# LECTURE 2:
# THE NORMAL BRAIN & THE DISORDERED BRAIN

***Focus:* The structure and function of the normal brain, mental health disorders as brain disorders, the brain and learning.** [SLIDE 4]

> [SLIDE 5] *I think educators ought to be interested in the brain because they teach brains! If you're a classroom teacher, you've got about 30 of them in your room and I can't imagine somebody who would teach a room full of brains who wouldn't be interested in brains. If you're involved in the development and maintenance of a brain, you need a kind of knowledge that is more than folklore knowledge.* (Robert Sylwester, Educator, quoted in D'Arcangelo, 2000)

An introductory knowledge of the brain is essential for today's teacher, so we'll start with the structure and functioning of the normal brain. Then we'll look at some of the ways the brains of children with mental health disorders differ from normal brains. The scientific information in this lecture is the foundation for the classroom accommodations and positive behavior supports presented later in this unit.

As well as introducing some fundamental brain structures, the lecture includes information on the process of information transfer within the brain (learning and memory). Two brain regions will be examined in more detail due to their implications for classroom activities.

The human brain is more complicated than any computer. It weighs just 3 pounds, but commands and controls every aspect of our lives.

> *Your brain determines how you think, how you feel, how you act, and how well you get along with other people. Your brain even determines the kind of person you are. It determines how thoughtful you are; how polite or how rude you are. It determines how well you think on your feet, and it is involved with how well you do at work and with your family. Your brain also influences your emotional well-being and how well you do with the opposite sex.* (Amen, 2002b)

Knowledge of specific brain regions has become quite detailed. Brain damage of any origin reveals itself in the day-to-day activities of the child or adult; but now practitioners are able to visualize the specific interruptions of activity in one brain area or the disruption of communication between different sections of the brain (Lehr Jr., 2003).

**PLEASE NOTE:**

Slides for this lecture can be downloaded at no charge from www.macmh.org.

## RISK FACTORS

**[SLIDE 6]** Because the brain and its processes are so complex, there are many opportunities for malformations or malfunctioning that may be temporary or permanent. These may reveal themselves in learning disabilities, mental health disorders, behavioral disorders, or any combination. Risk factors for brain disorders include (Hall & Inder, 2000):

- Genetic vulnerabilities or predispositions.
- Prenatal or early childhood exposure to toxins (including alcohol, lead, and some prescribed medications).
- Chronic stress and anxiety.
- Situational crises (including abuse, neglect, and emotional trauma).
- Malnutrition, especially prenatal and in the newborn period.
- Disease, especially with high fever.
- Traumatic head injury (including minor bumps and resultant concussions).
- A combination of these factors.

**[SLIDE 7]** Some of these factors fall into the traditional category of "nature" and some into "nurture." Modern science seems to indicate that both contribute to the brain's development and neither one nor the other can be singled out as the final determiner. As one brain expert puts it, "When it comes to building the human brain, nature supplies the construction materials and nurture serves as the architect that puts them together" (Kotulak, 1997).

### Continuing Risks

The brain at work shows definite vulnerability throughout life. Biological and psychosocial factors and their interrelationships influence the development of the brain and its functioning. In fact, research is establishing that actual physical or functional changes in the brain often emerge due to environmental stress or trauma, and that process may be self-perpetuating. A child exposed to maltreatment, for instance, may develop changes in the brain that lead to behaviors that "invite" further maltreatment, creating a dramatic downward spiral.

Many of these brain disorders cluster in families, which often indicates a genetic component or predisposition, not "poor parenting." It is not uncommon, for instance, to find a child with attention-deficit/hyperactivity disorder (AD/HD) whose parent reports, "He's just like I was as a kid." Other disorders may appear in families or neighborhoods, indicating an environmental cause, such as lead poisoning.

There is an interesting subset of children with Tourette syndrome and/or obsessive-compulsive disorder who develop symptoms after a childhood streptococcal infection that is thought to inflame the brain rather than produce the classic sore throat. In PANDAS (Pediatric Auto-immune Neuropsychiatric Disorders Associated with

Streptococcal Infections), a child may show a dramatic and uncontrollable increase in misbehavior or aggression even years later, often before or during another bout of strep infection (NIMH, 2003).

Teachers may see children with symptoms that are the result of damage to the brain and entire central nervous system from injury, infection, poor nutrition, or exposure to toxins. These children may have disordered reactions to changes of routine or interruptions. They may also under- or over-react to sensory stimulation including noise, light, movement, or touch.

Children who already suffer from neurobiological damage may worsen if they are exposed to stressful life events, such as; abuse, neglect, or other forms of maltreatment. This, in turn, increases the likelihood of adverse outcomes, including school failure.

Special care is needed when considering the behaviors of children in immigrant communities (See Background Brief B, page 48). Behaviors that may seem bizarre or at least abnormal in a typical classroom may have developed as a means of surviving traumatic experiences such as family disruption, mass starvation, war, or genocide. Children who live in the midst of multi-generational poverty may also have developed survival mechanisms that are not functional for them in the school context. These reactions need to be carefully assessed by a culturally competent provider as they may represent great emotional strength rather than mental illness.

### The Good News

The good news is that research on brain plasticity shows that new neuronal connections continue to be developed throughout the lifespan. While much of the activity during later development consists of "paring back" and refining neuronal connection, an enriched environment can still bolster brain development (SFN, 2002b). There is hope that a supportive atmosphere, coupled with targeted mental health treatment, can improve the possibility of a good outcome for the child. As one grade-school student stated in an entry for MACMH's annual poster contest: "Help and Hope! Mental Illness Can be Treated." Scientists have disproved the belief that a child's personality and future are determined forever by the events of the first 3 years of life. It is also becoming clearer that "poor parenting" is rarely the sole cause of mental health disorders and may not be present at all.

**Critical Incident**

Hand out the unlabeled diagrams of the brain and urge the students to label them as the PowerPoint slides appear. Remind them that brain research indicates that learning is enhanced when motor activity (writing) is combined with listening and seeing.

## ESSENTIALS OF BRAIN STRUCTURE

**[SLIDE 8]** The brain is divided into several portions or "lobes," each with a specific function.

**[SLIDE 9]** The **frontal lobe** sits behind the forehead and provides the planning and control of motor movement plus the executive functioning and higher-order thinking that links memory and current decision-making. It also governs creative activity. We will take a closer look at the frontal lobe later in the lecture, since many mental health disorders involve problems in this area's structure or functioning.

