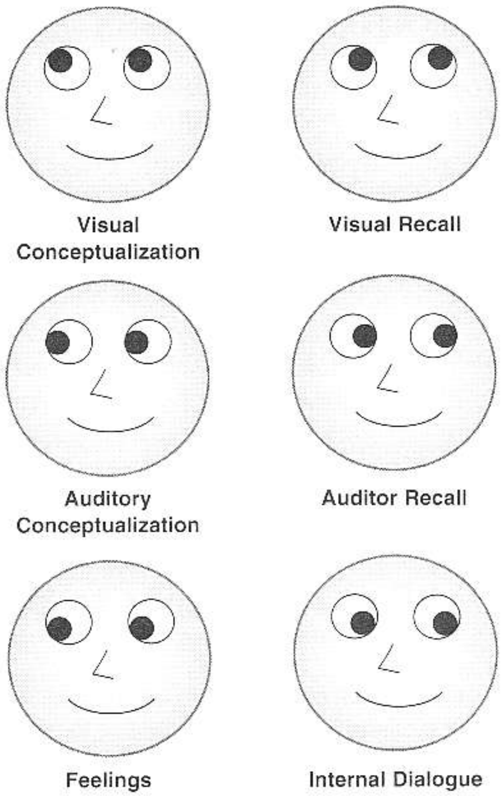
1. Visual recall. Looking up and to the left allows you to access stored pictures. Questions to ask yourself for verification: What car was parked next to yours in the parking lot? Describe your bedroom. Walk me through the clothes in your closet.

2. Visual conceptualization. Looking up and to the right allows you to create new images. Questions to ask yourself for verification: How would you look with a radically different haircut? What can you do to rearrange your living room? What would a dog look like with a cat's legs?

3. Auditory recall. Looking to the left allows you to access stored sounds (what was said or heard). Questions to ask yourself for verification: What did the other person say as you concluded your last phone conversation? What's the ninth word of the "Happy Birthday" song? When you were a child, how did your mother call your name when she was mad at you?

4. Auditory conceptualization. Looking to the right allows you to create new sounds. Questions to ask yourself for verification: How would a dog sound if it

Figure 17.3 Eyes movements and thinking



had a voice like a pig? What sound would you get if you heard a siren and a rooster at the same time?

5. Internal dialogue. Your eyes most commonly move down and to the left when you are engaging in internal dialogue. Notice others' eyes as they walk down the street alone.

6. Feelings. Your eyes go down and to the right when accessing feelings. Try it. Ask someone about something you know he or she has strong feelings about.

Eyes look straight ahead when no thinking is necessary, as when verbalizing an automatic response. For example, when someone asks how you are, your polite answer ("Fine, thank you") does not require you to search your brain for the answer.

Eye movements facilitate the processing and retrieval of information to and from the brain.

With learners who are having trouble, for example, with spelling, the following strategies can better hook the brain:

1. Access feelings with regard to the word. Start with eyes looking down and to the right.
2. Visualize the image of the word. Move eyes up and to the right.
3. Cement a word in auditory memory. Say the letters while looking to the right.
4. Cement a word kinesthetically. Trace its letters with your finger.
5. Recall a stored image of the word. Close your eyes, and look up and to the left.
6. Write out the correct spelling on paper. Review it, and look up and to the left.
7. To cement the success and celebrate the feeling of empowerment, look down and to the right.

What This Means to You

When you post students' work on bulletin boards, put it low if you want to access feelings, high if you want to facilitate discussion, or overhead if you want them to store the visual images in memory. When you present new material, stand to the right of learners (from their point of view). When you review, stand to the left of learners (from their point of view). This simple strategy enables learners to process and access the new information more efficiently. At test time, if you tell students to keep their eyes on their own paper, their ability to access information in their brain may be thwarted. As an alternative, have students spread out. This lowers everyone's stress levels.

The Use of Creative Problem Solving

The following account, from Leff and Nevin (1994), reflects a brain-based learning environment in which encouraging the use of thinking skills is one of the teacher's primary objectives. The teacher asks his high school science class to brainstorm a list of world problems. Working in small study groups, they narrow the list to 10. Then they brainstorm how the science topic of the week (weather) could impact, illuminate, or solve the problems. For example, overpopulation would be impacted by a natural weather disaster, or flooding could slow down tanks in a war. The class discusses these impacts. Then other academic areas are discussed in terms of their relationship to the topic of the week. Does physical education relate to an army at war?

> Forward thinking educators of today realize that any problem or situation can be turned into a creative-growth experience.
>
> —Herbert L. Leff and Ann Levin

How about home economics or math? Finally, students are asked to take these concepts home to discuss with their families and assess the personal impact.

Problem-Solving Strategies

The following specific strategies are flexible enough to be modified for various age groups and learning environments:

- Reframe a problem so that it is not a problem.
- Discover the source of the problem so as to prevent recurrence.
- Adjust your attitude to deal with life's difficulties.
- Consider how process impacts results.
- Analyze and discuss thinking (metacognition).
- Use various styles and models of thinking.
- Exhibit how your thinking skills add value and joy to your life.
- Apply your thinking skills so as to enhance the lives of others.
- Assign or read stories imbued with personal meaning—literally the oldest strategy in the book.
- Assign team projects, and incorporate a metacognition component (e.g., have team members keep a journal of the issues, challenges, and decisions faced and how they're resolved).
- Facilitate a group discussion in which you model (and/or comment on) higher-order thinking skills.
- Think out loud.
- Solve a problem or case study together using brainstorming, discussion, deduction, and decision-making skills.
- Set up debates between students or teams of students, and have them comment on the process.
- Put each learner in the role of teacher. Provide plenty of support and personal choice in the process.
- In groups of three, give learners the opportunity to play the role of listener, talker, and reviewer, respectively, while discussing a problem. The reviewer provides feedback to the talker and listener before exchanging roles.
- Assign projects that require reflection and personal expression.
- Take on class projects that benefit the school or community, and require students to use a wide range of real-life skills.
- Require learners to make mind maps or graphic organizers that reflect models or ways of thinking, patterns, sequences, and levels of detail.
- Honor the individual's feelings. Feelings are neither intangible nor elusive, but rather a very real and legitimate part of the thinking process.

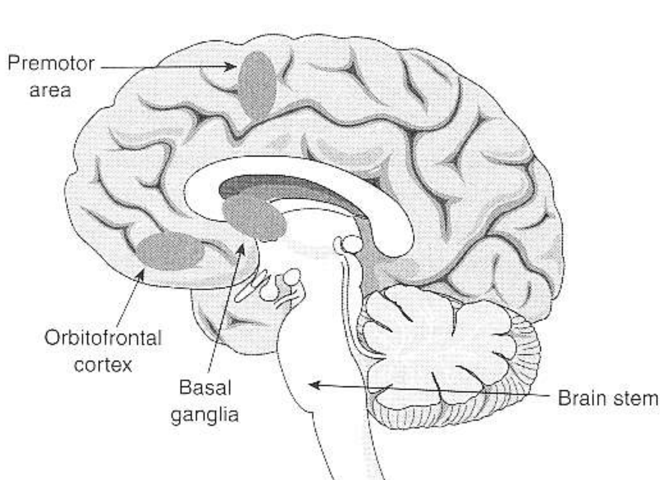
The Role of Intuition in the Thinking Process

When we feel that something's true, that doesn't necessarily make it true. Nevertheless, nonconscious learning picked up along life's winding pathway often triggers what we call *intuition*. So how do we know when we really know something as opposed to when we just think we know something? The fact is, the majority of our knowledge is implicit—that is, there is no symbolic language attached to it. For example, we certainly know how to get up from a chair, but could you accurately write out the steps for doing so?

Two areas of the brain, the basal ganglia and the orbitofrontal cortex (see Figure 17.4), seem to be primarily responsible for intuition. The basal ganglia help us regulate, manage, and translate our emotions into thinking. Situated near the eye sockets and at the bottom (ventral) of the frontal lobes is the orbitofrontal cortex, which helps integrate our emotions and thinking. This is where values are weighed, emotions are mediated, and thinking is modulated. When these areas are healthy, then violent, immature, or inappropriate behaviors are inhibited, and we exhibit normal inhibition. If either of these two brain areas is malfunctioning, however, our intuition will be affected.

A third structure—the amygdala—also contributes to intuition. It processes and stores intense emotions, such as trauma, celebration, violence, and phobia. Since there is no connection directly from the amygdala to the language areas of the brain, we store these experiences but usually have inadequate language to verbalize them. For example, a child abandoned by a parent may exhibit a pattern later in life whereby he or she leaves relationships before the partner can leave first. In spite of the repeated pattern, the adult whom the abandoned child develops into does not make the connection: he or she has no language for it. Normally we have no memory of early traumas (the amygdala is mature at birth, but the frontal lobes are not developed enough to make logical sense of a traumatic incident). Later on, our well-meaning intuition guides us in ways that may no longer be relevant because the emotion is deeply embedded in the amygdala.

Figure 17.4 Orbitofrontal cortex and basal ganglia



What This Means to You

We can help learners understand the role of intuition and emotions in learning and thinking by validating them. Ask students how an aspect of a lesson makes them feel. Encourage them to venture a guess when they are unsure of an answer. Realize that when learners act out illogically, a biological response may have been triggered that they don't have the awareness to stop. Learners who have sustained damage to key areas of the brain may exhibit inappropriate behaviors, which they cannot be expected to control. The most effective response is to effect a change in the students' state. Redirect them. Play some relaxing music, or take a break for stretching and deep breathing. Model solid problem-solving skills, and your learners will follow.

18

Memory and Creating Patterns of Meaning

CHAPTER OUTLINE

Stages of Optimal Learning
- Acquisition
- Elaboration
- Memory Formation

New Learning Maps

Most of us like to complain about our memory or that of our students. But nature has given us a very good memory for certain things. If you get food poisoning from a restaurant, do you remember to avoid that restaurant? Do you remember the names of your children, your parents, or your spouse? When was the last time you forgot your way home? Have you ever forgotten how to eat? When someone is rude to you, do you remember it? If someone did you a favor, do you remember him or her? Do you remember a divorce, an accident, a celebration, a honeymoon, or the birth of a child? These questions may seem laughable, but a second look at the kinds of things you consistently recall is quite revealing. If something is highly relevant, intense, or used often, it gets remembered. Our memories are not as bad as we might think. In fact, we are very good at certain, very specific types of memory. The good news is that the brain has the capacity to do that. This chapter, which focuses on both science and strategies, is about the brain's memory systems that help students remember things better in the classroom.

