Human Brain: Perspectives from Second Language (L2) Learning

Rahman M. Mahbub
Associate Professor, Department of English
City University, Dhaka, Bangladesh
Email: rahmanmmahbub27@gmail.com

Abstract

The educators have been using the discovery of cognitive sciences to improve both student learning and current teaching practices. The associations of neuroscience for educational improvement regarding second language (L2) learning can evidently be seen in the following categories: brain structures and the corpus callosum; neuronal development and the parts of the brain dedicated to language; the Brain Plasticity Theory and Language Mapping; memory and the information Processing Model, and of course, developing and utilizing a brain – attuned language curriculum that is meaningfully integrated into the basic content areas covered in all grade levels. This article describes and addresses relationships between corpus callosum and bilingual capacity; and provides recommendations to language teachers regarding brain-based learning through content – based language teaching for student learning and teaching practices.

Keywords: brain structures, corpus callosum, attuned brain, neuroscience, second language learning

Introduction

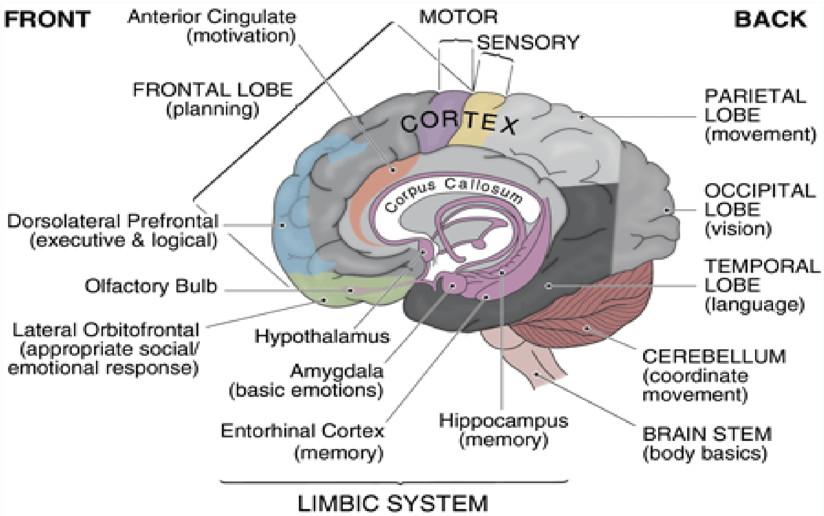
> "The human brain, a 3-pound mass of interwoven nerve cells that controls our activity, is one of the most magnificent--and mysterious--wonders of creation. The seat of human intelligence, interpreter of senses, and controller of movement, this incredible organ continues to intrigue scientists and layman alike." (Presidential Proclamation 6158, 1990)

Researchers actively began to study and propagate new information since 1990s that helping us to understand how the brain[1] functions. Meanwhile, thousands of new discoveries continue to be reported on regular basis, because of the advancement of technology that allows researchers to look inside the brain, inspect its physical structure, and monitor the constant activity taking place. Studying how the brain functions through the course of thinking and understanding can provide valuable insight into the learning process. Many researchers believe that the brain research findings highlighted now will ultimately give rise to comprehensive changes in education, especially guiding instructional practice followed in the classrooms in the future. Hence , pedagogically speaking, the vital next steps must be to apply new findings to the development of practical strategies and lesson plans that assist student learning in general, and more specifically, facilitate second language acquisition (SLA) for all students.