**[SLIDE 10]** The **parietal lobe** at the top of the brain contains motor and sensory cortex that takes in and processes information from the five senses and sends messages that govern limb movement in response to stimuli, for instance, jerking a hand away from a hot stove. **[SLIDE 11]** The **temporal lobes,** above and around the ears, are responsible for hearing, memory, meaning, and language. **[SLIDE 12]** The **occipital lobe** sits at the lower back of the head (the nape of the neck) and is primarily responsible for vision. **[SLIDE 13]** The **cerebellum,** at the back and bottom, governs posture, balance, motor movement, and long-term motor memory (Jensen, 1998).

**[SLIDES 14-16]** As you look at a cross section revealing the layers of the brain, you will notice a few notable landmarks:

- The **outer cortex,** which controls sensory input and motor movement.
- The **brain stem,** which controls the unconscious survival functions such as breathing, digestion, and heartbeat.
- The **corpus callosum,** which bridges the right and left halves of the brain, allowing them to share information.

**[SLIDES 17-20]** Deep within the brain lie the following:

- The **hippocampus,** which is involved in memory.
- The **cingulate gyrus,** which governs arousal.
- The **basal ganglia,** which governs involuntary movement.
- The **amygdala,** which is the brain's fear and arousal regulator.

This more "primitive" part of the brain that governs ancient survival mechanisms is another area that will be looked at in detail later in this lecture.

**[SLIDE 21]** The cortex holds the majority of **neurons,** the basic working unit of the brain. Neurons are vital to the flow of information within the brain, transferring information to other nerve cells as well as muscle and gland cells. A neuron consists of a specialized cell body containing the nucleus and a fiber called the axon; the axon conducts electricity and is the point of connection to other cells.

**[SLIDE 22]** Learning takes place at the gap between one neuron and another — the **synapse** —when electrical charges travel down the **axon** from the cell body to the tip and activate a release of chemicals.

The tip is filled with chemicals called **neurotransmitters** that are released by the electronic impulses, cross the synapse or gap, and move the message to the **dendrite** of another neuron. Every second of our lives, several billion bits of information pass through our brains this way, traveling at speeds up to 250 miles an hour (SFN, 2002b; Carlson, 1988). Learning problems may arise from a shortage of neurons, confused or blocked pathways, and/or an excess or shortage of one or more neurotransmitter chemicals. Neurotransmitters include dopamine and serotonin, plus many others not so well known. Some amino acids and hormones also function as neurotransmitters.

**Critical Incident**

A simple demonstration of signal transfers in the classroom can begin to solidify awareness of the brain differences involved in some mental health disorders. Have the class stand and form a circle by holding hands. Each person represents a neuron. Pass a signal from neuron to neuron by squeezing hands in relay fashion. Now, to simulate the disordered signals caused by problems with neural transmission, repeat the circle using a whispered message (like the child's game of telephone). When you compare starting and ending messages, you see a simulation of what might be happening in the brain of a child who never quite seems to know what the teacher said or meant.

## TWO VITAL BRAIN REGIONS

Before looking at the classroom manifestations of specific mental health disorders and possible classroom accommodations, there are two key brain areas that are worth examining in more detail because they play a major role in learning and behavior.

### [SLIDE 23] Prefrontal Cortex

The prefrontal cortex is the outer layer of the frontal lobe. It sits right behind the forehead. It operates as a control and self-control mechanism. It is the area most likely to be damaged by closed head injuries like concussions. Children, parents, coaches, and even some medical professionals tend to view these as minor injuries to be "shaken off." But a blow from a fall while roller-blading or repeated blows from heading a soccer ball can cause symptoms that last 6 months or even longer, even if there was no lump. Behavior may suddenly change or regress, aggression may increase, and memory and attention may be impaired. Sudden changes in these behaviors should elicit questions about possible recent head injury (SFN, 2002a).

**[SLIDE 24]** Whatever the source, damage to the prefrontal cortex can affect any or all of the systems it governs. These include attention span, perseverance, planning, judgment, impulse control, organization, self-monitoring, problem-solving, critical thinking, forward thinking, and the ability to learn from experience and mistakes. Because the prefrontal cortex influences the limbic system, which controls emotions, injuries to this part of the brain can affect the ability to feel and express emotions as well as the ability to empathize with others.

Behaviors that may alert you to damage in this area include (Amen, 2002a; SFN, 2003; Lehr, Jr., 2003):

- Distractibility.
- Persistence of a single thought (perseveration).
- Lack of impulse control.
- Hyperactivity.
- Poor organizational skills.
- Emotional "flatness" or heightened emotions and mood swings (lability).
- Poor judgment.
- Difficulty learning from experience.
- Problems with sequencing and problem solving.
- Short-term memory problems.
- Social anxiety, test anxiety.
- Lying or confabulation (a form of lying in which the speaker believes his words are true).

### [SLIDE 25] Basal Ganglia

This area is located toward the back of the brain and deep within. The basal ganglia integrates feelings and movements, suppresses unwanted movements, sets a person's level of anxiety, enhances motivation, and creates pleasure. The nearby amygdala governs the body's response to fear, and the hippocampus, also nearby, mediates short-term and long-term memory. The cingulate gyrus governs arousal in response to sensory stimulus (SFN, 2002b).

Problems in the basal ganglia will appear as anxiety or panic, negative thinking, conflict avoidance, muscle tension, tremor or tics, fine motor problems, headaches, and low or excessive levels of motivation. Because much of the functioning of the basal ganglia is mediated by the flow of neurotransmitters, symptoms can often be moderated or eliminated by medications (Amen, 2002a; SFN, 2002b).

### [SLIDE 26] Recent Brain Research

It bears repeating that a parent or teacher may see some of these signs in any child at times. It is not the symptom itself, but its unmanageable intensity and the persistence of these problems that signal the need for further investigation.

Historically, data about the function of different parts of the brain came from doctors who observed the deficits in the few patients who survived severe head injury or surgery. Now, there is a wide range of techniques for visualizing the brain at rest and even while it is doing real-life tasks. Neuropsychiatrists often speak of "seeing" too much or too little activity in a portion of the brain. Their research is part of an explo-

sion of information that emerged after the development of visioning techniques that record the actual functioning of the brain.

Beyond the static views offered by the more familiar CAT scan and MRI, scientists and practitioners now have PET scans that record how much energy (glucose) is being used during an activity. They also have SPECT scans that provide the clearest image of all. SPECT scans show both structural features of the brain, which areas are activated during specific tasks, and varying levels of activity.

**[SLIDE 27]** With this new understanding has come a new list of terms, more accurate than the historical term mental illness. Some of these terms are neurobiological disorders, brain or bio-brain disorders, neurobehavioral disorders, and neuropsychiatric disorders. Whether one term will prevail is yet to be decided. Meanwhile, teachers may see many or all of these in reports, research, and advocacy information.