HOW MEMORY WORKS

How do students store and recall what they've learned? Current neuroscience describes memories as dynamic and not fixed. We can define our memories as the process of creating a persistent change in the brain by a transient stimulus. Surprisingly, there's no single master filing cabinet residing in our brains, nor do our brains archive our memories by number or some other linear system. It seems that the process is much more complex and holistic. It is important to think process, rather than location, when discussing the memory system. The current understanding is that multiple memory locations and systems are responsible for our learning and recall (see Figure 18.1).

Researchers emphasize that the retrieval process activates dormant neurons to trigger memories. The idea is that you cannot separate memory and retrieval—memory is determined by what kind of retrieval process is activated. Each type of learning requires its own type of triggering. When enough of the right type of

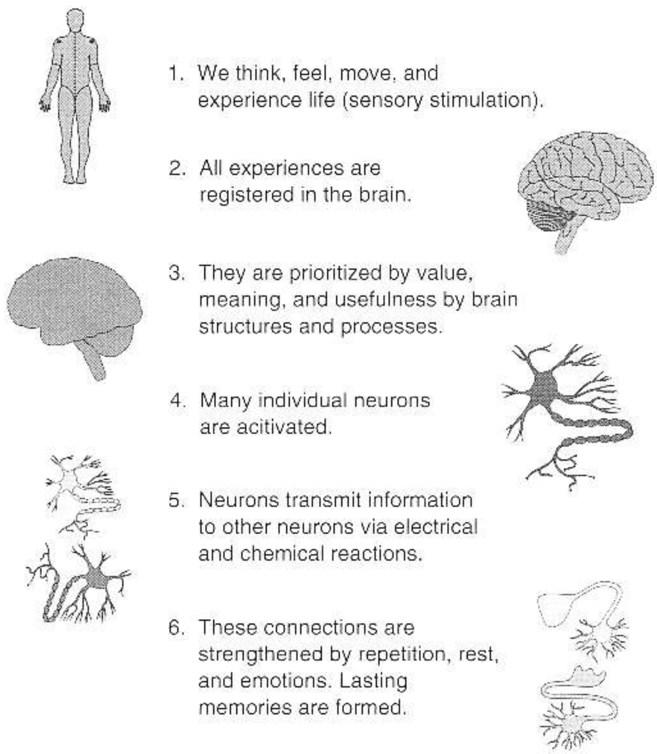


Figure 18.1 How memories are formed

neurons, firing in the right way, are stimulated, you get successful retrieval. In larger patterns, whole neuronal fields can be activated. For example, at hearing the word *school,* hundreds of neuronal circuits may be activated, triggering a cerebral "thunderstorm." This is due to the many associations and experiences most of us have with the subject. The how and where of memories are linked, so let's explore both of those issues.

Where Memories Live

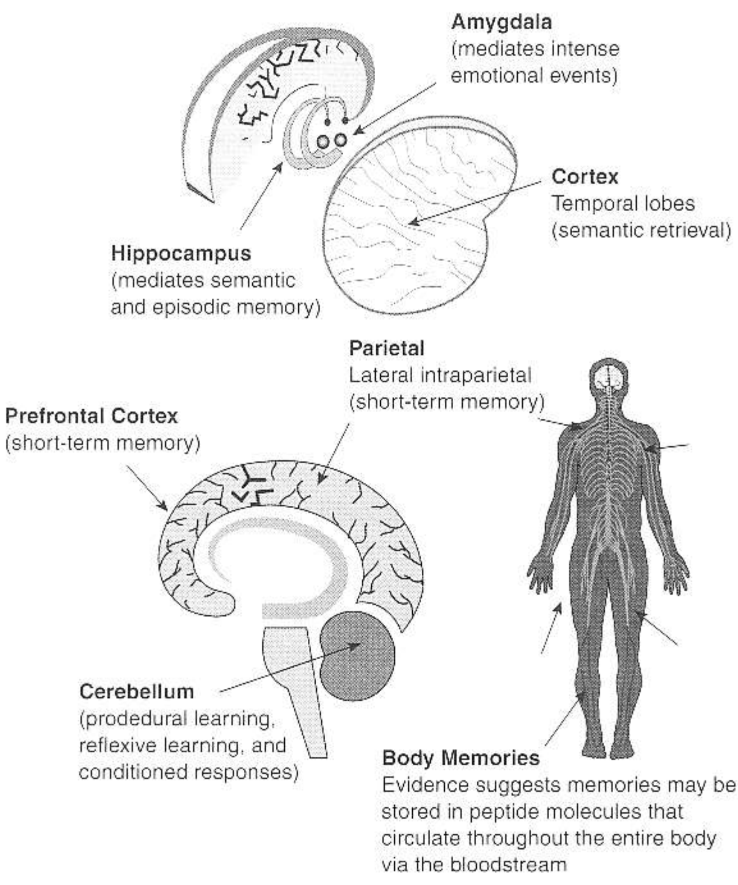
There is no one area of the brain that is solely responsible for memory. Most of our memories are well distributed throughout the cortex. This spread-the-risk strategy explains why a person can lose 20 percent of the cortex and still have a "good memory." It also helps explain why a student can have great recall for one subject, like sports statistics, and poor recall for another, like names and faces.

Memories are generated from all over the brain (see Figure 18.2). Memories of sound are stored in the auditory cortex; memories of names, nouns, and pronouns are traced to the temporal lobe. The amygdala is quite active for implicit, usually negative, emotional events. Learned skills involve the basal ganglia structures. The cerebellum is critical for associative memory formation, particularly when precise timing is involved, as in the learning of motor skills. Researchers have found that the hippocampus becomes quite active for the formation of spatial and other explicit memories, such as memory for speaking, reading, and even recall about an emotional event.

When you think of an idea, hear your internal voice, get an image, recall music, or see a color in your mind's eye, you are reconstructing the original memory. Your brain creates a composite of the various elements of the experience on the spot. This means that you remember something only once; after that, you're remembering the memory. And as time goes by, your versions change. And your memories get more and more re-created, and less and less true to the event. Your instant re-creation of the original takes a split second (usually) and operates a bit like a volunteer fire department: there's no building, office, or central system, but when a fire breaks out, the volunteers quickly unite from various locals to (everyone hopes) extinguish the blaze. Your memory is on call at all times of the day and night.

The prevailing theory on how this miraculous process happens is that we have indexes that contain instructions (not content) for the brain on how to rekindle the

Figure 18.2 Locations of memory activation



content. These convergence zones unite the pieces of a memory during the retrieval process. For the sake of analogy, consider that your semantic (words and pictures) memory works like just-in-time manufacturing: it creates a product on the spot, on demand, in its own store—an ingenious process considering that the parts are reusable on the next product or any other item you want to remember. For most word-based recall, we use mental indexes to help us find the word we want. A word like *classroom* is very likely linked to several related subjects like school, learning, kids, teacher, and principal. Our language is a classic example of having to pull hundreds of words off the shelf within seconds to assemble even the most common sentence. This theory explains why, when we are trying to say something, we often say a similar word (that is close, but still wrong).

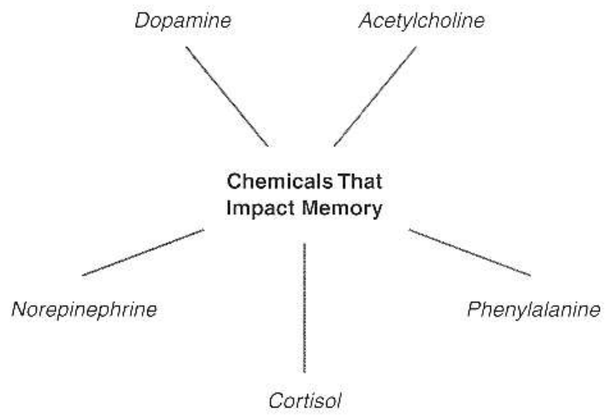
Long-Term Potentiation: What Is It?

The term scientists have used to identify the actual molecular process involved in the formation of explicit memories is *long-term potentiation* (LTP). This process is a rapid alteration in the strength of synaptic connections as a result of stimulation. The classic study on LTP (Bliss & Lomo, 1973), which earned the researchers a Nobel Prize, was done in the early 1970s, and recent research has supported the initial study. Tonegawa (1995) discovered that LTP is actually mediated by genes, which trigger a series of complex cascading steps. Around the same time, Kandel and Hawkins (1992) and Kandel and Kandel (1994) identified a critical protein molecule known as CREB, which serves as a logic switch, signaling to nerve cells whether to store the information in short- or long-term memory. Yin and colleagues (1995) demonstrated that CREB activation gives fruit flies a photographic memory—the ability to remember after just one trial what ordinarily requires many trials. Researchers believe that the physical substrate of memory is stored as changes in neurons along specific pathways. Finally, after decades of speculation, the process of LTP was confirmed by Fedulov and colleagues (2007). This means that, in a sense, memory has been confirmed as a probability that neurons will fire in a particular way.

Chemicals Impact Memory

Many modulatory compounds can enhance or depress recall if given at the time of learning (see Figure 18.3). Researchers suspect that calcium deficiency may be one explanation for the memory loss often experienced by the elderly. Norepinephrine is a neurotransmitter that is linked to memories associated with stress. Recently, vitamin A has been found to assist in memory formation. Phenylalanine, found in dairy products, helps manufacture norepinephrine, which is also involved in alertness and attention. Adrenaline acts as a memory fixative, locking up memories of exciting or traumatic events. Acetylcholine is used in long-term memory formation, and increased levels of this neurotransmitter are linked to subjects with better recall. Lecithin, found in eggs, salmon, and lean beef, may raise levels of choline (which is converted to acetylcholine in the brain) and

Figure 18.3 Chemicals that impact memory



has been shown to boost recall in repeated trials. Some studies even show that the presence of moderate levels of household sugar in the bloodstream can enhance memory, but too much impairs it.