Brain Structures and the Corpus Callosum

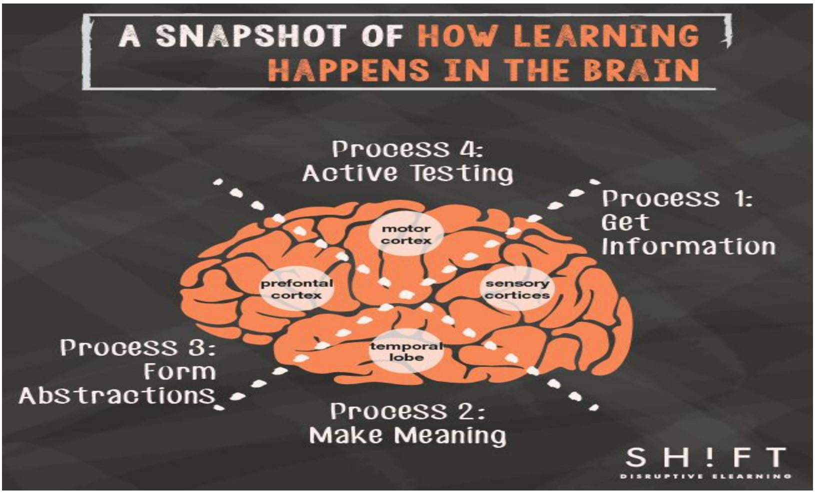
The ways about how the brain receives and processes information is pretty a complex procedure. We know during the course of any given moment in time, sensory input travels through the brain by way of the thalamus on its way to the cerebral cortex. This sensory input is filtered by the brain stem and limbic system. It is affected, and sometimes altered, by its passage through the lower, limbic systems of the brain, totally in control of our physical and emotional needs. The limbic brain is made up of clumps of specialized cells rather than the modularity found in the cortex. The thalamus is especially important to second language (L2) learners, as is the amygdala, which controls the emotional response to learning the new language. Information that survives the passage described above arrives at the frontal cerebral cortex, where information processing and learning begin to take place. It is at this point that the brain attempts to understand and make sense of the information registered via the senses. Information deemed meaningful and/or relevant is then stored in different localizations or modularity found in the cerebral cortex. The frontal cortex of our brain is the highly developed area that allows for problem solving. This is where sophisticated levels of thought processing occur and where information is processed so that one can understand it. Knowing why you do, what you do and having an appreciation for the potential consequences of your actions can help shape our behavior.

Figure 1: Limbic System



The various parts of the brain communicate by way of neurochemicals. During the last few decades, the chemical nature of nerve cell communication has been clarified significantly. Many neurochemicals, which serve as neurotransmitters, derive from dietary protein that must be included in daily consumption. Over 100 such compounds have been described. Studies have demonstrated that the human brain can and does grow new cells in the hippocampus (Eriksson, Perfilieva et al., 1998) and that brain is capable of building an infinite number of neuronal connections that strengthen the modularities found within the brain.

Figure 2 : How Learning happens in the Brain



Cortical pyramidal cells grow by adding dendrites, which given appropriate stimulation, will branch and re-branch. Enriched experiences enhance neural growth and thus enhance learning, indicating that brains construct themselves through life experiences. The more stimulation received, the greater the learning (Diamond, 2001). As Diamond has explained, environmental enrichment changes our neuronal network patterns or "maps of meaning." Time, stimulation, repetition, novelty, and motivation are essential to laying the foundations for later learning, which in turn results in either an impoverished or enriched neuronal composition (Jensen, 1998). By reflecting on this process, we can easily see how learning is directly affected by our students' emotional and physical well-being. Krashen's (1982) affective filter hypothesis is clearly in line with this notion, stating that the acquirer must be motivated, self-confident, and possess a low level of anxiety in order to receive the comprehensible input necessary for language acquisition to occur.

