The Gully in the “Brain Glitch” Theory

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Far from supporting phonics-heavy reading instruction, new advances in neuroscience show that learning to read is a complex process in which enjoyment plays an important role.

Learning to read is not a natural part of human development. Unlike speech, reading does not follow from observation and imitation of other people (Jacobs, Schall, & Scheibel, 1993) and has no specific regions of the human brain dedicated to it. Reading requires multiple areas of the brain to operate together through intricate networks of neurons; thus, many different brain dysfunctions can interfere with the complex process of learning to access, comprehend, and use information from text. Knowing how interdependent these areas of the brain are, we should hardly be surprised that an estimated 20 to 35 percent of students experience significant reading difficulties (Schneider & Chein, 2003). In fact, it is wonderful that anyone learns to read at all.

Unfortunately, misinterpretations of recent neurological research have ignored the complexity of the cognitive processes involved in learning to read. Some education policymakers have used the conclusions of this research to claim that neuroscience proves the necessity of intensive phonics instruction for students who struggle with reading. This oversimplified interpretation of the cognitive research harms students and schools.

An Oversimplified Picture of the Brain

During more than 20 years of practicing neurology and conducting electron micro-scope research analyses of the neurophysiology of the cerebral cortex, I have been fascinated by the connections among many parts of the brain that neuroimaging revealed. Since leaving my medical neurology practice to become a classroom teacher, I have felt compelled to respond to research analyses that oversimplify and misinterpret the results of neuroimaging scans.

Unfortunately, federal policymakers are currently using flawed research analyses to advance a narrow approach to reading instruction. When President George W. Bush promoted the Reading First program and introduced Head Start legislation that heavily favored phonics reading instruction, he assured the nation that “scientific” brain research had produced definitive data proving the merits of this

Source: From “The Gully in the Brain Glitch Theory,” by J, Willis, 2007, *Educational Leadership*, *64(*5), pp. 68–73. Copyright 2007 by ASCD. Reprinted with permission.

approach. To support such claims, phonics advocates often cite research conducted by Shaywitz and colleagues (1998, 2002, 2003)—research that falls far short of the medical scientific model. I have read this research, and I believe that its conclusions are based on flawed studies and misinterpretations of the findings.

Shaywitz and colleagues used functional magnetic resonance imaging (fMRI) to measure differences in the brain activity of normal and dyslexic readers as they performed such tasks as reading a list of rhyming nonsense words. Because the dyslexic readers' brains showed a disruption at the rear area of the brain, where visual and sound identifications are made during reading, the researchers concluded that a “glitch” in the brain circuitry holds the key to reading difficulties.

The major flaw in the brain glitch research was its assumption that subjects were actually *reading* during the fMRI scans. The reading tasks evaluated were not authentic reading. Rather, they were phonics-based sound-and-symbol tasks.

The researchers' interpretations of the fMRI scans considered only one portion of the brain's complex—and still not completely defined—reading network, focusing on a brain region known to be more active during phonics processing. Predictably, this brain region became more metabolically active when the test subjects performed phonics processing activities. Also predictably, when students receive intensive phonics instruction, this region of the brain shows more activity, and the students' performance on tests designed to measure phonics skills improves. But we cannot generalize from these findings that *all* reading improves when the so-called phonics center becomes more active.

Such a conclusion would be like taking a patient who has suffered permanent right-arm paralysis that has spared, but weakened the right pinky finger and treating the patient by performing intensive physical therapy on that one finger. If the patient moves that finger during an fMRI scan, the brain region with neurons dedicated to movement of the right pinky finger (there is such a place in the left frontal lobe) will show an increase in metabolic activity, use more glucose and oxygen, and light up the colors of the fMRI scan. If the patient receives physical therapy exercising that finger, a subsequent fMRI scan could show that the brain has responded by building more cellular connections around the neurons in that dedicated section. Yet, no improvement would necessarily occur in the movement of any other part of the patient's arm; the therapy would not affect the damaged neurons that control the whole arm.

In the same way, it is faulty science to conclude that reading ability has improved just because phonics-intense instruction has produced changes in phonics-functioning brain regions and improved performance on phonics-weighted post-tests. Nevertheless, researchers have used the brain glitch theory to lump diverse reading differences and learning styles under a single label of phonics impairment. And policymakers have used that label to promote one-size-fits-all, phonics-heavy reading instruction (Coles, 2004). A generation of students is paying the price.

Limitations of Neuroimaging

Functional magnetic resonance imaging and other neuroimaging technologies—which show increased blood flow and blood oxygenation in parts of the brain that are activated during various cognitive tasks—are exciting tools for studying what happens in the human brain as people learn. But it's important that we use caution in drawing conclusions from the results of brain scans. The brain glitch researchers' conclusions reached far beyond the current limitations of neuroimaging.