Memory Is State Dependent

Amazingly, mental, physical, and emotional states "bind up" information within that particular state. In other words, anxiety, curiosity, depression, joy, and confidence also trigger information learned while in that state. It's as if the states constitute different libraries: a given memory record can be retrieved only by returning to that library, or physiological state, in which the event was first stored. The following are some practical applications of state-dependent learning:

- Facilitate reviews that engage all five senses.
- Encourage discussions about learners' feelings and emotions regarding new learning.
- Get learners to somehow incorporate the new learning in their personal lives.
- Use storyboards (e.g., oversized comic-strip panels) to present key ideas.
- Make a video or audiotape—the more complex, the better.
- Use peg words to link numbers or pictures to an idea for ease in recall.
- Create or redo a song with lyrics that represent the new learning.

How and where we learn may be as important to the brain as what we learn. Why? Because the success of memory retrieval is highly dependent on state, time, and context. In experiments with color, location, and movement, findings suggest that recency effects are enhanced by identifying the stimulus at the time of the state change. In other words, if you pause and take notice of the circumstances of your learning, it will subsequently be easier for you to trigger its recall.

Context is critical to the memory. Each physiological state is a moment in time that locks together two elements—the mind-body circumstances (e.g., feelings, emotions, arousal) and the contextual circumstances (e.g., sights, sounds, location). Thus, studying and cramming for a final exam may present a problem: if students study in a hyped-up state with coffee or other stimulants to keep them awake, unless they can match this state during test time, they may perform below their abilities.

Have you ever had the experience of hearing a favorite song or melody and suddenly were transported back to a different time and place? Have you ever decided you want something from another room, but once you were there, couldn't remember what it was you came for? So then you go back to the original place in order to remember your intention. These are examples of context-bound memory cues.

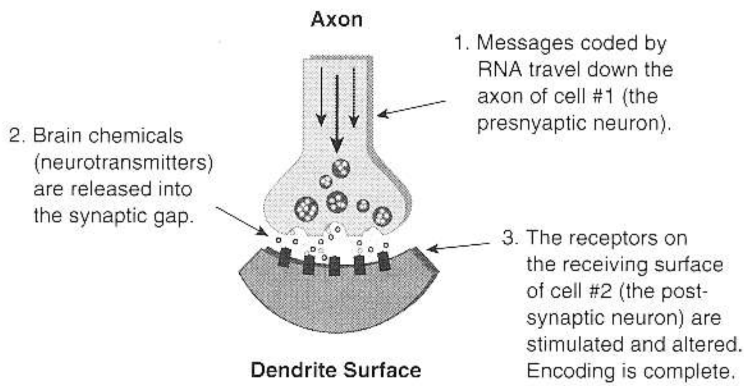
What This Means to You

Many learners may actually know the material they are being tested on but may not demonstrate it well during exam time. If they study under low stress but take the exam under high stress, for example, their brains may recall less efficiently than if the physiological states were matched. With so much subjectivity involved in the evaluation of learning, brain-based learning advocates that learners be evaluated with a wide range of methods and instruments, including portfolios, quizzes, projects, presentations, and tests that consider multiple learning objectives while emphasizing multiple intelligences.

Students who might be thought of as "lazy" learners may, in fact, be simply recalling only what they can. Just because particular students may be good at recalling names and dates doesn't necessarily mean they'll be good at recalling a poem, for instance. Learning is stored in distinctive pathways; if you can't retrieve it through one pathway, it may be accessible via another.

The fact that information is state-bound also lends credibility to the role of simulations, case studies, role-plays, and drama performances in the learning process. This may explain why the physical, concrete learning that happens when students act out new material better prepares them for real life. Pilots use simulators for training, the military creates mock war situations, and theater groups do rehearsals. In formalized learning situations, increased real-life simulation can also increase the applications of the learning. And, of course, this strategy is most productive when physiological, emotional, and mental states are matched as closely as possible between practice and reality. This is why popular self-defense courses that rely on mock attackers are so effective. And for this same reason, fire, safety, and health emergency drills are important and should be rehearsed periodically with some sense of urgency and an appropriate level of intensity.

Figure 18.4 What is memory?



The Role of Glucose in Memory Formation

Some schools have overreacted and decided to ban all sugar products from the school. This may be a poor idea. Extensive evidence indicates that glucose plays an important role in learning and memory. In humans, doses of glucose that elevate blood glucose to moderate levels enhance memory in healthy adults, the elderly, and those suffering from a variety of neurological disorders (Benton, 2001). Although modest increases in glucose typically enhance memory, high concentrations of it have deleterious effects on memory.

A majority of findings suggest that high levels of glucose produce learning and memory deficits (e.g., Korol & Gold, 1998; McNay, McCarty, & Gold, 2001). The ideal is moderate, not low or high, glucose for memory formation. If students cannot have munchies or other snack foods to maintain those levels, there is an alternative. Physical activity stimulates the liver to produce glucose, which may support memory function. This gives you another reason to encourage sufficient movement in the classroom.

Sleep Time's Effect on Memory

Stickgold and Walker (2007) suggest that sleep time may affect the previous day's learning. Cutting nighttime sleep by as little as two hours may impair your ability to recall the next day. The more complicated and complex the material is, the more important sleep is to the learning of it. It is believed that sleep gives your brain time to do its "housekeeping"—to rearrange circuits, clean out extraneous mental debris, and process emotional events. Neural networks can become much more efficient when certain memories are "unlearned," much the way your computer cleans up the desktop. By eliminating unnecessary information (usually during sleep time), the brain becomes more efficient. The fact that you have trouble remembering dreams may indicate how effective your brain is at cleaning up your cerebral house.

What This Means to You

Many learners may need either more sleep or better-quality sleep. Discuss with learners the importance of physical rest and dreaming, and encourage them to get adequate rest at night. Also provide learners with some downtime during the day for optimal brain performance. Give them the opportunity to move around, stretch, drink some water, or change their focus periodically.

Based on what we currently know about the brain and learning, it is appropriate to ask a different set of questions. We used to ask, how can we make sure students learn what is expected of their grade level? Now we ask the following:

- What is the optimal environment for learning?
- What learning strategies have the highest impact at the lowest cost?
- How can we interest staff in making changes?
- How can we find the necessary resources to support these changes?
- What one simple step can I take immediately to improve learning?

In short, the answer to all of these questions is to get proactive and use more brain-based learning strategies. Although you don't have control of everything, it is important to remember that you do have control of a lot.

What This Means to You

Since it seems that literal memory declines throughout the day, rather than forcing learners to pay closer attention in the afternoon, relate learning at this time to their personal experience. Present new information in the morning, and integrate previously learned information in the afternoon. For example, schedule reading, listening, and watching activities in the morning, and role-playing, projects, and simulations in the afternoon.

May, Hasher, and Stoltzfus (1993) set out to determine how recall relates to age and time of day. Their findings suggest that young adults do best on memory recall in the afternoon or evenings, while older individuals perform significantly better in the morning. Given all of the variations in personality types, no matter when you present a particular topic, it is likely to be out of sync, or presented at the wrong time, for about one-third of your learners. However, as May and colleagues found, when adolescents were allowed to learn subjects at their preferred time of day, their motivation, behavior, and scores in mathematics improved.

Of course it is impossible to accommodate every learner's individual time clock; however, numerous practices help make the classroom more accommodating to learners' variations. For example, if a standardized test is always given after lunch, some students will consistently underperform. And if test reviews are regularly scheduled early in the day, learners may better remember semantic material, such as names, places, dates, and facts, but more meaningful connections would be better grasped in the afternoon.

The question then arises: If we know what time of day learning is optimized, what can we do about it?

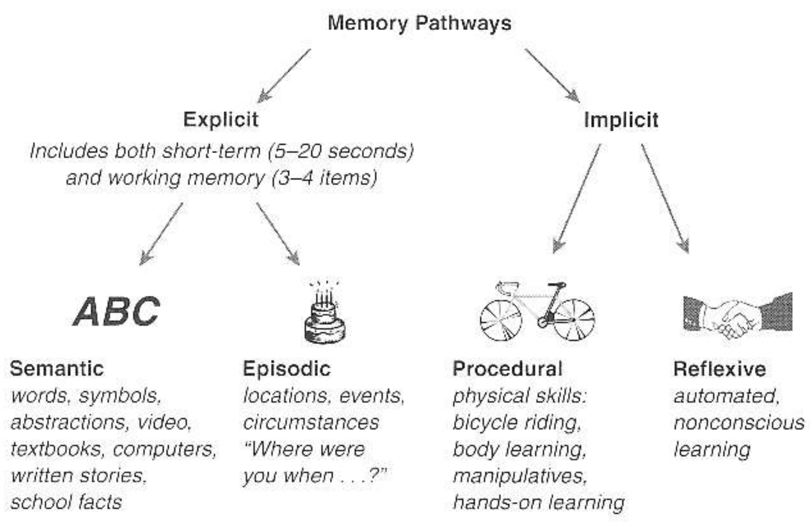
Memory Pathways

Why is it that learners tend to remember much more when learning is associated with a field trip, performance, disaster, guest speaker, complex project, or novel study location? Quite simply, when all of our senses are stimulated and our emotions aroused, multiple memory pathways are engaged. The two major memory pathways we'll focus on for our purposes here are *implicit* and *explicit*, meaning basically that information is automatically learned or learned by effort. These two memory types can be further divided into subgroups, as Figure 18.5 illustrates.

The brain sorts and stores information based on whether it is heavily embedded in context or in content.

The difference between the two primary ways the brain deals with explicit information is simple. Information embedded in context is *episodic* memory, which

Figure 18.5 Memory pathways



means it is stored in relationship to a particular location, circumstance, or episode, and information embedded in content is *semantic* memory (facts), which is usually derived from reading and studying.