Physical development also plays a significant role in dendritic growth and the development of an enriched neuronal composition. The brain continues to grow new cells and change throughout a person's life. From birth to about three years in age, babies expand their knowledge of the world around them through their senses, storing information related to sights, sounds, smells, tastes, and touch in their attempt to understand their immediate environment. These sensory experiences produce millions of connections. In order to become more efficient, the brain begins its first "pruning" stage, losing excess connections not being fully utilized at about the age of four. At this point, brain growth steadily decreases until about the age of five or six due to a competing period of extensive body growth. Around the age of seven, a strong growth period occurs in the brain before it engages in its second phase of pruning that occurs close to age 10 to 11, when the process of focusing on dendritic growth begins again. Age 14 to 15, the beginning of adolescence, marks the third phase of pruning, as the brain is focusing on emotional development, and in many cases continued bodygrowth. During the period of 16 to 20 years of age, strong connections are developed in the frontal lobes responsible for problem solving and higher-level thinking skills. These major connections continue to grow through adulthood, with new connections continuing to be established, however not as easily as they were during the periods of strong dendritic growth experienced in early youth. This pattern indicates that the brain progresses through formative stages of development during maturity. Understanding these developmental stages of the brain and tailoring instruction in a manner that maximizes students' abilities can make learning more relevant and lasting for students (Franklin, 2005). Although the brain in not fully functional until ages 23 to 29, it is hypothesized that some variation in growth may influence learning (Thatcher, 1991). The size and combination of modularities found within the brain ultimately gives an individual his or her unique mental potential. Both nature and nurture are essential components of this equation. Varied experiences then continue to mold each individual's brain throughout life. The permutations and combinations of modularity type and size are infinite, as are the number of experiences one could have.

The two hemispheres of the brain are connected through axonal links at the central corpus callosum[2] , a broad, thick band, running from front to back and consisting of millions of nerve fibers, in essence, connecting the two cerebral hemispheres of the brain down the middle (see Figure 1). Since the corpus callosum is the major commissure, or bundle of axons connecting the two cerebral hemispheres, there is a direct correspondence left to right and front to back in connections through the corpus callosum. Information received in the brain is transferred from left-to-right; therefore the right hemisphere controls the left side of the body and vice versa. Generally speaking, the left and right hemispheres of the brain process information in different manners. Although the exact function and interplay between the two hemispheres is not yet totally understood, in most people, the left hemisphere is more specialized for linear, logical thought and communication, while the right hemisphere deals with spatial relationships and is more active when we are relaxed, and in a dream state. As the brain develops, the corpus callosum is responsible for transferring information across each hemisphere, reinforcing connections related to tasks that one is genetically predisposed to, or connections related to areas that are adapting and strengthening. For example, when the left eye sees a word, the right hemisphere will pass the information about the word over to the left hemisphere for processing by the language centers. Therefore, even though we tend to process information using our dominant side, the learning and thinking process occurs only when both sides of the brain participate in a balanced manner. When not actively engaged in learning, the corpus callosum acts as a bridge between both hemispheres, enabling the accomplishment of tasks of varying difficulty levels. Again, it is important to note that the research cited above has not conclusively determined that all communication between regions in the different halves of the brain are transferred only via the corpuscallosum. In spite of the linguistic processing dominance of the left-hemisphere (in most people), behavior, including cognition and communication, are the result of unconscious and seamless coordination of activity between both hemispheres via the cerebral commissures. Although investigations into the organization of multiple languages indicate that in some instances, functional aspects of two different languages may be mediated by overlapping cortical regions, in cases where two languages are processed by separate cortical regions, one would clearly suspect that the commissures would undergo some adaptive modification in response to the organization of both languages. In cases where different languages do not make use of overlapping or convergent cortical regions, it has been postulated that commissural modification, though less extensive, still happens because of increased processing requirements of linguistic switching (Coggins, Kennedy, & Armstrong 2004).

