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Brain-Based Research & Language Teaching

BRAIN-BASED TEACHING AND LEARNING IS A TOPIC THAT HAS BEEN RECEIVING MUCH attention in English language teaching circles recently. Many EFL teachers seem to be interested in knowing what brain-based teaching and learning is and how to apply information about the brain to classroom practice. There is no doubt that neuroscience is a burgeoning field of study (Caine and Caine 1994, 1997a, 1997b; Kotulak 1996; Wolfe and Brandt 1998; Jensen 1995, 1998). We have learned more about the brain in the last five years than in the 100 years preceding them.

Teachers are excited about brain-based research because it helps them understand how the brain learns best and how they can take advantage of this knowledge to help their students learn as quickly and efficiently as possible. We need not become experts on brain anatomy, but we must have some understanding of how multifaceted the brain is in order to more fully appreciate the complexities involved in educating language students. In this article, I want to introduce brain-based teaching and learning, first, by reviewing some basic biological facts about the human brain and, second, by discussing seven principles based on recent research that have practical benefit for EFL teachers.

Technology

The human brain has been studied for years yet educators have paid very little attention to it. Why is there now a sudden explosion of interest among educators about the human brain? What has happened in brain research to provoke this change?

Until recently, the only way information could be acquired about how the brain works was from autopsy studies. For example, we learned that the human brain weighs two to three pounds and is about the size of two fists. If you make a fist with each hand and hold them next to each other, you can get an accurate idea of how large the human brain is. While these studies have been important in helping us understand the structure of the human brain, they have provided only limited information about the functions of a living human brain.

Recent technological advances have made it possible for neuroscientists to study living brains, enabling discoveries that reveal interesting features of the human brain. For example, even though the brain is a relatively small part of our body, in terms of size and weight, it uses as much as 25 percent of the body's energy. Each time the heart pumps blood through the body, about 20 percent of the blood goes through the carotid arteries to the brain, carrying oxygen and important nutrients, such as glucose. One type of technology, Positron Emission Tomography (PET), provides particularly useful information about how the brain works.

Positron Emission Tomography (PET) Scan

PET scan technology works by taking advantage of the brain's need for glucose. After receiving a minute injection of radioactive glucose (which is noninvasive and harmless), the person undergoing the PET scan is put in a large donut-shaped machine called a PET scanner, which is an imaging device. The PET scanner shows the amount of glucose utilization in the brain as the person engages in certain mental tasks, such as looking at something, solving a problem, or simply listening. The part of the brain used for a given task requires the most glucose and has the most radioactive particles. These particles are read by the PET scanner and transferred onto a color computer screen with orange, yellow, and red indicating the most activity, and blue and green indicating less activity. Thus, if a person in the PET scanner is engaged in looking at a photo, there would likely be increased activity in the occipital lobe—the lobe in the middle back of the brain responsible for vision. Through this technology, the PET scanner allows us to study a brain in action.

Brain biology

When I studied the human brain during my undergraduate years in college, I didn't believe that the information I learned would have much to do with my ultimate goal of becoming a language teacher. Today, I have an entirely different view of the relevance of knowing about the human brain. I am now aware of the usefulness of this information and would like to share it so that other language teachers can appreciate its relevance to language acquisition in general and to certain classroom learning and teaching practices in particular. But first, it is helpful to understand the parts of the brain and some aspects of brain biology.

Brain stem: The oldest, most primitive part of the human brain is the brain stem. It is responsible for regulating essential automated functions in the body, such as heartbeat and breathing. It is also responsible for the production of important chemicals, such as serotonin, which regulates sleep and wake cycles.

Cerebellum (Latin for *little brain*)**:** This part of the brain is responsible for maintaining one's balance, posture, and some motor movements. Some experiments (Thompson 1993) suggest that long-term memory traces are located in the cerebellum.

Cerebrum: This is the center of thought. It makes up about 75 percent of the total volume of the brain and is divided into two hemispheres, left and right, each with a slightly different function.

Corpus collosum: This part of the brain is a bundle of several hundred million nerves that connect the left and right hemispheres of the brain. It allows the two hemispheres to communicate with each other and exchange information.

Neocortex: This thin layer covers the brain. It is about as thick a coin and has many

We underrate our brains and our intelligence…. Learning is the brain's primary function, its constant concern, and we become restless and frustrated if there is no learning to be done. We are all capable of huge and unsuspected learning accomplishments without effort.

F. Smith
Insult to Intelligence
The Bureaucratic Invasion of our Classrooms
(1986:18)

folds and ridges. If it could be laid flat, it would cover about one square meter.

Limbic system: In the middle of the brain are two important structures. The first is an almond-shaped mass known as the amygdala, which is the seat of emotion. The second is the crescent-shaped hippocampus, which is involved in learning and memory.