**Critical Incident**
Quiz

## LECTURE 2: QUIZ OR DISCUSSION

### TRUE OR FALSE

1. The body's protective mechanisms ensure that there are few ways the brain can be damaged.
2. There has been little gain in knowledge of the brain since the beginning of the 20th century.

### ANSWER WITH A SHORT PARAGRAPH

1. Describe some functions controlled by the so-called "primitive" parts of the brain.
2. You sustained a blow to the head in a car accident over the weekend. What might you experience when you return to the classroom on Monday?

### FILL IN THE BLANK

1. The area of the brain that governs self-management is _____.
2. Tourette syndrome and other movement disorders seem to be centered in the _____ region of the brain.

## ASSIGNMENTS

**Assign one or more from the following.**

1. Read the article "How Julie's Brain Learns" (see page 50). Write a 2-page summary including information on brain development, learning style, and adaptations. Define "emergentism." Describe the brain's memory pathway. Note any information that was surprising and any remaining questions.

2. Using one of the following web sites, write a 1-page report analyzing another portion of the brain in the same way the lecture discussed the frontal cortex and basal ganglia. Focus on the implications for learning and/or behavior.
   - Brain Place (Amen): www.brainplace.com
   - Society for Neuroscience: www.sfn.org
   - Substance Abuse & Mental Health Services Administration: www.samhsa.gov

3. Review the article "Brain-Based Learning: Where's the Proof?" from the Jensen Learning Center (see page 57). Write a 1-page report that summarizes the article and discuss whether or not you agree with Jensen's conclusions. In either case, support your argument. Cite any other resources you use.

4. Review the following web sites and write a 1-page summary of the issues that are currently at the forefront of research and attention in the field of neuroscience.
   - Society for Neuroscience: www.sfn.org
   - American Academy of Neurology: www.aan.com
   - Substance Abuse & Mental Health Services Administration: www.samhsa.gov

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## Lecture 2: Answer Guidelines

### True or False

1-F 2-F

### Short Answer

1. Alertness, awake/asleep cycles, recall of items in memory, fear, anxiety, uncontrolled movement
2. Short term memory loss, disorientation, emotional over or under-reaction, distractibility

### Fill in the Blank

1. Prefrontal cortex (partial credit for frontal lobe).
2. Basal Ganglia

## BACKGROUND BRIEF B
### CONSIDERING CULTURAL DIFFERENCES

Culture is a complex web of values and behaviors. Beyond food, clothing, music, and stories are spiritual beliefs, attitudes, concepts of authority, concepts of illness and health. Long-term or multi-generational poverty also creates its own culture, as does the impact of immigration to a new country.

Cultural stress and conflict may contribute to academic and behavioral problems. Teachers may see signs of depression, disorientation, post-traumatic stress disorder, anxiety, or survival guilt. Many of Minnesota's foreign-born population are refugees with a great deal of stress and loss in their background. In addition, secondary school-aged students may enter our schools with no previous experience in a classroom or school community.

Experts in the field define a continuum of acculturation or adaptation to a new culture (Sattler, 1998) that occurs after immigration or even after moving between settings such as from a farm to a city and vice versa. The stages a teacher might identify in students and/or their parents are:

- **Culturally marginal** — the individual understands and identifies with a minority culture; chooses not to (or is unable to) interact with the dominant culture.
- **Culturally different** — individual understands and identifies with a minority culture; has some knowledge of dominant culture and attempts to "fit in."
- **Bicultural** — individual understands both cultures and comfortably operates within both frameworks.
- **Mainstream** — individual has adapted to and identified with the mainstream or dominant culture.

During this process, fluctuation between stages may occur, and the normal side effects of this process may look very much like traditional indications of a mental health disorder including heightened anxiety, withdrawal, fatigue, distractibility, confusion and disorientation, unresponsiveness, resistance to change, and apparent "loss" of language skills in the native language as the new language emerges. (Collier, 1985). Intergenerational conflict is common during this process, especially around issues of discipline, schoolwork, and participation in the larger community.

School personnel often complain about lack of parental participation in school meetings. Teachers should understand that many barriers exist, including language, distrust of authority figures, uncertainty over what is expected, and factors as simple as parents working two or three jobs.

Concepts of disabilities or "differences" may vary widely from cultural conceptions popular in more familiar communities. For the Hmong, for instance, epileptic seizures may be seen as a visitation by spirits and a mark of great favor. In cultures based on

## BACKGROUND BRIEF B, CONTINUED

hunting or farming, a child's "energy" is necessary to survival, whereas our structured culture of classrooms, offices, and factories may identify it as "hyperactivity." Another example is the custom in many Native American communities that discourages children from making eye contact with adults. Most teachers, however, believe that eye contact is a sign of respect and attentiveness.

When a student is not successful in school, evaluation procedures must determine whether the difficulties are related to cultural or linguistic difficulties, or whether they relate to a disability. State law recommends use of cultural specialists as informal supports during these evaluations and team planning.

### Socio-Economic Status

Socio-economic status is another aspect of diversity and these factors overlap and interact with cultural and racial differences. This is a factor that may shape group affiliations, relationships with peers and authority figures, and family characteristics.

Students growing up in poverty may not have the range of experiences that is assumed in the classroom and on standardized testing. They also may face anxiety, stress, and sleep deprivation due to situations at home. Inadequate housing and food, plus environmental risks associated with exposure to lead, asbestos, or other toxic substances may also contribute to problems with learning and attention.

Students from affluent homes, on the other hand, may suffer from anxiety and stress caused by trying to meet high expectations at home and from extreme peer pressure to experiment with sex, drugs, alcohol, etc. These are communities in which new drugs may spread as fast as new hairstyles and even suicide attempts often appear in clusters.

A teacher who is non-judgmental and in touch with the students in her class, can plan activities and modifications to help overcome the weight of these "outside" factors. Brain-based teaching experts recommend frequent use of activities that encourage emotional expression, such as drama, art, and music.

**RESOURCES**

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Student Handout

## How Julie's Brain Learns

*by Eric Jensen*

***Follow a typical student through her day at school—from the perspective of her brain.***

Julie seems like a bright kid. At least that's what her aptitude tests say. You can count her absences on one hand, and she's not a discipline problem. As far as the teacher knows, she comes from a fairly typical home. So why is she—and countless others in her school—driving her teachers crazy? Why do teachers have to go over things twice and even three times for the information to sink in?

We've known for years that teaching does not equal learning. But today we have a better idea of what's going on in Julie's brain. Julie's teacher spends a lot of time reteaching because she doesn't teach in ways that match how Julie's brain learns. This mismatch creates frustration, underperformance, and hopelessness.