Parts of the Brain that Make Way for a Second Language

The bilingual children who learn an L2 store that capacity, together with their native language, in one sector of the brain, while adult language learners store each new language learned in a separate area. This explains why children who learn two languages develop the ability to speak both with native pronunciation and proficiency when provided adequate time, supporting the argument that foreign language instruction should be included in the elementary and middle school curriculum. In response to second language acquisition (SLA) and use, the human brain undergoes cortical adaptation to accommodate multiple languages either by recruiting existing regions used for the native language (L1), or by creating new cortical networks in distinct adjacent areas of the cortex to handle certain functional aspects of L2. However, regardless of how the cortex organizes the circuitry required to handle multiple languages, all non-reflexive behavior, including cognition and communication, is normally the result of unconscious and seamless coordination of activity between both hemispheres via the cerebral commissures. Although language is lateralized to the left hemisphere in over 90% of the normal population, language (subsumed under cognition and communication) normally involves information processing between both hemispheres. Different centers in the brain cooperate to understand and produce speech. Broca's area, in the left frontal lobe, controls the production of speech sounds. It is located close to the area specialized in the formation of words by the mouth, lip, tongue, and larynx. Wernicke's area, located in the left temporal lobe, allows for the formulation of meaning gathered from words and sentences to be connected into speech. Other regions in the brain assist Broca's and Wernicke's roles. For example, one part of the temporal lobe supplies nouns, and yet another joins the two together into logical sentences. Another example of the interconnected nature of the areas of the brain in relation to literacy skills is to examine the brain of a dyslexic reader, which would highlight the lack of distinct modularities communicating with one another—linking vision to sound to meaning.

Studies involving sophisticated brain imaging technologies called functional magnetic resonance imaging, fMRI, have also revealed some intriguing patterns in the way our brains process first and second languages.

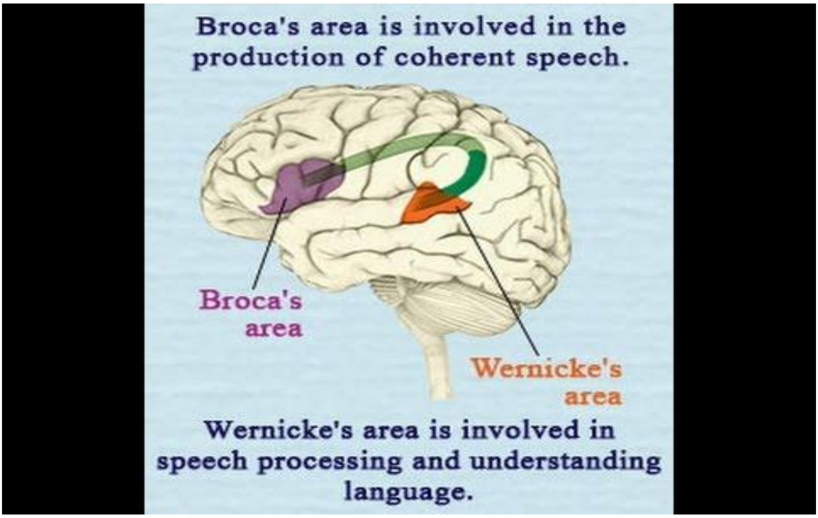
Joy Hirsch and her colleagues at Cornell University used fMRI(Brain Connection, 2001) to determine how multiple languages are represented in the human brain. They found that native and second languages are spatially separated in Broca's area, which is a region in the frontal lobe of the brain that is responsible for the motor parts of language-movement of the mouth, tongue, and palate. In contrast, the two languages show very little separation in the activation of Wernicke's area, an area of the brain in the posterior part of the temporal lobe, which is responsible for comprehension of language.

The fMRI studies (Brain Connection, 2001)suggest that the difficulty adult learners of a second language may have not with understanding the words of the second language, but with the motor skills of forming the words with the mouth and tongue. This may explain why learners of a second language can oftentimes comprehend a question asked in the new language, but are not always able to form a quick response.

Thus, for adult L2(English language) learners, techniques that emphasize speaking may be more successful than methods that focus more on reading and listening. For example, rather than lecturing to a class about vocabulary and grammar, an instructor perhaps should encourage his/her adult students to have conversations in L2, or to act out short skits incorporating the day's lesson, which would more closely link the students' abilities to understand and speak the new language. Speaking would thus equal understanding.

The Cornell researchers also studied the brains of people who were bilingual from a very early age. Presumably, this group of people is able to speak the two languages as easily as they can comprehend both languages spoken to them. The researchers found that these subjects showed no spatial separation in either Broca's or Wernicke's areas for the two languages, indicating that in terms of brain activation at least; the same regions of the brain controlled their ability to process both languages.