Episodic memory forms quickly, is easily updated, requires no practice, is effortless, and is used naturally by everyone. What did you have for dinner last night? This question triggers your episodic memory. Not only will context cues help you remember the answer, a body movement or posture, particular music, smell, sound, sight, taste, and so on can trigger your memory. The formation of this contextual memory pathway is motivated by curiosity, novelty, life experience, and expectations, and it is enhanced by intensified sensory input (sights, sounds, smells, taste, touch). The information can also be stored in a fabric or weave of *mental space,* which is a thematic map of the intellectual landscape, where learning occurs as a result of changes in location or circumstances.

Semantic memory, on the other hand, is usually formed (or attempted to be formed) through rote practice or memorization. It requires rehearsal, is resistant to change, is isolated from context, has strict limits, inherently lacks meaning, and is linked to extrinsic motivation. If I ask you, "Who was the author of that book we read last week in class?" your semantic memory is being tapped. This memory pathway is more difficult to establish; it is unnatural and requires practice and consistent rehearsal to encode. This is why we forget so much of the curriculum we are taught in school. Our episodic memory is absorbing knowledge all the time, which is what the brain attends to first.

Semantic memory (facts and figures) may be a relatively new requirement in the history of humankind.

Engaging Multiple Memory Pathways

It is difficult for the brain to remember content when it is removed from context; yet this is the type of learning typified by traditional schoolwork and homework. How often have you heard or said, "Study for Friday's test by reviewing Chapter 6"? Although this is the least efficient way to learn, it is the way most teachers teach. With some imagination, however, we can create a more context-driven environment that makes learning more memorable—through real-life simulations, storytelling, ethnic celebrations, virtual learning, field trips, and so on. Also, when various cultural viewpoints are presented, the learning becomes more relevant to a greater number of students.

For most teachers, planning time is short, so simple alternatives have to suffice. Although it would be ideal to enmesh students in the places they're learning about, this is unrealistic in many cases. So although a trip to China to learn about the country's political system is out of the question, asking students to plan such a trip is not. Of course, to accomplish the task, they will have to learn something about the political climate, geography, money, language, passports, weather, foods, people, and customs. Students would have to problem-solve, organize, do research, discuss viewpoints, and discover what resources might help them in attending to the task.

Should we throw out book learning? No. Just because the brain is generally very poor at learning this way, the solution is not to discard the source. Semantic learning does have its place. When you ask for directions, for example, you want the shortest route from A to B. You don't want to drive all over the city to figure it out (although that would create a stronger contextual map). On the other hand, if you ask people what of significance have they learned in the past year, 90 percent of what they tell you will probably be contextually embedded information as opposed to rote or semantic learning.

What This Means to You

Learners may seem to forget a great deal of what is taught, but the problem may stem from an over-reliance on a singular memory system. We may have accidentally created generations of "slow" learners who easily forget, and through no fault of their own. There are better ways to reach learners so that recall improves and self-confidence soars. First, do what you can to avoid excessive use of semantic memory strategies.

Through the use of real-life simulations, thematic instruction, interactive contextual learning, and a focus on multiple intelligences, we can activate multiple memory systems so that learning sticks. When you present a new topic, have learners read about it, listen to a relevant lecture about it, discuss it, and watch a related video. Then follow up with complex projects, role-playing, at-home assignments, and related music, discussion, field trips, games, and simulations.

Instead of putting most of the emphasis on memorization and recall, it may be smarter and more efficient to place more emphasis on the context in which something is learned. Contextual learning provides more spatial and locational "hooks" and allows learners more time to make personal connections. Reading, hearing, or experiencing the background on a topic aids understanding and recall. Placing the information being learned into a conceptual context (e.g., historical, comparative) boosts recall.

Other Influences on Recall

Research has verified that an easy way to remember something is to make it new, different, novel. This is because the brain has a high attentional bias toward something that does not fit a normal or expected pattern. When the brain perceives something as different, stress hormones are released, and the result is better attention. If it's perceived as a negative threat, the body may release cortisol, but if it's perceived as a positive stress (challenge), the body releases adrenaline.

The BEM Principle

BEM stands for *beginning, end, and middle*. When information is presented, it is most likely remembered in this sequence. What is presented at the beginning is the most memorable, followed by that which is presented at the end, and finally by that which is presented in the middle. Why does this happen? Researchers speculate that an attentional bias exists at the beginning and end. The novelty factor inherent in beginnings and the emotional release of endings foster chemical changes in the brain. These changes in our chemistry tag the learning and make it more memorable. Figure 18.6 illustrates this memory phenomenon.

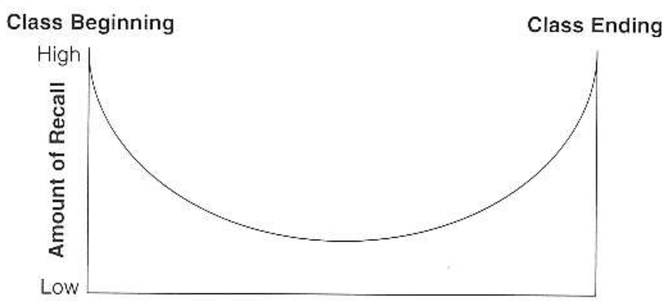
There is a distinctly different mental set at the beginning and end of an experience (anticipation, suspense, novelty, and challenge) than there is at the middle, when the status quo (nothing new, boredom) mental state sets in. Thus, when reviewing a list of items, notes, or facts, or when presenting a lengthy lesson, remember to break up the middle part of the session with some surprise elements, a brain break, and/or some conscious strategies for remembering the material presented.

What This Means to You

Your students may be able to remember much more if you provide more novelty in the lesson plans and more beginnings and ends (with shortened middles). Introduce short modules of learning instead of long ones. Break up long sessions into several shorter ones.

All learning requires consistent review and updating. Even medical doctors are required by law to continue their education. Make time for reviews in class, and consistently draw from prior learning to reinforce connections. There are many ways to keep the memory of learned information alive in your learners. Have students participate in weekly peer-review sessions, or have them create a mind map representing their current understanding of a topic. Assign class murals, mindscapes, and student projects (see Figure 18.7 for more ideas). Continual revision, week after week, encodes the learning in more complex neural networks.

Figure 18.6 Learner recall of class material



We tend to recall most strongly the material that is learned at either the beginning or the end of class.

Figure 18.7 More memory, storage, and retrieval ideas

- Increase the use of storytelling, visualization, and metaphors in your presentations.
- Attach a strong emotion to new learning with a purposely designed intense activity.
- Review or repeat new learning within 10 minutes, then after 48 hours, and again after a week.
- Attach concrete reminders to new learning, like a token or an artifact.
- Act out new learning in a skit or role-play.
- Attach an acrostic to new learning (the first letter of each key word forms a new word) and other mnemonic techniques.
- Depict new learning on a large, colorful poster, and put it up in the classroom.
- Ask students to identify patterns and to look for connections with prior learning.
- Personalize the lesson by incorporating students' names, ethnic customs, and real-life issues.
- Ask learners to summarize new learning with a mind map.
- Give new learning strong context with field trips, guest speakers, and concrete objects to touch and feel.
- Have students identify "What's in it for me?" to increase meaningfulness and motivation.
- Start a new learning session with something exotic, then familiar, then unusual again.
- Increase accountability with frequent reviews and checkups.
- Incorporate real-life problems and situations to teach about content as well as process.
- Facilitate frequent group discussions on new material.
- Incorporate journal writing and other forms of personal reflection.
- Provide downtime and frequent short breaks to consolidate learning.

STUDY SKILLS MASTERY

Students who struggle are not lacking memory capacity but are more likely using a system of thinking and processing that cannot keep up. When learners are instructed in learning-to-learn skills, their ability to process new information can rise substantially. Better study skills upgrade the operating system in the brain instead of just flooding it with more content. New pathways, more efficient pathways, and better connections can boost student learning. If we fail to teach these skills to our students, who will prepare them for a fast-changing global society? What are the key ingredients for study skills mastery? Most sources suggest that learners do the following:

- get proper nutrition and enough sleep
- set goals and develop a purpose
- browse the material, learn how to identify key concepts, and build perceptual maps
- develop mind maps that reflect their thoughts, questions, concerns, and connections to prior learning
- read with a highlighter in hand and make notes in the margins
- summarize what has been learned, reflect on it, and ask questions
- act on the learning, build models, do projects, give PowerPoint presentations, and so on

What This Means to You

Among the many benefits of study-skills programs are that they (1) help students incorporate their preferred learning style; (2) improve students' confidence in learning, thus improving self esteem; and (3) encourage students to become more proactive—to take control of their learning. Ensuring that learners have the study skills necessary to succeed is a worthwhile investment of teaching time.

Importance of Pre-exposure

Pre-exposure to information (or exposure to information on a nonconscious level), sometimes called *preliming*, makes subsequent learning proceed more quickly. The greater the amount of priming stimulus, the more the brain extracts and compartmentalizes (lateralizes) the information (Gratton, Coles, & Donchin, 1992). The brain seems to have a way of putting information and ideas into a buffer zone, or cognitive waiting room, for rapid access. If the information is not utilized over time, it simply lays unconnected and random. But if the other parts of the puzzle are offered, the understanding and extraction of meaning are rapid.

There is a long history of studies suggesting that prior exposure to content (the *priming* effect) or even a simple presentation of questions leads to quicker responses. Learning and recall also increase when a pattern is provided prior to exposing learners to new material. Providing postorganizing clues is also useful as a framework for recall.

Mind Mapping

One of the key characteristics of the cortex is the ability to detect and create patterns of meaning. This process involves deciphering cues, recognizing relationships, and indexing information. The clues best assembled by the brain are those presented in a Gestalt format, rather than a sequential, linear format. Of course, the majority of teachers mistakenly learned that teaching must be sequential and linear to be effective. The result of this traditional approach is bored and frustrated learners.

The brain's capacity to elicit patterns of meaning is one of the key principles of brain-based learning.