Fortunately, new knowledge in neuroscience is redefining possibilities for education. There are five critical variables in the brain's learning process: neural history, context, acquisition, elaboration, and encoding. To find out where neuroscience and the classroom link up, let's explore these from the perspective of Julie's brain.

**Neural History**

Julie's brain is not blank like a tabula rasa but customized by her life experience. Julie's neural history includes more than her grades and test scores. A seemingly trivial accident—a fall and bump on the head at summer camp—has created a brain insult in her temporal lobe, an area responsible for Julie's semantic memory. That means that although Julie's memory might be good for names and places, it's weaker for numbers and formulas. This behavior puzzles teachers who often think she's simply not trying hard enough in math classes.

Our neural history is founded on a dynamic interplay between nature and nurture called *emergentism*. At each development stage, different genes are affected by the environment and are uniquely expressed (Elman et al., 1998). Genes, however, are not templates for learning. For example, if there really were a "language gene," then a child raised in isolation would automatically speak. Prior learning, character, the environment, peers, and life experience also influence how we learn.

For instance, many students who have spent too much time in car seats and not enough time on swings, merry-go-rounds, and seesaws have insufficient early motor stimulation and experience poor school readiness. Exposure to constant threat or early trauma often alters the brain's behavior, creating extreme levels of serotonin and

noradrenaline. A lack of early enriching activities may influence brain development. Extended television watching in the early years may create learned helplessness or unduly passive or aggressive behaviors. Drug usage can desensitize the opiate receptor sites for pleasure.

At birth, Julie's brain had a trillion neural connections, known as synapses, that were wired in. By now, Julie's 15-year-old brain has countless unique life experiences, and her three-pound operating system is rich with intricate neural wiring that represents information, complex patterns, mental models, and belief systems. She, like others in the class, brings this personal neural history to school each day. Her teacher has the difficult challenge of customizing information for each learner.

Given students' unique experiences, it may be impossible to create a level playing field. However, studies suggest the value of increasing motor activity, arts, music, choices, challenges, and feedback. Teachers should also take time to socialize students through well-orchestrated groupwork to create better social behaviors and a common class history. Evidence suggests that peers are a significant influence on students' academic performances (Hartocollis, 1998).

**Learning Context**

Julie's teacher influences her learning brain every day by designing the physical and emotional environment. For example, though Julie finds it easy to arrive on time, she tends to cut it close. Today's close call relates to boyfriend problems. The allotted time between classes is just long enough to start a conversation, but not long enough to finish it. If the broken conversation threatens a potential romantic relationship, trouble begins.

New evidence from Deborah Yurgelun-Todd of Boston's McLean Hospital (personal communication, 1998) suggests that the typical adolescent brain is too immature to read complex facial clues. Misreading peer or role model facial cues often results in inappropriate reactions. However, pioneering neuroscientist Candace Pert of Georgetown University Medical School says, "Unexpressed emotions can inhibit many functions, including learning" (Pert, 1997). Accordingly, teachers must allow for a wider range of emotional expression, even when the expression may be misguided. Classroom examples may include more drama, open discussions, and celebrations.

Educators can assume that some students will arrive at class distressed and even threatened. Therefore, we should invest the first few minutes to accomplish three goals. First, we need to provide an outlet for emotional expression—through discussion, singing, sharing, writing, music, or drawing. Second, we must reconnect learners with one another. Even a positive greeting at the door can reconnect learners with their teacher. Peer contact is also valuable. Third, we must help learners reconnect with the content. Let students have open group discussions, journal writing, paired activities, or mind mapping.

When a person is threatened, the hypothalamus and the adrenal glands team up to release adrenaline, cortisol, and vasopressin. Julie's threat response is great for

escaping from predators, but not for learning. The short-term impact of this chemical release includes impaired spatial-episodic memory, weakened ability to prioritize, and greater likelihood of repeated behaviors. Julie's brain is just not ready for learning when the bell rings. But she's lucky; other students are even more threatened by insurmountable language barriers, bullies in the hallways, and hostile home lives. Overcrowded classrooms, unreasonable rules, and impossible deadlines can also feel threatening.

Good teachers who know that emotional climate is critical invest the first few minutes of every class in activities that allow students to get into a positive learning state. Activities might include nonthreatening open-class discussions, journal writing, stretching, paired discussions, mind mapping, listening to music, reflecting, or dancing and games.

As important as emotional safety is physical safety. The brain's optimal physical environment includes a temperature near 70 degrees and a humidity level near 70 percent. Too much heat or too little humidity triggers stress. Students should also have water available without having to ask permission to get it. Nutrition, too, is a factor. We are, after all, always trying to ensure our own survival.

Attentional chemicals also run Julie's brain. Her midday amine level is at its lowest since bedtime. Amines are stimulants, like amphetamine. By early afternoon, Julie's brain is ready for a nap. Although this happens every 90 to 110 minutes, the nadir occurs 12 hours after the midpoint of last night's sleep. Because Julie sleeps from 10 p.m. to 6 a.m., her lowest energy time occurs at 2 p.m. Studies suggest that short, brisk activity increases energy levels (Thayer, 1989). Schools need to integrate more movement into the daily schedule. Repeated physical activity like stretching, playing games, swimming, or walking releases epinephrine and dopamine, which usually lift Julie's spirit.

Another attentional modulator is a common neurotransmitter called serotonin. Its release is triggered by many factors, including dietary tryptophan. Julie's high carbohydrate lunch is coming back to haunt her. She doesn't know that a better lunch might include more protein and trace minerals and fewer carbohydrates. Tuna salad, fruit, yogurt, or nuts can keep the brain going for hours. Educators need to inform parents and kids about what to eat to help them learn.

**Acquisition**

Julie's teacher has strong models of so-called "good teaching," including the traditional stand-and-deliver model, in which the goal is to get and keep students' attention. But the process of learning is complex. First, much of what we learn comes to us indirectly. Second, the physiological state in which we learn mediates how much we comprehend. A hopeful student and a discouraged student learn differently. Finally, by engaging in trial-and-error learning, students will more likely become lifelong learners.

Too much attention to *anything* may be counteradaptive. An excessively focused brain may be more susceptible to predators. Although we no longer fear saber-toothed tigers, school threats today come in more subtle packages, such as peer embarrassment. In addition, when teachers insist on holding students' attention, they miss the fact that much learning comes through indirect acquisition, such as peer discussion or environmental stimuli. By making excessive attentional demands on students, teachers can create resentful learners.