Figure 3 :Broca's area and Wernicke's area



The idea that second languages learned early in childhood are not separately processed in the brain is supported by fMRI studies of brain development in children. Researchers at UCLA (Brain Connection, 2001) report that the language areas of the brain seem to go through the most dynamic period of growth between the ages of 6 and 13. In contrast to the "first three years" idea of child development that has received so much press in the past few years, the UCLA study instead suggests that the elementary and middle school years are the biologically most advantageous times for acquisition of a second language.

These various neuroscience studies tell us that the brain is a remarkably plastic entity. A combination of listening and vocalization seems to be the most biologically advantageous method of acquiring a second language for both adults and children. Incorporating what we know about the way the brain processes language into the way languages are taught will benefit not only students who want to learn L2 (English), but also all those who wish to extend their linguistic range.

One theorist, Gazzanaga (2000), has implied that the corpus callosum provides clues to high conceptual level individuals. The Gazzanaga team noted that each hemisphere has specialized functions, but the corpus callosum allows these developments to be integrated into a constant functional system.

With respect to L2 education, it seems that bilingual learning and use can have a profound effect on brain structures in general, and on the corpus callosum in particular, since callosal adaptation might facilitate increased interhemispheric transfer by way of increased myelination, or by way of an increased number of fibers that provide greater cortical connectivity.

Neuroscience and Educational Reform

Theories have been developed to investigate the optimal age to undertake the study of an L2. Research has shown that the Brain Plasticity Theory (Nash, 1997), the Biological Predisposition Theory (Genesee, 1996), the Imprinting Theory (Celestino, 1993) and the Native Language Magnet Theory (Kuhl, 1994) commonly share the theme that the younger the individual is when he or she is exposed to a new language, the greater the probability of acquiring native pronunciation as well as proficiency in that language. Lending further support to this thought, researchers often refer to a newborn's mind as unprogrammed circuits of a computer that have almost infinite potential, additionally comparing the mind to Pentium chips found in a computer before the factory has preloaded the software (Begley, 1996). Begley reported that the circuits in the auditory cortex of the brain are wired by the age of one year, concluding further that the learning window for total language learning is from birth to 10 years of age. This implies that the critical periods for language learning close with each child's passing birthday. More recent research has concluded that the window for acquiring syntax may close as early as age five or six, while the window for allowing for the addition of new words may never close (Nash, 1997). However, Nash found that the ability to learn an L2 undergoes a steady and inexorable decline after the age of six. Many researchers suggest that after this critical period, brain plasticity becomes slowly less effective, in other words, the brain may be less able to make particular changes that organize the location of specific information processing functions resulting from experiential effects ("Language Learning and the Developing Brain", 1996).

Examining the methods that enhance L1 learning, and the types of activities and environments that positively affect the learning process, provides teachers with an insight into truly creating a brain-compatible classroom for students that are trying to acquire an L2 after the initial neuronal pruning stages have occurred. Almost all language skills are more easily acquired through natural language acquisition experiences, even for adult learners. The natural approach to language learning outlined by Krashen and Terrell (1983) maintains that beginning language learners should be taught a new language in the same manner that they acquired their first, encouraging observation, listening, and understanding before developing skills in speaking, reading, and writing. Of particular importance is the variable of time. Studies have shown that it takes thousands of contact hours to achieve the ability to function beyond the tourist level in Spanish and French; four to five times longer for other languages such as Arabic, Japanese, Korean, Mandarin, or Russian (Brown, 1997).

It is important to note that in nearly all adults (90%), the language center of the brain resides in the left hemisphere, but interestingly enough, the brain appears to be less specialized in children. According to a recent PBS special on the brain, "scientists have demonstrated that until babies become about one year old, they respond to language with their entire brains, but then, gradually, language shifts to the left hemisphere, driven by the acquisition of language itself" (*The Secret Life of the Brain*, 2002)[3] . Emotion, experiences, and learning of meaningful information strengthens useful connections and results in cortical pyramidal cell branching.