Pattern recognition depends heavily on what experience one brings to a situation. Our neural patterns are continually revised as new experiences provide us with additional information, insights, and corrections. In fact, learning is the extraction of meaningful patterns from confusion—in other words, figuring things out in your own way. For young children, cognitive understanding is limited by their ability (or lack thereof) to create personal metaphors or models for the information. This point is quite important with regard to the brain, so here it is again:

> We never really cognitively understand something until we can create a model or metaphor that is derived from our unique personal world.

Many teachers know that comprehension increases when readers create a mental model for the material while reading it. Making connections between the characters' actions and a learner's own goals or values, for example, creates a mental marker in the learner's neural map. Activating these kinds of personal connections results in increased reader recall and comprehension.

Generally speaking, learning results from the operation of neural linkages between global mappings and value centers. Learning is achieved when behavior leads to synaptic changes in global mappings that satisfy set points. In other words, we are learning when we can relate the knowledge from one area to another, and then personalize it. Three essentials of higher brain functions are categorization, memory, and learning. The second depends on the first, and the last depends on the first two. Perceptual categorization is essential for memory, and the value centers for this function are located in the hypothalamus and the midbrain.

Consider this example: When you arrive in a new city, you need to know not only how to get where you want to go but also where you are in relation to your destination. The spatial, contextual relationships are the patterns that help you understand and get around in the world. You might link up information such as where the hotels, entertainment, and McDonald's are with personal meanings, such as why am I here or where should I eat dinner?

What This Means to You

Knowing facts may provide answers at test time, but it is pattern detection that helps learners become thinking adults. Before beginning a new topic, ask your students to discuss it orally or to represent it graphically in a mind map; then post it. This gives the brain an "address" or a visual storage space for the new information. Reduce the amount of piecemeal learning. During a course, continually have students make maps, storyboards, graphic organizers, paintings, models, or other artistic renderings of the material. At the end of the course, ask them to make a video, a play, or a larger, mural-sized map of their learning. The key is getting students to relate the learning to their own lives and increasing the contexts surrounding it.

How Mind Mapping Aids Learning

Did you know that hanging a poster-sized graphic organizer or a mind map on the wall in your classroom can improve learning? It's true! The process of creating a mind-map graphic visual display of a subject depicting key relationships with symbols, colors, and buzzwords creates meaning for the learner. Mapping ideas gives learners a way to conceptualize ideas, shape their thinking, and better understand what they do and don't know. But most important, when learners produce mind maps, it helps them feel as if the learning is really theirs.

Consistent pre-exposure encourages quicker and deeper learning.

Mind mapping is an excellent method for pre-exposing learners to a topic. Through the use of color, movement, drawing, contrast, and organization decisions, information becomes encoded in learners' minds. Once the maps are created, learners can subsequently share them with others, thus further reinforcing the learning.

What This Means to You

Many students who seem like slow learners may simply need pre-exposure to lay the foundation for better comprehension and recall. Pre-expose learners to your topic before officially starting it. First expose them to the topic by mentioning the subject prior to exposure, then post mind maps two weeks before beginning the topic, then preview the texts to be used, and then provide handouts. You can also get learners ready with oral previews, music, personal examples, storytelling, and metaphors. Kinesthetically, you can facilitate role-plays, create simulation situations, or play games that expose learners to the new learning in a subconscious manner.

When prior learning is activated, the brain is much more likely to makes connections to the new material, therefore increasing comprehension and meaning. Let's say you're a student attending a new class and the instructor immediately starts in on the new material. You're lost and overwhelmed in the first 10 minutes. By the end of the first class, you're already worried about how you'll do. Wouldn't it have helped to first find out what you already know and then tie that into the course material?

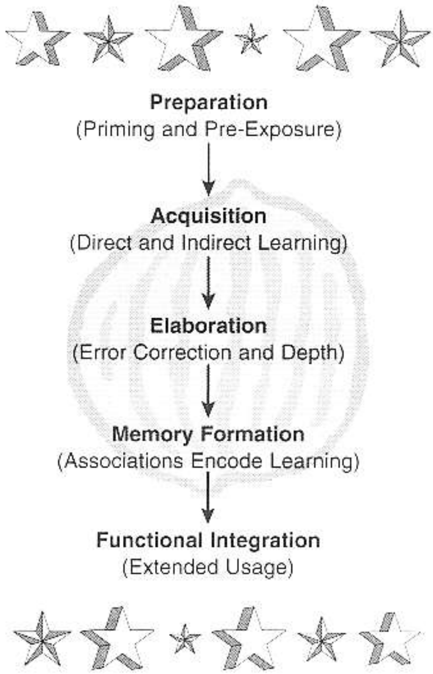
What This Means to You

Many learners who should do well in a subject actually underperform because the new material seems irrelevant. If you don't make connections to students' prior learning, comprehension and meaning may be dramatically lessened. Before starting a new topic, ask students to discuss what they already know about the subject, do role-plays or skits, make mind maps, and brainstorm the topic's potential value.

Stages of Optimal Learning

Classroom learning for explicit material (content with text and/or pictures) occurs in a predictable sequence of five stages (see Figure 18.8). First, *preparation* provides a framework for the new learning and primes the learners' brain with possible connections. The more background learners have in the subject, the faster they will absorb and process the new information. Second, *acquisition* is achieved through either direct means (e.g., providing handouts) or indirect means (e.g., putting up related visuals). Both approaches can work, and they actually complement each other. Third, *elaboration* explores the interconnectedness of topics and encourages depth of understanding. Fourth, *memory formation* cements the learning

Figure 18.8 Five stages of optimal learning



so that what was learned on Monday is retrievable on Tuesday. Finally, *functional integration* reminds us to use the new learning so that it is further reinforced and expanded upon.

Ultimately, learning is the development of goal-oriented neural networks: Remember, single neurons aren't smart, but integrated groups of neurons that fire together, on cue, are very smart. This orchestrated neural symphony is what learning is all about. Elaborate neural networks are developed over time through the process of making connections, developing the right connections, and strengthening the connections. In a nutshell, the three most critical aspects of learning are acquisition, elaboration, and memory formation, which are described in detail below.

Acquisition

The neurological definition of *acquisition* is the formation of new synaptic connections. As described in earlier chapters, the cell body of a neuron has spindly branches (dendrites) and a single longer projection (axon). The cell's axon reaches out to connect with the dendrites on other cells. These connections are formed when the experiences are both novel and coherent. Quite simply, if the input is uninteresting and/or incoherent, only weak connections (if any) will be made. However, if the input is novel and/or coherent, existing connections get strengthened, and learning results.

The first stage of learning is receiving sensory input. A moment of insight does not necessarily translate to learning, but it is a vital step in the learning process. Making connections between cells is one thing; retaining them is quite another. And maintaining accurate connections is yet another. The point here is a critical one: never confuse a moment of insight with learning. *Ha ha* and *Ah ha* have the same impact on the brain, so to remember something, elaboration is necessary. As the Chinese saying reminds us, learning is not a singular event—it is the process of using it over time.

AH HA! HA HA! Both are the same type of neurological event from the point of view of how we learn and remember. Both are moments of insight, which trigger chemical releases, but unless processed for depth, meaning, and storage, these moments weaken.

Remember, making connections is not enough. We need to elaborate on them to make the right ones, strengthen them, and integrate them into other learning. Thus, the acquisition stage involves making connections, that is, getting neurons to "talk" to one another. The sources for acquisition are endless. They may include discussion, lecture, visual tools, environmental stimuli, hands-on experiences, role modeling, reading, manipulatives, videos, reflection, group projects, and pair-share activities. But remember that this first step of making a connection is highly dependent on prior knowledge.

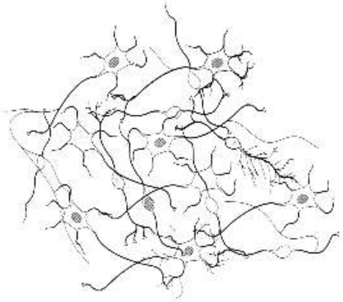
What This Means to You

Pre-exposure provides learners with a foundation on which to build connections. The more background you provide, the better and faster learning will occur. Let learners be surprised by the process rather than the content. Post a summary of what will be learned a month in advance, and suggest to learners that they start exploring the subject with video previews, museum visits, library exploration, TV viewing, and so on. The more they know before they get to you, the better off they'll be and the more fun you'll have together. Pre-exposure is a strategy that has been used at the college level for some time. University students often review the texts their professors will be using before the first day of class.

Elaboration

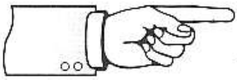
An enormous gap exists between what a teacher explains and what learners understand. To reduce this gap, teachers need to engage students for deeper understanding and feedback with implicit and explicit learning strategies (see Figure 18.9). If you don't know what students don't understand, how can you elaborate effectively? Making corrections as we go along is a critical approach for teaching with the brain in mind. Once a learner is lost, the brain somehow switches off. Experienced brain-based instructors adjust their course before this happens.

Figure 18.9 Explicit and implicit learning



Explicit Learning	Implicit Learning
• Discussion	• Simulations
• Reading	• Theater Projects
• Listening	• Field Trips
• Spelling	• Role-plays
• Math Facts	• Complex Games
• Q and A	• Role modeling
• Worksheets	• Life Experiences
• Lectures	

The larger pattern or model is just as important (or more so) than the data itself.



What This Means to You

Implicit and explicit approaches are useful in the elaboration stage. Explicit strategies, such as answer keys, peer editing, debriefing, or videotaping provide valuable student feedback, but this feedback can also be provided in a more subtle or nonconscious fashion with implicit strategies, such as simulations, role playing, role modeling, field trips, complex games, and real-life experiences. Elaboration gives the brain a chance to sort, sift, analyze, test, and deepen the learning. When multiple sources of feedback are engaged, not only do students learn more, and more accurately, but their intrinsic motivation is deepened as well.

In the elaboration process, students learn to review and evaluate their own and others' work and receive constructive feedback in a productive way. This is the step that ensures learners aren't merely regurgitating rote facts but are developing complex neural pathways that connect subjects in meaningful ways. This stage is a precursor of remembering.