Ultimately, brain-compatible teachers may engage learners' attention only 20 to 40 percent of the time and still do a great job. Teachers need to keep attentional demands to short bursts of no longer than the age of their learners in minutes. For a 1st grader, that's about 6 consecutive minutes; for a high schooler, that's up to 15 minutes. Julie's teacher will want to use attention sparingly for introductions, key ideas, directions, lecturettes, reviews, stories, and closings. The rest of the overall learning time (processing, encoding, and "neural rest") ought to be *student time*, used for processing, projects, discussions, group work, partner work, self-assessment, journal writing, feedback, design, research, mapping, interviews, review, or memorization.

Another strategy to boost acquisition is enhancing prior knowledge. Teachers can provide content slowly, increasing the quantity over a period of days or weeks. This builds connections so that when it's time to explore a topic in depth, every student has the necessary background. Julie is better off not jumping in all at once, but nibbling at learning over time. To do this, teachers should post key points on the bulletin board weeks in advance of assessments.

State-of-mind management is another factor behind acquisition. Great learning states include curiosity, anticipation, and challenge. Each state is defined by a unique brain chemistry formulation that includes neurotransmitters like dopamine and serotonin and hormones like adrenaline. The best teachers successfully manage these optimal learning states. Better yet, they empower their learners to manage them for themselves. Julie's teacher might want to give directions for a complex project in smaller, more interesting chunks. This prevents students from hearing all the directions at once, feeling overwhelmed and discouraged, and then being unmotivated to do the task.

In-depth learning requires the formation of complex, multilayered neural networks. Individual neurons are not very smart. Timely and accurate feedback helps neurons learn first to fire together, then to wire together as a network. When we activate the right neurons, we get a "smarter" organism. Superior learners learn by systematic trial and error. Eventually, they will get the right answer, but more important, they eliminate the wrong answers. In some ways, the worst thing that can happen is for a student to get the right answer immediately. Teachers need to orchestrate circumstances that allow more trial and error. This might include research, discussions, team problem-solving, and projects that have built-in opportunities for self-correction.

What should be the proportion of student time to the total class time? That depends on several variables: learner background, content complexity, and accountability.

Teachers ought to spend 55 to 80 percent of their time allowing students to process information. Most teachers don't set aside this time and therefore do an enormous amount of reteaching. Typically, state curriculum standards push each year for more in-depth critical thinking and, paradoxically, for more wide-ranging content. Teachers can go wider or deeper, but not both; something's got to give.

We see evidence of acquisition by the formation of new synaptic connections. Each cell body, or neuron, has spindly branches called dendrites and a single longer projection called an axon. The axon of one cell will typically connect with the dendrites of another. These connections are formed when experiences are both novel and coherent. If experiences are familiar, the existing connections may simply be strengthened. If experiences are incoherent, no learning may result. The sources for acquisition are endless. They may include discussion, lectures, visual tools, environmental stimuli, hands-on experiences, role models, reading, manipulatives, videos, reflection, projects, and pair-share activities. No single way is best for students to learn, but the age-old rule still applies: Students who do the talking and the doing do the learning.

**Elaboration**

When Julie's teacher asks questions and gets a blank look or a trivial answer, she's puzzled. She shouldn't be. A synaptic connection is often temporary. Neural space is expensive real estate, and the brain builds only what's needed. To ensure that the brain maintains synaptic connections, we need elaboration to strengthen the original contact.

Elaboration is the sorting, sifting, analyzing, testing, and deepening of learning in a way that gives students genuine feedback on how well they understand. It ensures not only that students "own" information, but also that the information is correct. The best feedback is specific and timely.

Julie's teacher still lives in the old paradigm for feedback, in which the classroom teacher is the primary source. But because there's not enough time for any teacher to give enough feedback to every student, teachers have to make sure students get feedback from multiple sources: peer editing, discussions, student-generated rubrics, answer sheets, pair-share, video or audiotaping, predictions, journal writing, outside speakers, or reference materials. When all these are used collectively, students can get sufficient feedback every 30 minutes or less, every single day. Not only will they be more accurate in what they learn, but they will also develop greater intrinsic motivation. Students' brains develop better patterns of thinking because they have more thorough, detailed, reality-tested models for learning.

**Encoding**

After elaboration, you'd think Julie's brain would have permanently encoded the day's learning. Not necessarily. Learning the information may create a memory trace, but this may not be strong enough to activate at test time. The retrievability of newly created memories depends on many factors: rest, emotional intensity, context, nutrition, quantity of associations, matching states, and learned pathways. But unless

Julie's teacher knows this, she'll persist in the old model that says that memory is like a bank of records that students just need to try harder to retrieve.

Rest is a powerful memory aid because during our dream time, we process learning from the previous day. We discard meaningless information and strengthen the rest. When deprived of dream time, or REM (rapid eye movement) sleep, we can still learn material with strict memorization, but we are weaker at logic and can't learn complex material. The more students are exposed to new learning, the more time their brains should engage in the critical REM state. Infants dream the most, elderly people the least. Teachers must remind students that getting enough sleep will maximize their studying.

Intense emotions during or after learning is a reliable way to produce long-term memory encoding. Emotions excite the brain's chemical system, and the adrenaline released acts as a memory fixative, locking up memories of exciting or traumatic events. To engage appropriate emotions, Julie's teacher could use such strategies as better role modeling, competitions, journal writing, celebrations, dramas, creative writing, humor, student presentations, and impending deadlines.

If Julie learns in a classroom and then is tested in a media center or an auditorium, she'll likely underperform. Similarly, if Julie learns in a particular emotional state, she will most readily recall her learning in that same state. If Julie's teacher makes the initial learning fun and playful, the teacher needs to create a second, "rehearsal" stage before giving the more stressful exam.

The neurotransmitter acetylcholine is instrumental in long-term memory formation. Dietary sources include lecithin (found in eggs, salmon, and lean beef). Calpain (derived from calcium) helps digest protein and unblock receptors. Phenylalanine, found in dairy products, helps manufacture norepinephrine, which is also involved in alertness and attention. Researchers postulate that the chemistry of our body, which regulates our physiological states, is critical in triggering our recall.

Increasing the quantity of associations is a good way to increase recall. Because all recall is associative, the more *ways* that Julie knows the material, the better. She could know about a country through economics, geography, politics, culture, business, and entertainment. She could learn U.S. history through many different points of view: a male, a female, a Caucasian, an Asian, or a Hispanic.

Finally, teachers must match the memory mechanism at assessment time. Otherwise, a student will know the information but will not be able to demonstrate knowing it. The semantic memory system processes words, facts, pictures, stories, and text. If students learn with this pathway, they will need to activate similar associations to retrieve information. This highly volatile and malleable storage system needs constant reviews, mnemonics, word associations, prompts, and practice.