As an example of one such limitation, the observation that a brain area is metabolically active *during* a reading task does not prove that it is active explicitly *in* the reading task. To increase scan analysis precision somewhat, we can use subtraction analysis (Friston, Zarahn, Joseph, Henson, & Dale, 1999). This technique takes baseline scans when the subject performs a task identical to the task being studied in all but one cognitive variable and then subtracts the baseline scan's areas of metabolic activity from the overall metabolic activity shown during the experimental scans. This presumably leaves only the single cognitive operation as the remaining part of the brain that is different from the baseline scan. The brain glitch analyses did not use this technique and thus did not account for the complex patterns of brain activity that are involved in the reading process.

Another problem with current neuroimaging technology is speed. Both fMRI and positron emission tomography (PET) neuroimaging scans show changes in metabolism over seconds, but many parts of the reading process take place during the 20 to 200 milliseconds before the eyes move from one word to the next. To "see" cognitive events occurring that rapidly, such as individual word identification or naming, some research has used time-precise neuroelectric monitoring systems that measure the activation of small clusters of cells (Kail, Hall, & Caskey, 1999). The brain glitch scanning studies did not use such technology and thus relied on the gross metabolic activations of fMRI scans to represent the complex brain activity that occurs as children read.

The Complex Brain

Although the brain glitch theory treats learning to read as an isolated, independent cognitive process, reading is actually a complex process connecting multiple learning and association centers in the brain. Neuroimaging shows that specific sensory inputs (sound, visual images, and so on) are received in the brain lobes specialized to accept them. Any new information en route to its designated lobe passes through a type of alerting system in the limbic system (parts of the temporal lobe, hippocampus, and amygdala). Here, the sensory information is linked to previously learned memory, connecting new data with the prior information and thus forming long-lasting relational memory. After the initial response to the new input, feedback goes back to the medial temporal lobe where the relational memory is sent along neural circuits to long-term memory storage areas. This process both reinforces and expands brain neurodendritic circuits that connect the multiple brain lobes.

Just because fMRI scans during sound-and-symbol phonics activities show activation in one brain center, that does not prove that other brain areas are not equally or more metabolically active during other types of reading tasks or for children with different learning styles. Regardless of which center shows initial activation or even sustained activation, all brain operations are complex and involve communication among multiple lobes. At the minimum, reading stimulates the limbic system, occipital cortex, associational subcortical frontal lobe centers, and medial temporal lobe. Reading instruction that stimulates multiple brain areas is likely to be more successful for different styles of learners and more efficient in facilitating the multicentric, dynamic process of reading.

Combining Science with the Art of Teaching

The implications of neuroimaging for education and learning research are still largely suggestive. Researchers have not yet established a solid link between how the brain learns and how it metabolizes oxygen or glucose. It is premature to claim that any instructional strategies are firmly validated by a solid combination of cognitive studies, neuroimaging, and classroom research. For now, educators must be guided by a combination of the art of teaching and the science of how the brain responds metabolically and electrically to stimuli. Here are some promising areas of research and practice.

The Amygdala—Where Heart Meets Mind

The education literature has included theories about the effects of emotion on language acquisition for decades. Dulay and Burt (1977) and Krashen (1982) proposed that strong positive emotion reinforces learning, whereas excessive levels of stress and anxiety interfere with learning. Educators know from subsequent cognitive psychology studies and firsthand classroom experience that high stress, boredom, confusion, low motivation, and anxiety can hinder students' learning (Christianson, 1992).

Research using neuroimaging and neuroelectrical brain wave monitoring supports the connection between emotion and learning, enabling us to see what happens in the brain during stress (Introini-Collison, Miyazaki, & McGaugh, 1991). The amygdala, part of the limbic system in the temporal lobe, senses threat and becomes overactive, delaying or blocking electrical activity conduction through the higher cognitive centers of the brain. When the amygdala is in the overactive metabolic state associated with stress, the rest of the brain's cortex does not show the usual fMRI or PET scan activation that represents the processing of data (Chugani, 1998; Pawlak, Magarinos, Melchor, McEwen, & Strickland, 2003). New information coming through the sensory intake areas of the brain cannot pass as efficiently through the amygdala's affective filter to gain access to the brain's cognitive processing and memory storage areas, such as the left prefrontal cortex.

Additional evidence of the amygdala's role as an affective filter comes from real-time neuroelectric studies, which demonstrate that the somato-sensory cortex areas are the most active areas of the brain during the moments when new information is received. These are regions found in each brain lobe that receive input from each individual sense—hearing, touch, taste, vision, and smell (Andreasen et al. 1999). Mapping studies show that bursts of brain activity from the somatosensory cortex are followed milliseconds later by bursts of electrical activity in the hippocampus, the amygdala, and then the other parts of the limbic system (Sowell, Peterson, & Thompson, 2003). This is one of the most exciting areas of brain-based learning research because it shows which strategies stimulate and impede communication among the parts of the brain when an individual processes and stores information (Shadmehr & Holcomb, 1997).