Memory Formation

After incorporating the elaboration strategies described above, you'd think that learners' brains would have permanently encoded the day's learning.

Unfortunately, it's not quite this simple. Sometimes even after learners are provided with plenty of opportunity for experimentation and interaction, the memory trace is still not strong enough to be activated at test time. Additional factors that contribute to the issue of retrievability include adequate rest, emotional intensity, context, nutrition, quality and quantity of associations, stage of development, learner states, and prior learning. All of these encoding factors play a vital role in the depth of processing and learning that occurs. As you make your way through the following chapters, these factors will be addressed in more detail.

New Learning Maps

It wasn't long ago that we thought more learning simply "filled up" the brain with ideas and facts. But no responsible scientist 50 years ago would have thought that learning physically changes the quantity and size of cells and the connections as well the area they take up in the brain. Yet we now know that learning physically changes the brain. In fact, if a musician plays an instrument over time, the corresponding area of the brain (the motor cortex) actually gets larger as more and more cells become involved in the process (Pantev et al., 1998). Every new experience we encounter actually alters our electrochemical cellular and chemical maps. The more novel and challenging the stimuli (up to a point), the more likely it will be to activate a new pathway. The new learning happens like this:

- A new experience may trigger an electrical impulse from the cell body.
- It travels down the axon of a neuron and triggers the release of chemicals (neurotransmitters).
- Included with these chemicals are messenger ribonucleic acids (mRNA), which are the molecules that carry information.
- Simultaneously, a process known as *synaptic adhesion* takes place by using protein "strings" to help bind the two neurons at the synapse.
- The mRNAs and the other neurotransmitters dock into receptor sites on the surface of the receiving dendrite.
- When the electrochemical threshold is reached, long-term potentiation is created. This is a use-dependent alteration in the strength of the synaptic connections.
- This reaction stimulates new electrical activity in the dendrite, sending it toward the cell body of the receiving neuron.
- Many factors influence the efficacy of this connection, including chemicals known as *neuromodulators* (i.e., stress hormones).
- Learning is the result of the strengthening of the connection between two neurons.

If the stimuli are not considered meaningful to the brain, the information will be given less priority and will leave only a weak trace. If the brain deems something important enough to commit it to long-term memory, a memory potential occurs.

Bigger changes can happen when we compound our experiences over time. While one good day or one bad day won't usually change the brain, over the course of months and years, a new process can. The body has 50 trillion cells, and every cell has tulip-shaped receptors that receive information. Different cells have different receptor sites for different molecules. Things such as light or heat activate some receptors, whereas histamines, stress hormones, nutrition, or androgens active others. Amazingly, receptor sites don't just process this information, but they begin an electrochemical cascade of activity that can eventually affect our genes (Giancotti & Ruoslahti, 1999). So while there is a core of genes that maintain your basic functions, often called *housekeeping genes,* there are thousands of others that are responsive to environmental signals.

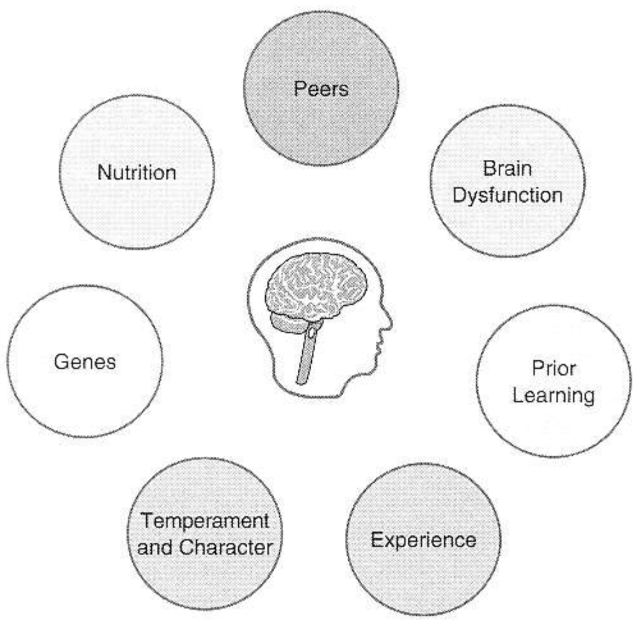
Gene expression has been known about for decades. This simply means that genetic material gets used strategically. How does gene expression turn into changes in behavior? It's a sequence of steps whereby the messaging from genes activates proteins, which influence our behavior. Remember that genes are blueprints, and just like blueprints for a house, they are useless without a contractor to turn them into a "home." For decades, the body and brain were thought of as a one-way street, unfolding from genes outward. The new science tells otherwise. It's actually a two-way street, where genes influence our lives and our lives influence our genes. The meaning of this is profound. The fact that the process goes *both* ways is a revolution in biology, and we now know that it is possible to influence gene expression purposefully, which has implications for educators.

At each stage of development, particular genes are affected by particular environmental factors. Recent research has focused on what has been called *windows of opportunity*: a period of heightened readiness for learning. It is thought that exposure to appropriate stimuli during these peak times can optimize a child's natural appetite for learning—especially learning related to language, music, and motor development. Genes are not templates for learning, but they do represent enhanced risk or opportunity. Thus if children are born with the genes of a genius but are raised in nonenriched environments, the chances of their actually becoming geniuses are low. On the other hand, children with average genes who are raised in supportive and intellectually stimulating environments may achieve greatness by virtue of their enriched environments.

Neural networks are developed through trial and error. The more experimentation and feedback, the better the quality of the neural networks. Smarter humans don't always get the answers first, and they don't always get them right. But they do eliminate wrong answers better than their peers. This ability to avoid bad choices is a result of trial and error, not of someone else telling us the right answer and then having us repeat it back to them. This type of rote learning may produce high scores on a standardized test, but it does not produce high-level thinking.

Typical learners arrive not with blank slates but with highly customized brain banks of experience. Their cognitive maps are already a reflection of much more than just previous grade coursework and test scores. This, in fact, is only a small sliver of the neural pie. Even by preschool age, learners' brains have already been shaped by a multitude of influences, including home environment, siblings, extended family, playmates, genes, trauma, stress, injuries, violence, cultural rituals and expectations, enrichment opportunities, primary attachments, diet, and lifestyle (see Figure 18.10). Even a seemingly trivial incident like a bump on the head can have a lifelong impact on learning ability. For example, if the fragile temporal lobes (or other key brain areas) are injured, a child may experience emotional, processing, and/or memory function problems. And it is likely that the association between the head injury to the learner's challenges will never be made. This example illustrates the complexity of issues that educators face.

Figure 18.10 Influences on learners



20 Enriching the Brain

CHAPTER OUTLINE

Typically we think of intelligence as a combination of both environment and genetics. Genetics means "you are mostly what your parents gave you" and "things won't get much better—at least not in the brains department." In fact, for most of scientific history, the prevailing paradigm was that humans have a brain of fixed capacity. We fill our brains with experiences and memories, people thought. Of course, this brain grows some in size after birth—but it was believed that it reached adult size by 10 years old. This traditional wisdom told us that intelligence was a fixed number (IQ), and it stayed that way. This idea of an immutable brain was adopted by many early educators who, once some learners were identified as slow and some as gifted, kept these learners sequestered with peers, as if each had a communicable disease. We now have special ed, regular ed, and gifted ed almost as if we were sorting laundry or nuts, bolts, and washers. The prevailing view—still found in many schools today—is that students will continue to be the way they are right now. This belief is so widespread that it's the dominant model for most public and private schooling.

The "fixed brain" theory is not just dead wrong, but—embarrassingly—it may be doing a great deal of harm. The human brain is so malleable that it can be fixed at artificially low levels by getting a constant diet of a below-average status quo. Millions of students young and old begin to believe that their intellectual destiny is stuck at entry-level testing scores. As a result, millions live far below their biological potential. Here's an exciting thought: Enrichment is the whole purpose of schooling. There is no other reason to send a kid to school unless we are enriching the mind, body, soul, and brain. This chapter is about how to fulfill that potential. Enrichment is an exciting concept, and it can apply to everyone.

GROWING A "BETTER" BRAIN

Can we grow a better brain? The answer seemed to be "no." Many consider Canadian psychologist Donald Hebb to be the original trailblazer in the world of changing brains. Sitting at home and watching as his pets roamed the house, he got an idea. Why not test which was better for an animal—free roving or cage raised? It didn't take long for him to test his hypothesis. Naturally, the free-roving rats did better on maze running. Hebb realized that the brain changes as a result of the environment. His 1949 book, *The Organization of Behavior*, remains a classic to this day.

In 1964, biopsychologist Mark Rosenzweig, of the University of California at Berkeley, led a research team that revealed that rats in an enriched environment indeed grow better brains than those in an impoverished environment (Bennett, Diamond, Krech, & Rosenzweig, 1964; Rosenzweig, Love, & Bennett, 1968). The evidence that an enriched environment could enhance brain development was supported further in groundbreaking research by University of California, Berkeley, pioneer Marian Diamond (see Diamond & Hopson, 1998) and, separately, by University of Illinois researcher William Greenough (Greenough & Anderson, 1991). Based on these pioneering studies and many subsequent to them, we now know that the human brain actually maintains an amazing plasticity throughout life. We can literally grow new neural connections with stimulation, even as we age. This means that nearly any learner can increase his or her intelligence, without limits, using the proper enrichment.

Initial studies with rats were eventually extended to human subjects. The animal studies suggested that, when exposed to an enriched environment, the number of connections in the brain increased by 25 percent. Diamond (see Diamond & Hopson, 1998) found that increasingly enriched environments led to larger and heavier brains, which meant that the nerve cells were better able to communicate with each other. She also saw that larger nerve cells resulted in more support cells and increases in the dimensions of the synapses between cells.

Eventually, we learned that in addition to increased dendritic branching, synaptic plasticity was evident in enriched environments. We now know how the brain modifies itself structurally and that it is dependent on the type and amount of usage. Synaptic growth varies depending on the complexity and type of activity we regularly engage in. For example, when we engage in novel motor learning, new synapses are generated in our cerebellar cortex. And when we engage in repeated motor learning (or exercise), our brains develop greater density of blood vessels in the molecular layer.