Memory and Emotion

The cognitive side of learning usually gets a great deal of attention, but the affective side of learning is also important (Krashen 1985; Stevick 1976). Neuroscientists are only now mapping out this important component of learning (Jensen 1998). During the PET scan explanation above, we learned that blood flows to different areas of the brain depending on the mental activities in which a person is involved. When we feel threatened, anxious, or fearful, the blood flows from the neocortex to the amygdala. MacLean calls this *downshifting* (1990). The limbic area of the brain is not the area of logical thought and decision making. Those processes happen in the neocortex. When downshifting occurs, the neocortex does not get sufficient glucose to function properly. For a short period of time, the amygdala "hijacks" the brain (Goleman 1995). We are not able to make rational, logical decisions when the neocortex does not get sufficient glucose.

We often talk about memory as if it were a one-step process, but memory is not a singular process or simple skill. Memory is a process (Jensen 1998) with several key steps. First, there must be sensory register for conscious and nonconscious stimuli. Second, short-term memory occurs, which usually lasts for only 5 to 20 seconds. Next, active processing and thinking must take place. Finally, information, including explicit memories and implicit learning, can pass into long-term memory. There is no single location for memories in the brain. The hippocampus has long been considered central to memory, but other parts of the brain are also involved in memory formation, even the amygdala (Schacter 1992).

There are four different pathways through which memories and information are retrieved. Our ability to recall information often depends on which pathway we access, but each pathway is important in the overall processing of information.

One pathway is procedural, for repeated actions that become somewhat automatic. For example, each time you participate in an activity, a certain number of neurons (cells in the brain) are activated. When you repeat the action over and over again, the same neurons respond. The more times you repeat an action, the more efficient your brain becomes. Eventually, you need only trigger the beginning of a sequence of an action for the remaining pieces to fall into place. This pathway is procedural memory.

Emotion is a hook that helps us remember events. If we want to help our students remember important information, we need to hook the information to a positive emotional episode in the classroom. If I asked you to recall an event from your early childhood related to school, my guess is that the event you would recall had some negative or positive emotional impact. These emotional triggers are attached to events in our lives and trigger episodic memory.

Semantic memory is the most frequently used memory pathway in the second and foreign language classroom. When we ask students to learn new vocabulary words, memorize grammar rules, or perform other similar tasks with factual information, we call on semantic memory.

Information constantly comes to us from our environment. All of our five senses are sometimes bombarded with information simultaneously. In order to handle such a large amount of information and not become overwhelmed, our brains have learned to sift and sort input. The sensory receptors act like a sponge, and the conscious mind acts like a sieve. It takes less than a second for the brain to process most sensory information. What is dropped from sensory memory in this process is gone forever. Deciding what to keep and what to get rid of is an individual process that can be affected by a teacher and the classroom.

Brain-based principles for the EFL classroom

So far in this article, I have summarized some general information on how the brain appears to work. What I would like to do next is present some accumulated insights from research on the human brain that have practical benefit to second and foreign language educators. The following seven principles can provide a general framework for learning and teaching and offer some guidelines for selecting classroom strategies, materials, and methodologies.[1]

Principle 1: The brain is a parallel processor

The human brain is capable of doing many different tasks at one time (Caine and Caine 1994; Ornstein and Sobel 1987). Our thoughts, emotions, and imagination as well as automated functions all operate simultaneously. Brain-compatible teaching should orchestrate the learner's experience so that many different aspects of the brain's operations can be addressed. Although there is no single method, strategy, or technique that can encompass the diversity and variation of the human brain, teachers who actively involve their learners in a variety of activities in the classroom and who consider learning styles and multiple intelligence theory in their lesson planning are creating classrooms that take advantage of the brain's parallel processing abilities.

Principle 2: The brain downshifts under threat

When students feel threatened, uncertain, afraid, or intimidated in the classroom, the brain downshifts (Goleman 1995). When downshifting occurs, the brain does not get sufficient glucose for cognitive functions such as clear thinking and problem solving. Downshifting suggests that emotions are critical to learning and that emotion and cognition cannot be separated (Ornstein and Sobel 1987). As language teachers, we must understand that students' feelings and emotions can determine the effectiveness of their learning and our teaching. Emotions are also crucial to memory because they facilitate the storage and recall of information (Rosenfield 1988). The challenge that teachers face is to make the classroom experience an emotionally positive one for students. An effective teacher must focus on student learning and continually consider the impact of classroom activities on the students themselves.

Principle 3: The search for meaning occurs through patterning

Patterning is the meaningful categorization and organization of information (Nummela and Rosengren 1986). The search for meaning occurs through patterning as the brain attempts to discern and understand events and stimuli in its environment. Individuals pattern differently from one another. When the brain's natural tendency to construct meaning from patterns is exploited in teaching, learning in the classroom becomes more like learning in real life. Because the brain creates patterns, the task for teachers is to organize and present material in a way that allows the brain to create meaningful and relevant connections to extract the patterns. This type of learning is most easily recognized in the whole language and content-based approaches to language learning. Both of these approaches seek to connect meanings through the development of problem solving and critical thinking skills.