The episodic memory pathway is activated by unique circumstances and locations rather than content. Julie will remember *where* she was when she learned something

more easily than she will recall *what* she learned. Teachers can activate episodic memory by providing frequent location, posture, group, and scenery changes to create unique "addresses" for learning.

The procedural and reflexive pathways are less malleable and harder to test because they reflect a different kind of learning that includes body learning, conditioned responses, and intuitive knowing. Teachers can engage and assess this type of learning through activity, movement, emotion, drama, repetition, and games.

Each memory pathway appeals to different students and has strong implications for assessment and learning transfer. Realistically, matching learning with assessment is just one of many challenges teachers face to make their classrooms brain-compatible. But it's worth striving for. The more that schools more closely match teaching to the way students' brains actually learn, the more likely they are to reach students and bring out their natural motivation to learn.

**Increasing Brain Power**

Even the best schools can't turn a mediocre student into a genius. But the experiences that we provide for students can make an enormous difference. Frederick Goodwin of the National Institutes of Health estimates that we can influence students' IQs 20 points in either direction—that's a 40 point IQ swing (Kotulak, 1996)! We educators can and must do our best to bring out the talents of tomorrow's citizens. Brain-compatible learning is a strong and positive step in the right direction. *

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## Brain-Based Learning: Where's the Proof?

Questions are often raised about the reliability of brain research for training or classroom applications. Cautious, conservative skeptics will, by nature, be hesitant to embrace new things. Overzealous or impulsive risk-takers will, by nature, try almost anything, founded or not.

A better-informed educator usually makes better decisions. At Jensen Learning, we collect the research, form conclusions and make suggestions. Eric Jensen has made over 40 visits to neuroscience labs and meets with many neuroscientists every year. Every effort is made to select from reliable sources with supporting data. If the studies are conflicting, we'll either say so or not present it to you. You'll need to be the ultimate judge as to whether and how the research fits in your particular learning climate.

One must be cautious and prudent in how research is interpreted and ultimately used. Our policy is to look for both the basic neuroscience research and match it with data from applied psychology or cognitive science. When there are multiple studies, with good samples and clear evidence, you'll hear about it.

One thing you'll never find is a single, definitive study that "proves" brain-based learning is better. Why? You would have to do the following:

1. Train teachers in brain-based learning, then insist and guarantee that they'll use the strategies during the study. (That won't happen)

2. Have a "control" school to compare with that is using NO brain-based strategies. That would mean a school with threats, constant confusion, mismatched curriculum, no arts, P.E. or fair social structure. Teachers would be unskilled, all lecture and no processing time for the kids. (What parent would allow their kids in that school?)

3. Create a fair assessment. What do you want to assess? Do you want higher state and federal mandated test scores? Or do you want a healthier, happier, more self-reliant human being with confidence, lifelong learning skills and a sense of fairness, honesty, confidence, humility and in support of diversity? (That assessment won't happen).

4. Use double blind and longitudinal studies. Ones in which neither the researchers or the classroom students or the teachers knew which methods were being used. That can't happen—it's too obvious and the teacher methods would bias the results. Doing studies over time is better but who would fund this—these take hundreds of thousands of dollars to fund. In short, none of this will happen.

Having said that, it is easy to use one single strategy and compare it to another teacher (or the same one) who is not using that one strategy. But I would never say that a single strategy "equals" brain-based learning. Nor would I would never say, "Brain research proves...." because it does not prove anything. It may however suggest the value of a particular pathway. We have heard five basic complaints about brain-based learning. You should know what they are and know our position on them.

**ACCUSATION #1.** "The findings are often exaggerated, misinterpreted and taken way too far."

*RESPONSE:* This criticism is genuine. Many well-meaning educators have gone way beyond the research and said that it "proves" that a "certain" classroom strategy is justified. We often hear educators making claims that have no basis in research. Educators who are going to use or quote research ought to know what makes a good study, who is funding it, the reputation of the researcher, the design of the study, what are the implications and constraints on the findings. A little information can be dangerous. To be accepted as professionals, educators must know their stuff.

We assert that brain research proves nothing. There is no body of brain-based research that justifies every strategy of so-called "good teaching." In fact, most of what passes for good teaching is a collection of folk wisdom, basic psychology and common sense refined by trial and error. However, new findings can steer all of us in more productive directions.

*What educators should say is the following...*"These studies suggest that XYZ may be true about the brain. Given that insight, it probably makes sense for us, under these conditions, to use the following strategies in schools." This approach, which is cautionary and not causal, sticks with the truth. First that there are valuable, new studies and second, that insight of those studies, certain actions seem to make good sense." We do not claim that the "brain-based" is or should be the only criteria for deciding what to do. It's a bad idea to base a school on biology alone. However if schools ignore it, they are being equally reckless.

**ACCUSATION #2.** "There is nothing new in this approach"

*RESPONSE:* When people say "good teachers have been doing this for years," two things are true. First, you may be very young or have a short memory. Only 40 years ago, good teaching was defined by all-lecture, content-laden classes, clean desks, quiet students (in their seats), with little movement. Yes, it's true that some teachers, in some schools or situations have been using brain-compatible strategies but they were the exception. Certainly, there was no research to it in the early days.

Keep in mind that if you don't know why you do what you do, it's less purposeful and less professional. It's probably your collected, refined wisdom. Nothing wrong with that, but some of the "collected, refined wisdom" has led to some bad teaching, too.

But to be purposeful about your work; ah... that is another matter. Are there recent discoveries from the world of brain-mind science that can be applied to the classroom? You bet! Here's a list highlighting a few specific areas of research that have important implications for learning, memory, schools and trainings.

- The growing brain: the human brain can and does grow new cells
- The social brain: how interactions and social status impacts stress levels
- The hormonal brain: hormones can and do impact cognition
- The moving brain: how movement influences learning
- The plastic brain: changing: how to better enrich the brain to rewire changes
- The spatial brain: how space and relational learning & recall works
- The attentional brain: prefrontal cortex, what really drives attention and ADD
- The emotional brain: impact of threats on hormones, memory, cells and genes
- The adaptive brain: the impact of distress, cortisol & allostatic states
- The patient brain: the role of time in the learning process
- The computational brain: the role of feedback in forming neural networks
- The artful brain: the role of arts and music
- The connected brain: how our brain is body and body is brain
- The developing brain: what to do and when to do it; value of the first 3 years
- The hungry brain: what to eat: the role of nutrition in learning and memory
- The memorable brain: how our memories are encoded and retrieved
- The chemical brain: which chemicals do what & how to activate the right ones

As you can tell, these discoveries come from many areas. Critics who worry over *where* the research comes from are missing the point. Educators need to and ought to combine the findings of the brain/mind field with other fields to diversify and strengthen the applications. Neuroscience is not the only source for research; it's an important part of a larger puzzle. When you synthesize it with other fields like sociology, chemistry, anthropology, future studies, anthropology, therapy and others, you can get some powerful applications.