This brain research supports educators' firsthand experience, which tells us that superior learning takes place when learning activities are enjoyable and relevant to students' lives, interests, and experiences (Puca & Schmalt, 1999). Teachers recognize the state of anxiety that occurs when students feel alienated from their reading experiences or anxious about their lack of understanding. I witnessed this response when, as a student teacher, I worked in a school district that had implemented time-and-page synchronization of its phonics-heavy reading program (Open Court). All teachers were required to cover material at a mandated pace, so that students at each grade level were on the same page of the program each day. Second graders were brought to tears or outbursts of frustration when they were confused; their requests for help went unheeded as teachers struggled to keep to the timetable. Students were told, "Don't worry. If you don't understand or finish now, you'll be taught this same material in a lesson some time in the future."

Neurochemical, neuroimaging, and neuroelectric research support a learning model in which reading experiences are enjoyable and relevant. The brain research evidence reinforces the need for classrooms to become places where students' imaginations and spirits are embraced when reading time begins.

The Chemistry of Motivation

Research on neurochemistry also supports the benefits of intrinsically rewarding, positive experiences associated with the learning process. Chemical impulses in the brain enable information to travel across nerve synapses—the gaps between neurons. (Information travels along the nerve cells' branching and communicating sprouts—axons and dendrites—as electrical impulses and is temporarily converted from an electrical impulse into a chemical one to travel across the synapses.) Neuro-transmitters, such as dopamine, are brain proteins that are released by the electrical impulse on one side of the synapse and then float across the synaptic gap, carrying the information with them to stimulate the next nerve ending in the pathway.

Neurochemical neuroimaging analyses show that dopamine release increases in response to pleasurable and positive experiences (Brembs, Lorenzetti, Reyes, Baxter, & Byrne, 2002). Early studies suggested that when an individual engages in certain activities (for example, playing, laughing, exercising, being read to, and recognizing personal achievements), the amount of dopamine released by the brain increases. Later studies discovered that neuron circuits going from the limbic system into the frontal lobe and other parts of the cerebrum, rich in dopamine receptors, respond to this dopamine release (Wunderlich, Bell, & Ford, 2005). Follow-up research has also shown increased release of dopamine even when subjects *anticipated* pleasurable states (Nader et al., 2002).

Because dopamine is the neuro-transmitter associated with attention, memory, learning, and executive function, it follows that when the brain releases dopamine in expectation of pleasurable experience, this dopamine will be available to increase the processing of new information.

Unfortunately, most phonics-based reading curriculums do not place a priority on providing enjoyable reading materials that induce pleasurable states in the brain, pacing lessons at comfortable speeds, giving students opportunities for self-satisfaction, and acknowledging authentic achievement. The decodable reading books in phonics-heavy reading systems are often overly simplistic, and their language sounds unnatural because of the limitations of phonetically decodable vocabulary. Such books lack personal relevance or interest to many young readers. They do not stimulate a student's intrinsic interest in reading.

Brain Stimulation in Action

Researchers at the University of Maryland (Guthrie, Wigfield, Barbosa, & Perencevich, 2004) mixed reading strategy instruction and motivation support in a paradigm called Concept-Oriented Reading Instruction (CORI). The program helped students establish content goals for reading, allowed students to choose texts, used interesting texts, and encouraged social collaboration during reading. It also employed the cognitive strategies of generating related questions, activating background knowledge, summarizing text, searching for information, organizing information graphically, learning the structure of stories, and monitoring comprehension.

Concept-Oriented Reading Instruction was implemented in whole classrooms of elementary students. Using a variety of standardized tests to measure understanding, reading strategies, and motivation, the researchers found that classrooms that used the combined CORI formula scored significantly higher on standardized tests of reading comprehension and on measures of reading motivation than did classrooms that used strategy instruction alone. The researchers concluded that teaching reading strategies is effective for improving reading, but not nearly as effective as coupling those strategies with motivational strategies. Considering the research on the amygdala, limbic system, and dopamine, it is not surprising that the motivation support paradigm of this program was so successful.

Where Are We Now?

The stated goal of much education legislation is for all students to learn to read. The goal of most educators extends beyond that—for students not only to learn the mechanics of reading, but also to develop a love of reading. We can begin to achieve these goals when we teach students to read in nonthreatening, engaging, and effective ways.

Cognitive psychology, affective filter data, and neuroimaging, neuroelectric, and neurochemical evidence do not support an approach that puts phonics first at the expense of intrinsic appeal and significance to the young reader. They do support a phonics-embedded approach that uses literature as a medium through which motivated, engaged students can enjoyably learn reading skills and strategies.

Although valid neurological research offers exciting possibilities and must continue, we should not be fooled by policymakers or program developers who use the term *brain-based learning* in ways that many medical and teaching professionals consider irresponsible. Until there is a direct connection between double-blind, variable-controlled analysis and confirmed results, interpretations of data to "prove" that certain instructional strategies are superior fall into the realm of speculation. As educators, we can only evaluate the research, read objective evaluations by neutral third-party reviewers, and create or use strategies that are compatible with what we know about the brain. Teaching reading is still far from being pure science, and educators need to call on their training and experience as well as consider the findings of neurological research to shape their instruction.

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