There are at least four ways teachers can provide more patterning for learners. First, before we begin working with a new text, we can try to find out what students already know about the topic. Second, we can give global overviews on overhead transparencies and large posters. Third, we can help students form patterns by encouraging discussion of the material. Finally, we can help learners form patterns by creating models and using graphic organizers.

Principle 4: The brain is meaning driven

Principle 4 is closely related to principle 3. The ability to make meaningful sense out of countless pieces of data is critical to understanding and motivation. Because the brain is pattern-seeking, patterning occurs all of the time. The brain's craving for meaning is automatic; we cannot stop the brain's natural process of seeking patterns. Each pattern that the brain discovers can be added to the learner's perceptual maps. When this happens, the brain avoids a state of confusion or anxiety. It becomes maximally effective and is ready for more challenges.

The challenge for language teachers is to create activities and materials that are meaningful. Students can master rote memorization, but they often become full of information yet starved for meaning. Unless information carries meaning for the students, they will not be able to use it. The process of

1. This set of seven principles is revised from an earlier set of principles of brain-based research presented in a plenary speech at the 1998 TESOL convention (see Christison 1998 and Christison 1999).

helping students derive meaning from texts and from their day-to-day interactions should be a critical focus of teachers.

Principle 5: Each brain is unique

Every student is unique, and every brain processes information slightly differently. Teachers must be open to different interpretations and different ways of seeing information. Getting the correct answer is only part of the picture. Finding out what students think and know is also crucial. Brain compatible learning requires greater choices for learners and more diversity in instructional choices. As teachers, we are sometimes guilty of jumping to conclusions about learners based only on the answers they give to questions that have only one right answer.

Jensen (1995) gives an example of a physics teacher who asks the following question to students: "Using a barometer, how can you tell the height of this building?" The expected correct answer is: "Measure the air pressure at the bottom of the building and then compare it with the air pressure at the top of the building. Then, using the prescribed formula [which the physics teacher had given them in class], compute the difference in feet or meters to come up with the height of the building" (1995:133). Jensen says that some students found more creative ways of calculating their answers:

1. Tie a string onto the barometer and throw it off of the top of the building. Then when it lands, measure the length of the string needed.
2. On a sunny day, use the shadow cast by the barometer and the building as a comparison and compute the ratio.
3. Take the barometer to the building inspector, engineer, or architect. Offer to trade the barometer to that person in exchange for the exact height of the building. (Jensen 1995:133)

If we do not look at the unique processes that our students use in the context of any given learning situation, we miss out on a huge opportunity to know more about our learners and how we can best facilitate their learning.

Teachers can address learner uniqueness and diversity by allowing learners to work together in groups to assess and evaluate their own learning. Instead of telling students what is right and what is wrong, teachers should give learners opportunities to shape their own learning and practice self-assessment. Instead of asking only questions that require statements of fact or yes/no answers, teachers should ask more thought-provoking questions. Redfield and Rousseau (1981), in their meta-analysis of research on teacher questioning behavior, reported that the better the quality of questions asked, the more the brain is challenged to think. The same conclusion is also reached by Berliner (1984) in his review of research on teaching. This research suggests that teachers should have students make up their own test questions and answer them. Students should also quiz each other on simple, factual questions (those with only one right answer) so that teachers can direct their attention to more complex and provocative questions.

Principle 6: Movement and exercise improve brain functioning

Dienstbier's research (1989) shows that aerobic exercise can improve thinking and learning. Physical exercise seems to train a quick adrenaline response and rapid recovery in the brain. Aerobic exercise also improves mental functioning by increasing blood flow, and therefore oxygen flow, to the brain, which helps students think better.

Moving students around in the classroom, and getting them involved in activities that require them to get into groups, go to the board, retrieve materials from various locations in the room, and rotate groups are helpful in increasing oxygen flow to the brain. Making certain that classroom activities include physical movement is important for optimally functioning brains. If possible, students should have permission to get up on their own, move around, and stretch.

Principle 7: Brain growth is enriched by continued learning

Continued learning develops better brains than remaining intellectually inactive. Jacobs, Schall, and Scheibel (1993) documented the positive effects of enriched environments on humans. Level of education had a consistent and substantial effect on dendritic branching. Problem solving is to the brain what aerobic exercise is to the body. Brains stay younger, smarter, and more useful by working out with "mental weights."

Enrichment may come from many different sources, including positive and engaging social contact; high-challenge, low-stress activity; and life experiences that are novel and exciting. In the classroom, students can participate in teams, with partners, and in project work for positive and engaging social contact. High-challenge, low-stress activity is possible in the classroom through variations of student-generated activities. Contact with individuals from other language and cultural backgrounds, traveling, and participating in cultural events are excellent activities for satisfying the need for novel and exciting experiences.

Conclusion

The English language teaching profession may be on the verge of a major transformation as we gain increased scientific knowledge about the physiology of the human brain. This information has the potential to affect greatly how we approach teaching in the classroom. If we, as teachers, want to provide informed leadership on the complex educational issues arising from current brain theory, we must pay attention to this research and its implications for the second and foreign language classroom.

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