Cognitive science, psychology, neurobiology, and neuroscience are all studying the same thing! They are interested in the brain/mind and how it works. The brain is what you have, the mind is using it. Different fields do research at different levels. Basic neuroscience research is usually done at the molecular, genetic or cellular level. At this level, we hear of neurogenesis and the growth of stem cells. That's contrasted with applied cognitive sciences which may feature animal studies or clinical studies that show the real world behaviors we are equally interested in.

The point is, we now know enough about the brain to justify specific strategies, that only a few years ago, were just good ideas without scientific basis. Here's an example. We have irrefutable evidence that embedding intense emotions (like a celebration or drama) into an activity may stimulate the release of adrenaline which may encode the memory of the learning much stronger.

**ACCUSATION #3.** "Brain research is tenuous and changes too rapidly to be of value"

*RESPONSE:* First, every dynamic field like medicine, technology, genetics and communications is changing fast. The computer you bought five years ago is considered old today. But, it worked when you needed it. Today, maybe a newer one is faster or more user-friendly. But it doesn't invalidate your old one. The same attitude is helpful to maintain in brain research.

A classic example of how research changes is the so-called "Mozart Effect." While several critics are trying to de-bunk the whole Mozart effect, the story behind it is worth telling. First, when studies are done precisely the way the original study was done, there is a minor cognitive enhancement. The studies that could not or did not replicate the results were measuring abstract reasoning, long-term reasoning, general intelligence or some other result. But that's not what the researchers were claiming was true. The original studies by Dr. Shaw and Dr. Rauscher showed only a short-term enhancement of specific spatial skills (object rotation only), nothing else. They believed that music may have other potential effects (it does), but never claimed that listening to a few minutes of Mozart was going to make one into an Einstein.

So-called "pop" authors like Don Campbell ("The Mozart Effect") are talking about the larger, broader effect of music. If you read his book closely, he reminds us of the healing, therapeutic, social, communication and mood enhancement value of music. He mentions the fact that some studies show that music training enhances memory (these studies are genuine). Products that pushing classical music for your youngsters are valuable simply because they may expose children to music, serve as mood regulators and the auditory system is very receptive to sounds in the 5000-6000 Hz range. Personally, I would endorse a wider cultural variety of music to children than European music from 1720-1850. Current research particularly supports the use of strong rhythms. Rhythm is to the ears what patterns are to the eyes. They are natural meaning-makers, valuable for building coherence.

In general, early, cutting-edge studies tend to be incomplete. The Mozart studies were not proven wrong. They were clarified, narrowed and shown to exist only under

certain experimental conditions. What was disproved was a "blanket effect" for intelligence or memory for Mozart. What is often missed in all the hoopla about the so-called Mozart effect it's not the short-term effects we're after, but the longer, more lasting ones.

While those are interesting to learn about, they have limited value in schools. The real gems, the studies that haven't been getting their share of publicity demonstrated conclusively that early age long-term music instruction (particularly keyboards) does positively impact learning, memory and intelligence. Those studies are the ones educators ought to be focused on, not the 10 minute "magic-bullet miracles."

**ACCUSATION #4.** Consultants and products that push brain-based learning are only trying to capitalize on the "Decade of the Brain."

*RESPONSE:* There are two types of consultants; those who do their homework and those who don't. Most of the consultants, trainers, and staff developers in this field make a good effort to stay abreast of the field. They qualify their statements and stick to the truth.

Unfortunately there are many teachers and consultants who stretch the truth, avoid doing the research, mislead teachers and make false claims about what brain research says and does not say. These presenters should be made aware of what they're doing by peer review and upgrade the quality of their talk. Or, they should find another profession.

The larger point here is that we all (I trust) share the same mission. We all want to make positive, significant contribution to learners everywhere. And since learners are unique, it takes many shapes, sizes, formats and packages to successfully appeal to every learner. So far, there's no "magic bullet" for learning. Anyone who is trying to sell you a "one size fits all" has got snake oil. The human brain is unique.

**ACCUSATION #5.** Brain-based learning is confusing. One person says one thing, another says the opposite.

*RESPONSE:* I agree. There needs to be better sharing and networking so that all of us are on "the same page." Many ill-informed educators are still confused about some learning basics. Here is a summary of some of the myths and false claims made public.

**MYTH:** Early childhood experiences causes our synaptic count to multiply rapidly.

*REALITY:* If anything, we lose synapses through a "pruning" process in the first five years.

**MYTH:** Low stress learning is best.

*REALITY:* In general, moderate levels optimize learning. Under some conditions, low stress is better and other higher stress is better.

**MYTH:** Research proves the critical need to capitalize on the early windows of opportunity.

*REALITY:* Normal childhood experiences usually produce normal kids. The most critical windows are those for our senses, the parent-infant emotional attunement, language learning and a non-distressed sense of safety. Those are irretrievable time slots in our lives—once they pass, it's too late. There are "windows" that can "shut" on the learner. But most learning is more likely to have "sensitive periods" where it is simply more opportunistic for other reasons to teach a skill or subject. Other opportunities, like social skills, reading, music and language have a much longer "sensitive period."

**MYTH:** Rote memorization is brain-antagonistic

*REALITY:* The brain strengthens learning through repetition. It's not repetition that's bad, it's when it becomes too boring. There are many creative and fun ways to review.

**MYTH:** Environments primarily determine learner success

*REALITY:* Many factors influence learner success including parents, peers, genes, trauma, nutrition and environment. There is no way to quantify them and say one of them is more important than another.

**MYTH:** Most learners use only 5-10% of the brain.

*REALITY:* There is no objective evidence that this is true. On a daily basis we probably use most areas of our brain. Increases in creativity or productivity can come from doing the right thing, or doing it more often, rather than simply doing more.

**MYTH**: Emotions and intelligence are separate.

*REALITY:* While they may originate in separate places in the brain, their paths usually cross in the orbitofrontal cortex. So, in a sense, they are inseparable.

**MYTH:** Mozart is the best music for enhancing learning.

*REALITY:* Recent studies show many kinds of music can work as wells as or better than Mozart if the task is abstract reasoning involving spatial object rotation. One of Mozart's compositions (K.448) has shown a modest enhancement in spatial-temporal learning. But rhythm has been a more robust and reliable booster for this single skill.

**MYTH:** Learning Styles and Multiple intelligences are brain-based

*REALITY:* These make good sense based on what we know about the brain. They address the uniqueness of the human brain. But both were developed before our current understanding of the brain and have stronger roots in psychology and social science than neurology.