An area of the midbrain, the superior colliculus, which is involved in attentional processing, has been shown to grow 5 to 6 percent more in an enriched environment. Using functional magnetic resonance imaging (fMRI) technology, researchers at the University of Pennsylvania discovered that the human brain has areas that are stimulated only by letters, not words or symbols (Ackerman, Wildgruber, Daum, & Grodd, 1998). This suggests that new experiences (e.g., reading) can get wired into the malleable brain. In other words, as we vary the type of environment, the brain varies the way it develops.

The brain changes itself in several ways. First, intrinsic forces, otherwise known as *genetics* or *prewiring*, create a template for processes that drive change in the brain. Second, *experience expectant* processes create massive overproduction of synapses prior to (not after) demand; this occurs when (1) the learning is commonly needed by all members of that species, (2) certain events will reliably occur, and (3) the timing is relatively critical. And third, the brain responds to *experience dependent* processes triggered by environmental stimuli.

A Biological Look at Enrichment

When scientists extended enrichment studies to human subjects, they found definite correlations with the animal studies. University of California, Los Angeles, neuroscientist Robert Jacobs and colleagues found in autopsy studies that graduate students had 40 percent more neural connections than high school dropouts did (Jacobs, Schall, & Scheibel, 1993). The graduate students, who were presumably involved in challenging mental activities, also exhibited 25 percent more overall brain growth than the control group. Yet education alone was not the only differential; the learning experiences needed to be frequent and challenging for the effect to occur. Graduate students who coasted through school exhibited fewer connections than those who challenged themselves daily.

The research by Jacobs and colleagues (1993) on cortical dendrite systems in 20 neurologically normal right-handed humans (half male and half female) evaluated the following variables:

- total dendritic length
- mean dendritic length
- dendritic segment count
- proximal versus ontogenetically later-developing distal branching

These variables are known to relate to the complexity of the brain, the ability to solve problems, and overall intelligence. Jacobs and colleagues investigated several independent variables, as well: gender, hemisphere, and education. The results of their research revealed the following:

Gender: Females had greater dendritic values and variability than males.

Hemisphere: The left hemisphere had greater overall dendritic measurements than the right, but the results were not consistent with each individual.

Education: Level of education had a consistent and substantial effect on dendritic branching; the higher the level, the greater the measurements.

Can enrichment actually make you smarter? The answer to this question is still unclear. But Calvin and Ojemann (1994) say that cortical-area growth does have something to do with being "smart," even though the internal efficiency of our wiring and connections is more significant. A student's early sensory deprivation can play a role as well: as a result of negative experiences, the brain sheds the wrong synapses and ends up malfunctioning (Fuchs, Montemayor, & Greenough, 1990). Retaining excess synapses can be harmful, as in the case of Fragile X mental retardation.

Summary of Enrichment Findings

Enhanced environmental stimulation can affect the brain in many ways. Studies have described at least six fundamentally different effects:

- **metabolism:** chemical allostasis and blood-flow changes (changes in the metabolism and chemical baselines of key brain chemicals)
- **physiological effects:** enhanced anatomical structures (neurons and other cell structures may be larger)
- **mapping:** increased connectivity—new circuitry (far more branching from one neuron to another)
- **responsiveness and learning efficiency:** electrophysiological changes (cells may be much more efficient and have greater plasticity, meaning that one can learn faster)
- **increased neurogenesis and growth factors:** increased production of new brain cells, supporting better learning and memory
- **recovery from tissue, drug abuse, and system damage:** greater capacity to heal when damaged

In working with children, Craig Ramey (1992), at the University of Alabama, found that he could increase intelligence with mental stimulation. His intervention program studied children of low-IQ parents. Divided into two groups (one control group), the children who were exposed to the enriched environment scored significantly higher (20 points) on posttreatment IQ tests. And the results lasted: when the children were retested after 10 years, the effects of early intervention had endured. This provides quite an endorsement for challenging learning environments.

Human Neurogenesis Is Possible

Early studies demonstrated that enrichment of the brain leads to greater spine growth on the dendrites (connection points for cell-to-cell interaction), heavier cell bodies, longer dendrites, and more glial (support) cell growth. As early as 1965, Altman and Das claimed that the mammalian brain can not only grow better dendrites but also grow new cells (*neurogenesis*). The scientific establishment, however, was not ready for this radical claim. The mainstream thinking was that, yes, the human brain can be enriched, but growing new cells was impossible.

Then in 1997, a research effort led by scientists at San Diego's Salk Institute of Neuroscience discovered that neurogenesis is, in fact, a reality in rat brains (at least in the hippocampus; O'Leary, 1997; Van Pragg, Kempermann, & Gage, 1999). A year later, the study was extended to humans, and the findings were reconfirmed (Eriksson et al., 1998). The human brain also has the capability of growing new neurons!

Even though we inevitably lose brain cells each day, new ones can be germinated in a fertile environment. The impact of this finding on the general public has yet to be fully realized, but the scientific community is buoyed by the medical potential of these recent findings. Injuries once viewed as permanent may soon be repairable with accelerated cell-growth prompting. A cure for the dreaded Alzheimer's disease may soon exist. Although we are still a long way from the reality of these prospects, scientists are hopeful.

The Keys to Enrichment

In examining the many enrichment studies that have been conducted over the past few decades, the following common factors have emerged:

Novel Learning

First, to get the enrichment effect, the stimulus must be new. An old stimulus just won't do; it must be novel. Second, the stimulus must be challenging. Routine efforts do little for the brain's growth. Third, the stimulus must be coherent and meaningful. Random input will not enrich the brain. Fourth, the learning has to take place over time. How much time depends on the extent of the neural changes, but the only changes that happen instantly are stimulus-response learning. And finally, there must be a way for the brain to learn from the challenging, novel stimuli; the brain needs feedback. For example, if you're learning to walk a tightrope and you make a mistake, you fall: that's feedback. If you press a lever, you get food or you don't: that's feedback. The more consistent, specific, timely, and learner controlled the feedback is, the better. There you have it! In a nutshell, the critical ingredients for enriching the brain are novelty, challenge, coherence, time, and feedback (see Figure 20.1).

What This Means to You

Create a more multisensory environment. Add posters, aromas, music, and relevant activities. Increase social interaction and group work. Move to novel locations frequently (e.g., take fieldtrips, go outdoors, exchange rooms with another teacher for the day). On a daily basis, modify the environment in some minor way (e.g., seating, displays, bulletin boards). Encourage students to explore new ideas and express themselves creatively. Provide quality, not just quantity, time. Teach and practice critical skills such as logic, categorizing, counting, labeling, language, cause and effect, debate, and critical thinking. Provide positive feedback, and celebrate accomplishments with fun celebrations. Use words from several languages in a variety of contexts. Reduce all forms of severe negative experience, punishment, or disapproval. And most of all, offer students choices so that their learning is meaningful.

Diamond and colleagues have researched a number of enrichment effects, including a thicker cortex (Diamond, Krech, & Rosenzweig, 1964) and increases in the size of neurons (Diamond, Lindner, & Raymond, 1967). In addition, researchers have found increased dendritic length (Green, Greenough, & Schlumph, 1983) and more complex (higher-order) branching on the dendrites

Figure 20.1 Enrichment keys

☑ **Challenge**
time • standards
resources • circumstances

☑ **Novelty**
contrasting • new

☑ **Feedback**
timely • specific • in control often

☑ **Coherence**
meaningful • choice

☑ **Time**
greater changes need more

(Juraska, Fitch, Henderson, & Rivers, 1985), better enabling them to make more future connections (Volkmar & Greenough, 1972). It sounds as if all of these changes would add mass to the brain, and they do: brain weight increases with enrichment (Altman, Wallace, Anderson, & Das, 1968; Bennett, Rosenzweig, & Diamond, 1969).

Arnold Scheibel, director of the Brain Research Institute at the University of California, Los Angeles, has said that unfamiliar activities are the brain's best friend. The fact that the brain is so stimulated by novelty may be a survival response: anything new may be threatening to the status quo and, thus, represents a potential danger. Once we have grown accustomed to an environment or situation, however, it becomes routine, and the reticular formation in our brain begins to operate at a lower level. Once a new or novel stimulus is reintroduced, the reticular formation gets alerted once again, and the brain is stimulated to grow.

The work of Greenough and colleagues (1992) and Black (1989) confirm that for the enrichment effect to occur, the challenges presented must engender learning, as opposed to being mere activity or exercise. When Black isolated other factors, such as aging and stress, from complex environments, he affirmed that it was the learning, not simply the motor activity, that caused optimal brain growth. This tells us that *how* you enrich an environment is critical.

The enrichment effect does not necessarily take months or years to show up. Significant structural modifications in the dendritic fields of cortical neurons have been reported after just four days. Greenough and Anderson (1991) suggest that brain enrichment happens in stages—from surface level to depth growth. They draw four important conclusions:

1. Rats in enriched environments grow heavier brains with more dendritic connections that communicate better. They also exhibit increased synapses, greater thickness in sensory areas, increased enzymes, and more glial cells (which assist in growth and signal transmission).

2. Enriched environments need to be varied and changed often (every 2 to 4 weeks) to maintain the positive differences in rat intelligence. In studies, this meant frequently introducing other rats, more toys, and additional challenges; this holds true for humans as well.

3. Rats of any age can experience increased intelligence if they are provided challenging and frequent new learning experiences.

4. The real world—outside the cages (even the enriched ones)—provides one of the best environments for brain growth.

Schools today are developing greater interest in creating the right kind of enriched environments for students. One of the most convincing arguments comes from the former director of the National Institute of Mental Health, Frederick Goodwin. He says you can't make a 70-IQ person into a 120-IQ person, "but you can change their IQ in different ways, perhaps as much as 20 points up or down, based on their environment" (quoted in Gordon, 1999, p. 298).