The physiological architecture of the brain changes in response to life experiences, adapting in response to environmental stimuli. It is not surprising to find that studies show young infants are predisposed to attend to the language spoken by others around them, using context to figure out what someone must mean by various sentence structures and words. Language development studies illustrate that children's biological capacities are set into motion by their environments (Bransford, Brown, & Cocking, 1999). Research has also shown that we are born with an ability to distinguish among different language sounds (Kuhl, 1994). Similar sounds are chunked together into one single category, and according to Kuhl, “language magnets” are developed that attract babies’ ears to the specific phonemic sounds found in the language(s) they are accustomed to hearing. For example, a baby that listens to Swedish (16 vowel sounds) will have different language magnets than a baby who hears Hangul (10 vowel sounds), English (8 or 9 vowel sounds), Bengali (7main vowel sounds), or who hears Japanese (5 vowel sounds). According to Kuhl, while the Swedish baby retains all the distinctions, the babies lose the ability to distinguish those vowels because their languages do not contain or utilize them. Kuhl’s research postulates that infants’ perceptual systems are established by six months of age and are at that time configured to acquire their native languages. She further explains that this wiring, or perceptual map, accounts for the accents that signal our national and regional origins. In contrast, the perceptual map experiences a certain amount of language interference with adult language learners. For example, many times, adult language learners have difficulty readily separating similar sounds in a foreign language. Basic examples include the difficulty experienced by adult native English speakers in regard to distinguishing the difference between a [B] sound and a [V] sound in Spanish, or that adult native Japanese speakers typically have difficulty hearing the difference between the [L] and [R] sound in English. This is explained by the opposite linguistic filters listening to the [B] and [V] or the [L] and [R] sound for English and Japanese speakers. However, it is misleading to characterize the acquisition process as simply easier for children in comparison to adults. The fact remains that the most difficult task for children and adults alike may be the attempt to acquire second language proficiency in academic environments. Older students typically excel in their initial rate of L2 learning since input is more comprehensible for them due to their extensive background knowledge and advanced learning skills they have already acquired and are prepared to apply—they are faster acquirers as well as faster learners, and because of this they have a greater ability to consciously learn grammar rules, and due to their past experiences, more easily make connections with vocabulary between L1 and L2. However, it has been shown that younger students excel in long-term L2 achievement, especially in pronunciation. And, for adult English language learners, techniques that emphasize speaking may be more successful than methods that focus more on reading and listening. For example, rather than lecturing to a class about vocabulary and grammar, an instructor perhaps should encourage her adult students to have conversations in L2, or to act out short skits incorporating the day's lesson, which would more closely link the students' abilities to understand and speak the new language. Speaking would thus equal understanding. The basic points to remember are:

- Language processing involves many senses, including vision, both in early infancy and in adulthood.
- Time and age are critical factors that affect the processes associated with language acquisition.
- Favorable and enriched environments promote neuronal development.
- The brain stores information based on functionality and meaningfulness.
- Emotions drive attention.
- Attention drives learning and memory.
- Repetition is necessary but it requires novelty with regard to instructional design (which should incorporate all five language processes—observation, listening, speaking, reading, and writing—and utilize a variety of methods and approaches).

Acquiring new vocabulary involves actively storing information gathered by explicit memories that have been processed combined with implicit learning, including skills and conditional responses. Access to long-term memory is an immediate goal in language acquisition. Given the average retention rate after a 24-hour period, we must help our students move information into long-term storage by providing them with higher level activities promoting application, analysis, synthesis, and evaluation. As a result of participating in small-group activities that promote practice by doing, and verbally working through meaningful problems, students are able to retain 90% of newly acquired knowledge.