**MYTH:** The adult brain cannot grow new cells.

*REALITY:* Studies have demonstrated that the human brain can and does grow new cells in the hippocampus. Just as importantly, the cells do take on functional roles and interact with existing ones.

**MYTH:** Getting the right answer quickly is best.

*REALITY:* Given the value of trial and error learning, probably those who are not the quickest (and not the slowest) are more likely to be better, more reflective thinkers.

**MYTH:** An enriched environment is one with posters, mobiles, manipulatives & music.

*REALITY:* Enrichment occurs more because of the process that the learners are undergoing. than the decorations. Challenge, activity, feedback, novelty, coherence and time are crucial ingredients for re-wiring the brain. Enrichment means heavier cells, greater dendritic branching, more glial cells, multiple synaptic junctions and, in some cases, new cell growth (in the hippocampus).

**MYTH:** More focused classroom attention by students on the teacher improves learning.

*REALITY:* More attention on whatever is being learned is better. But it does not have to be on the teacher. Students need time to digest, think, reflect and act on their learning and for connections to strengthen.

**MYTH:** More content per hour is better.

*REALITY:* Each subject and each learner probably have an ideal amount of “ideas per hour” that can be learned based on learner background, motivation, learning skills and subject complexity and novelty. Only language acquisition occurs better with more content per hour.

**MYTH:** The left brain is logical.

*REALITY:* The left hemisphere is better with sequencing, language, parts and creating internal dialogues (interpreting events). Any logic produced is not a structure=function relationship result.

**MYTH:** We now know how to best assess learning.

*REALITY:* Much of what we learn we still don't know how to assess. Examples include volition, subject affinity and the development of mental models.

**MYTH:** More synapses formed means greater intelligence.

*REALITY:* There is no evidence that this is true. There are some correlations, but the evidence is not causal.

**MYTH:** All can learn and meet high standards.

*REALITY:* This is true *only* for those who have healthy brains. Add up all the students with some kind of brain dysfunction problems (depression, brain insults, ADD, drug usage, dyslexia, OCD, distress, alcohol, trauma, etc.) and you'll have from 40-60% of your school population, depending on the school. Healthy brains make for good learners who can reach high standards. Students with unhealthy brains commonly have learning problems. Can they be reached? Most of them, yes, if there are sufficient resources. Others may never reach their potential.

**MYTH:** The right brain is creative.

*REALITY:* The right brain processes spatial information, works randomly and with wholes (the gestalt). None of these attributes guarantee creativity. There are very clear, anatomical and functional differences between the left brain and right brain. But how much value there is in applying that knowledge is questionable.

## Summary

Brain-based learning is not a panacea or magic bullet to solve all of education's problems. Anyone who represents that to others is misleading them. It is not yet a program, a model or package for schools to follow. One critic of brain-based learning said, "It will at least be 25 years before the benefits of brain research reach the classroom." I'll cite just one example to show you why I disagree.

Two neuroscientists, Stanford's Dr. Michael Merzenich and Dr. Paula Tallal from Rutgers, developed the phonological processing improvement product FastForword. That product is already in use today in thousands of classrooms around the country. Many students have been helped by it. It specifically uses discoveries in neural plasticity to change the brain's ability to auditorally process the printed word. The fact is, the benefits are already reaching the classroom. And they're not just through thousands of books and in-services.

**How would one know if you're doing Brain-based learning?**
Brain based learning is the informed process of using a group of practical strategies that are driven by sound principles derived from brain research. If you are doing what's working and your students are having fun, that still doesn't mean it's brain-based learning. If you agree with the principles of brain-based education, or went to a brain-based workshop, that doesn't mean you're doing the real thing. So, how exactly would you know if you were doing something brain-based?

1. You would be able to articulate what the brain-principle was you were using and why you chose the strategy you chose. Your work would be purposeful. *(e.g. "I understand that certain emotions can enhance memory. I'm going to first use suspense and then a celebration with this activity.")* You would also know the critical "how we learn" principles that give you guidelines (constraints and possibilities).

2. You would know the research or where to find the research on the particular strategy you used. Your work would be authentic. *(e.g. "I know some very good work on this topic was done by Dr. Larry Cahill at Univ. of Calif. at Irvine.")* You would also know 10 of the hottest and best WEBsites, four of the top "brain-based" universities and a half dozen of the elite, premier sources for staying current with the exploding new brain research.

3. You would know what kind of results you could expect and if you needed a change of strategies. Your work would be flexible. *(e.g. "I know enhanced noradrenergic activity boosts long-term memory for explicit learning.")* Even more importantly, you'd know what are the variations and exceptions to the rule and how to present them. In most cases, the devil is in the details and you'll want to learn them.

4. You would be challenged by the prospect of changing student brains on a daily basis, yet feel up to the task. Your work would be meaningful. *(e.g. "I know that the human brain can and does change every day and I'm excited to be part of that process.")* Knowing THAT you change brains every day is very powerful, but it's also daunting. What you need to know are the 14 specific variables that enhance positive change in the brain. Knowing how and when to enrich is empowering and exciting.

5. You would have the content knowledge matched with the presenting skills so that what you knew became what was learned. Knowing about the brain is useless unless you're a neuroscientist—educators *must have the tools* to translate it. That means you're using top quality presenting skills. Why? Most of what students learn is NOT in the lesson plan. Unless your posture, tonality, gestures, directions, expressions and activities are fully aligned with the other content-related messages, the strongest message (implicit, nonverbal) will win out!

Schools should not be run based solely on the biology of the brain. However, to ignore what we do know about the brain would be equally irresponsible. Brain-based learning offers some direction for educators who want more purposeful, informed teaching. It offers the possibility of less hit or miss in the classroom. We have learned

about how environments impact our learning, the role of trauma and the effects of distress and threat. With additional clarity in research, brain-based approaches may soon suggest far better options for those struggling with learning.

Yes, we are in the infancy of brain research—there's so much more to learn that we don't know. But dismissing it as fad-like, premature or opportunistic is not only short-sighted, but also probably dangerous to our learners. Of course brain research seems conflicting, hazy, confusing, and contradictory. It's new! That should be expected! But to criticize it? At this early stage, that would be like calling the Wright Brothers first flight at Kitty Hawk a failure because it only went a few hundred yards.

The future belongs to those with vision who can grasp not just trends, but the importance of them. Nothing is more relevant to you than your brain or the brain of your spouse, parents, or children. We might as well get used to it. Integrating brain research with our every day lives is here to stay. Relax because no one learned all the research in one day. Set yourself a goal, and learn and use one new thing a week. In time, you'll get where you want to go. Replies may be directed to eric@jlcbrain.com