Have you ever noticed how much more passion and motivation learners exhibit when they are talking about real-world experiences versus book learning? Real-life learning provides a valuable springboard for delving deeper into the meaning or analysis of things. Some learning opportunities that inspire this type of reflection include field trips, travel or study abroad, library study, the home environment, the park, on-the-job training, a convention, a rally, a special meeting, or vacation—anything rich and varied that naturally occurs in life.

Feedback Spurs Learning

While enriched environments (both mental and physical) are important, research by noted brain expert Santiago Ramon y Cajal (1988) emphasizes that the brain needs feedback from its own activities for optimal learning.

The best feedback is immediate, positive, and dramatic.

Feedback is critical, but it does not necessarily have to be teacher generated. One of the best ways to encourage self-feedback and boost thinking is to have learners reflect and record audio of their own perceptions. This examination into one's own thinking, sensing, and organizing process provides a powerful vehicle for the brain's development as a problem solver and as a thinker.

A teacher's greatest feedback resource may be other learners. And yet, many learning environments are not organized to take advantage of this asset. Group work and teams are ideal for learning, especially when they are multiage and multistatus groupings. Group work can help learners feel valued and cared for, in which case their brains release the neurotransmitters of pleasure: endorphins and dopamine. This helps them enjoy their work more. Groups also provide a superb vehicle for social and academic reinforcement. When students talk to each other, they get direct feedback on their ideas as well as their behaviors.

The most effective feedback is specific and immediate. Video games and computers both meet this requirement, as does peer editing of a student's story. Also, interaction among learners and with outside sources can provide valuable feedback. A great deal of feedback is obtained nonverbally; facial expressions and body language tell us a lot about our performance on a nonconscious, if not conscious, level. Building a classroom model, playing a learning game, creating a class video, and planning a community project are all activities that provide indirect feedback from the interaction process.

Ideally, feedback involves some learner choice. That is, it can be generated and modified at will. If it's not relevant or if it cannot be immediately applied, however, performance won't be altered. Recall a college class in which your only feedback may have come from a midterm or final exam. That's an example of poor, other-controlled feedback. Fortunately, immediate and self-generated feedback can be achieved in many simple ways. For example, have learners review their own work against performance criteria, provide self-assessment guidelines, post grading criteria, have students review their personal goals, and use computer learning programs if appropriate.

To summarize what we've learned about enrichment, consider the following:

- Learners do best when they are presented with novel stimulation—something out of the ordinary.
- Beware of learner overload. Don't provide too much new material at a time. A presentation of 30 to 90 minutes with intense (preferably nonstop) sensory stimulation is good, followed by a rest period.
- Provide proper downtime after new learning. Repeat new learning 24 to 48 hours after the initial encounter, then daily, and then every other day.
- Interacting with peers, teachers, or other adults regarding the subject matter allows learners to create a conceptual framework for the learning and gather critical feedback.
- Consistent feedback helps learners improve the quality of their understanding and observe their own progress.
- When learners are provided with a roadmap or framework for the new learning—an overall picture of where they are and where they are going—understanding is enhanced.

Activating More of the Brain

Intelligence is largely the ability to bring together random bits of information to inform thinking, problem solving, and analysis. The brain relies on a multitude of circuits to do this effectively. These connections are called *phase relationships* because they tie together simultaneous stimuli. When learners are provided with more consistent feedback and better-quality feedback, they are better able to tie pieces of the learning puzzle together and integrate the information into higher-quality relationships and patterns.

Many of the great thinkers in history (e.g., Leonardo da Vinci) kept elaborate journals of their work. Perhaps these recordings represent a sort of self-feedback mechanism. As a child, you had plenty of environmental stimulation, but you also got all-important feedback. When you first learned to ride a bike, you experienced immediate and conclusive feedback: you either stayed up or fell down. Imagine trying to learn to ride a bike without knowing how you were doing until a month later. You would go nuts! We may be accidentally retarding thinking, intelligence, and brain growth, and ultimately creating slow learners, through lack of feedback and the wide lag time or feedback loop we have built into the typical learning environment.

If after reading this chapter, you want to start increasing the enrichment opportunities in your teaching/learning environment, begin first by simply increasing the frequency and quality of learner feedback. With this intervention alone, you will notice immediate improvement in learners' motivation and achievement.

What Have We Learned?

The results of over 40 years of enrichment studies have suggested that no single experimental variable can account for all of the effects of an enriching environment. Because of the wide variance of models used to study enrichment, both the variables and the effects create a complex puzzle. There is also no standard protocol for all enhanced, complex environmental studies, and while mammals have been used extensively, no one at this time can safely extrapolate all studies to all species. The results are far from final, and more studies always need to be done. Having said that, we can reliably draw some conclusions about the key factors. The single strongest thing to keep in mind is contrast. The greater the contrast from the prevailing or preexisting environment, the greater the benefit. Now, contrast of what to what?

These factors have been shown to create the "delivery" of the contrasting effects:

- **Physical versus sedentary activity**
  the ideal is voluntary, gross-motor-muscle effort
- **Novel, challenging learning versus doing what is already known**
  the ideal is learning tasks that are meaningful to the subject
- **Coherent complexity versus boredom or chaos**
  the ideal is busy, but not overwhelming
- **Managed stress levels versus distress or threat**
  the ideal is low to moderate stress, a healthy concern
- **Good nutrition versus a bland, fatty, or low-nutrient diet**
  the ideal is a balanced, low-fat, high-nutrient diet
- **Sufficient time versus minutes, hours, or days**
  the ideal is weeks, months, or years for the conditions to become lasting
- **Social or community support versus being alone**
  the ideal is having positive status in a safe, affiliated social group

Notice what's not on the list. Specific experimenter actions and things—lectures, posters, mobiles, pets, music—have no guaranteed benefit. Each of those might contribute in some way, but no enrichment studies conducted thus far can prove that any specific element helps make for an enriched environment.

How Much Enrichment?

Enrichment is all about contrast. If a student is in an impoverished environment at home for eight hours a day, then gets one hour of enhancement at school, that one hour constitutes only a tiny fragment of the total. That one hour is unlikely to produce substantial long-term benefits, though it's certainly better than nothing—and adding more hours can produce more striking benefits relatively easily. If, in contrast, a student's prevailing environment is already fairly enriched, even five hours a day of positive school enhancement will have to be very targeted to skills and knowledge that the student does not already have to be of value.

How do average students use their 24 hours a day of allotment? Let's use the following as just an average:

- sleep time = 7 hours (varies from 6 to 9 depending on the child)
- daily routines of eating, dressing, grooming, home chores = 3 hours (varies from 2 to 4 hours depending on age, interests, and gender)
- commuting to and from school, doing homework, and relaxing = 3–6 hours (varies from 2 to 4 hours depending on age, interests, and gender)
- school time = 6 hours (varies from 5 to 7 hours depending on grade level or extracurricular activities).

Out of the 6 hours, at least an hour is spent (over an entire year, as an average) on classroom routines, transit time, or testing. This leaves the potential for school enrichment at just 5 hours per day. Remember, this also has to include any time for part-time jobs, video games, studying, or hanging out with friends. This means school time (5 good hours) and "off time" (5 good hours) are both about the same. That's approximately 10 hours a day that are up for grabs for many students. To maximize the enrichment response, you'd want as many of those 10 hours per day to be enriching.

Possibly the entire intake process for so-called enrichment programs may need to be reexamined. They should include a detailed student and parent lifestyle profile. As an example, students who come from homes with just a magazine or a book for reading material and a stay-at-home diet of constant TV are clearly not getting enriched. There are huge opportunities for their brains to become enriched if schools do a strong inventory of students' skills, aptitudes, and interests.

Many of the parents who take their children on airplane trips and to concerts, museums, and fairs, and engage in rich dialogue are most likely doing many positive things for their children, and it's just as important that the schools conduct the previously mentioned inventory. These students may need programs that target lateral enrichment (learning a wider range of skills, developing emotional intelligence). Or they may need more vertical enrichment (the opportunity to dig deeply into individual subjects or skill areas via project learning). If students get into special education programs via testing, the same can be done for the rest of the students.

Changing the Brain—On Purpose!

The enrichment response indicates two primary benefits that may interest educators. The first involves learning and memory; the second involves repair and renewal in cases of brain injury, impairment, and disorders. The first change suggests that we may be able to affect the cognition of all learners, from the average to the gifted. The second change suggests that we may be able to improve the cognition of those with impaired learning, the disadvantaged, or those with brain damage. But there is another option for changing the brain, and parents, educators, and trainers should know how the brain changes in order to better implement their change policies.

The enrichment response is the result of a positive, contrasting environment. But what if you can't change the subject's whole environment? What if you can change only a few localized variables? If the rest of the environment stays the same but the subject is getting a specific skill that's new to the brain, the brain is still likely to change—it's just a different type of change. The ability to change the brain on purpose (i.e., with the cooperation of the subject) can happen because of *neuroplasticity*: the capacity that allows for region-specific changes. It's what occurs when the impact is narrow, such as that of playing the piano over time or being exposed to a localized head trauma. Neuroplasticity is a significant quality that allows for a change in the structure, topology, mapping, or function of the brain—but it can be a negative force, too. People who are consistently violent could literally train and design their brains for more violence. Unfortunately, the evidence suggests that the general capacity for neuroplasticity diminishes a bit with increasing age; fortunately, though, it remains present throughout life.

Enriching the Environment

When a sufficient number of positive factors are brought to bear, it is not unreasonable to speak of enriching the brain. Generally, with environmental enrichment, the changes are less specific to a spot in the brain (though the differences can certainly be located and quantified) and are more of a global experience. In a profound way, environmental enrichment is different from all other forms of experience. It has a far more global and quite widespread effect across the brain that can be summed up as follows:

> Enrichment is a biological response to a positive, contrasting environment in which measurable, global, and synergistic changes occur.

The term *enrichment classes* is commonly used, and people speak of *enriching experiences*. Such phrases tend to involve social, political, and educational definitions that may differ from the biological one I tend to use. But you cannot know if something is an enriching experience before the event itself. Enrichment comes about only as a result of a contrast; without a contrast from the prevailing environment, no enrichment can take place. Make your classroom and your school as big a contrast as you can from the students' daily experience. That's what will maximize brain development.