In order to stimulate active involvement and evoke memory hooks that engage the learner, it is recommended that teachers provide their students with multiple opportunities to use vocabulary in meaningful and creative ways that stimulate the mind, which directly affects the growth of enriched neuronal connections (Jensen, 1998). Words should be heard and spoken before seen in written form to assure correct pronunciation as well as to facilitate memory recognition and word retrieval.

The Multiple Intelligences theory (Gardner, 1999) suggests that there are eight or possibly nine, intellectual variables associated with human performance. This theory is supported by the contention that the frontal cerebral cortex is made of thousands of modular units responsible for our conscious thinking, remembering, and behaving (Gazzanaga, 2000). This theory suggests that some individuals could possess different language competencies due to their experiences in each of the areas, as identified by Gardner, which allow them to readily make connections with the vocabulary. Since vocabulary must be heard between 40 to 80 times, depending on the complexity of the word, before it is stored in long-term memory, language teachers must create learning experiences for their students that are centered around many different activities. The multiple intelligences theory provides a guide for language educators to create meaningful experiences using language in a variety of areas, and more importantly, developing areas that may not have extensive experience.[4] The finding of plasticity, and the growing understanding that brain activities are directly linked by networks of neurons that simultaneously perform a variety of operations, suggests that education must broaden its scope to integrate language learning across the entire school experience.

Recommendations and Conclusion

Brain-based learning through content-based[5] foreign language teaching utilizes multiple teaching strategies, takes into consideration the different learning styles and intelligences represented in the classroom, and of course, follows the guidelines set forth by national as well as local standards in all areas of instruction. Teachers must employ curriculum design focused on high-powered, content-based lessons that truly keep the learners' brains in mind. The challenge ahead for teachers will be to incorporate brain-based activities framed around content-related topics into their classroom teaching, and of course, to promote programs that begin language learning as early as possible in a sequentially organized framework. The various neuroscience studies including the study of Joy Hirsch and her colleagues at Cornell University (Brain Connection, 2001) tell us that the brain is a remarkably plastic entity. A combination of listening and vocalization seems to be the most biologically advantageous method of acquiring a second language for both adults and children. Incorporating what we know about the way the brain processes language into the way languages are taught will benefit not only students who want to learn L2, but also all those who wish to extend their linguistic range.

NOTES

1. The **brain** is made of three main **parts**: the forebrain, midbrain, and hindbrain. The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system). The midbrain consists of the tectum and tegmentum. The hindbrain is made of the cerebellum, pons and medulla. For more details on brain see http://serendip.brynmawr.edu/bb/kinser/Structure1.html.

2. The term *corpus* refers to the main portion of any anatomical part, structure, or organ. The ***corpus callosum*** is an arched mass of white matter, found in the depths of the longitudinal fissure of the brain. It is composed of three layers of fibers, the central layer consisting primarily of transverse fibers connecting the cerebral hemispheres. The subsections, from anterior to posterior, are called the rostrum, genu, trunk (truncus), and splenium. An extended definition can be found at http://en.wikipedia.org/wiki/Corpus_ callosum.

3. ***The Secret Life of the Brain***, a David Grubin Production, is a five-part series that initially aired in the United States on PBS in the winter of 2002. It revealed the processes involved in brain development across a lifetime and provided new information in the brain sciences from the foremost researchers in the field. See *http:// www.pbs.org/wnet/brain/3d/index.html* for visual imagery that can help explain the complicated manner in which the brain functions.

4. For more information regarding the **brain research** discussed in this article as well as suggested activities associated with each of Gardner's ***Multiple Intelligences***, refer to the following Web site: *Language Study and the Brain* (http://www.teresakennedy.com).

5. **Content-Based Instruction** (CBI): Content-Based Instruction is an approach to language teaching that focuses not on the language itself, but rather on what is being taught through the language; that is, the language becomes the medium through which something new is learned. In the CBI approach the student learns the TL by using it to learn some other new content. For example by studying the French Revolution while using the French language. The language being learned and used is taught within the context of the content. The theory behind CBI is that when students are engaged with more content, it will promote intrinsic motivation. Students

will be able to use more advanced thinking skills when learning new information and will focus less on the structure of the language. This approach is very student-centered as it depends entirely on the students' ability to use the language.There are many things that can be considered 'content'; what is important is that what is being taught or discussed through the language not be language instruction related. Aspects of the curriculum, discussions about current events and world cultures or even general topics of interest are all valid 'content' options.See *https://sites.educ.ualberta.ca/staff/olenka.bilash/Best%20of%20Bilash/content.html*

FIGURES:

1. http://www.brainwaves.com/images/brain-basic_and_limbic.gif&imgrefurl=http://www.brainwaves.com/&h=317&w=450&tbnid=IPtlL8CR9hJyVM:&tb

2. https://www.google.com/search?q=Image+of+Information+Routing+Through+the+Brain+Step+by+Step&source=lnms&tbm=isch&sa=X&ved=0ahUKEwin1qW2yPfUAhUHq48KHWTTBAQQ

3. https://www.google.com/search?q=broca's+area+and+wernicke's+area&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjxv

REFERENCES

Begley, S. (1996, February 19). Your child's brain.*Newsweek*, 55–59.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999).*How people learn: brain, mind, experience, and school*. [Online] Retrieved July 18, 2017 from: http://books.nap.edu/html/howpeople1/ch6. html. The National Academy of Sciences.

Brown, C. (1997). A Case for Foreign Languages: The Glastonbury Language Program. *Learning Languages*, 2(2), 3–8.

Celestino, W. J. (1993, December). Total Physical Response: Commands, not Control. *Hispania*, 76(4), 902–903.

Coggins, P. E., Kennedy, T. J. & Armstrong, T. A. (2004).Bilingual Corpus Callosum Variability.*Brain and Language*, 89(3), 69–75.

Eriksson, Perfilieva et al., (1998).“Neurogenesis in the Adult Human Hippocampus”.*Nature Medicine*, 4(11), 1313- 1317. [Webpage] Retrieved July 10, 2017 from www.nature.com/nm/journal/ v4/n11/full/nm1198-1313.html.

Franklin, J. (2005, June). “Mental Mileage: How Teachers are Putting Brain Research to Use”.*Education Update*, 47(6), 1–7.

Gardner, H. (1999). A multiplicity of intelligences.*Scientific American Presents*, 9(4), 18–23.

Gazzanaga, M. S. (2000). “Cerebral Specialization and Interhemispheric Communication: Does the Corpus Callosum Enable the Human Condition?”*Brain*, 123, 1293–1326.

Genesee, F. (1996, Winter). “Integrating Language and Content: Lessons from Immersion”. *Learning Languages*, 15–16.

How the Brain Learns a Second Language. [Webpage] Retrieved July 10, 2017 from http://brainconnection.brainhq.com/2001/01/27/how-the-brain-learns-a-second-language.

Jensen, E. (1998). *Teaching with the Brain in Mind*. Alexandria, VA: ASCD.

Krashen, S.D. (1982). *Principles and Practice in Second Language*. New York: Pergamon Press.

Krashen, S. D., & Terrell, T. D. (1983). The natural approach: Language acquisition in the classroom. Oxford: Pergamon Press.

Kuhl, P. K. (1994). Learning and Representation in Speech and Language. *Current Opinion in Neurobiology,* 4, 812–822.

Language Learning and the Developing Brain. (1996, Winter). *Learning Languages*, 1(2), 17.

Nash, J. M. (1997, February 3). “Fertile Minds”.*Time*, 49–56.

Presidential Proclamation 6158. [Webpage] (July, 1990). Retrieved July 7, 2017 from http://www.loc.gov/loc/brain/proclaim.html.

Thatcher, R. W. (1991). Maturation of the Human Frontal Lobes: Physiological Evidence for Staging. *Developmental Neuropsychology*, 7(3), 397–419.