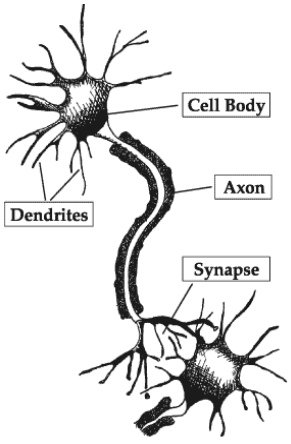
The Dynamic Brain

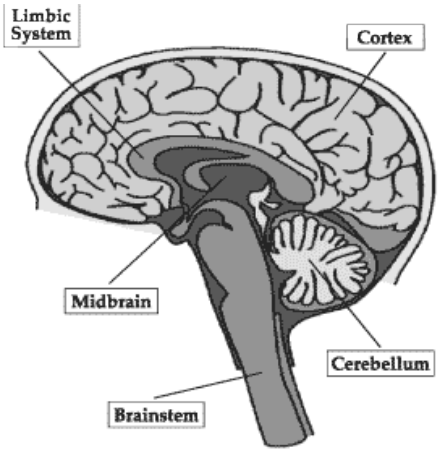
Imagine a child's brain as a house that has just been constructed. The framework of the house is up, the side paneling and roof, the doors and windows. After construction, the builder goes to the store to buy electrical wiring, the fuse box, and other electrical supplies. When he returns to the house he sets the newly purchased materials on the floor with the expectation that the electricity will work. Needless to say, it does not. One must first make all the connections in order for there to be electrical light in the home. Similarly, humans are born with over 100 billion neurons (Brotherson, 2005). That is 14 times the number of people in the world! When humans are first born, the brain cells have not yet established a "pattern of wiring". Neurons must form connections with one another to craft an operating system, which, at the basic level, lays the circuits for all of human learning.

Each neuron is made up of a cell body, an axon, and axon terminals. *(See diagram to the right).* Emerging from the cell body are dendrites which pick up chemical signals (neurotransmitters) from other dendrites. The space between neurons is called a synapse; this is where electrical impulses between neurons occur. When a neuron receives a signal, an electrical impulse is sent through the axon to the axon terminals and transmitted to neighboring dendrites. Throughout the first years of life, more synapses (connections) are created between neurons. However, starting at about six or seven years old, pruning of neurons takes place (Aizawa, et al., 2004, p. 199). This process—called the "use it or lose it" phenomena—is the brain's way of weeding out unused neuron connections to allow for strengthening synapses that are frequently used.



Through experience, learning, and practice, these connections are refined and help to give definition to the way that people learn, understand, and experience the world.

Scientists estimate that 60% of human genes are dedicated to brain development (Nash, 1997). The brain is split into five basic sections, which develop sequentially overtime, from bottom to top. The brainstem is the least complex, most vital system in the brain. The brainstem controls basic functions in the body such as blood pressure, body temperature, and breathing. Just above the brain stem is the midbrain. The midbrain controls bodily functioning such as appetite, sleep and motor control. When a child is born, their brainstem and midbrain are fully developed. The cerebellum, also at the base of the brain, is developed within the first years after birth. The cerebellum coordinates movement and balance (Viewpoint, 2002).

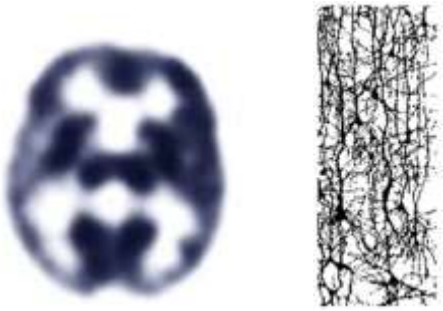


The last two areas of the brain are the most complex and develop throughout life. The limbic system is in the central region of the brain; it controls one's emotions, attachments, and memory. The cortex is the top layer of the brain which regulates decision-making, thinking, reasoning, language, and learning (Viewpoint, 2002). Scientists believe that the cerebral cortex contains 80% of the total neurons in the brain (Brotherson, 2005). The brain's ability to respond to information depends greatly on the development of the brain. School experiences compliment these waves of development. Ideally, teaching is differentiated between grade levels based on what the students can handle at that age. Gradual changes in the brain occur over the years, and a pattern of major academic leaps can be seen (Viewpoint, 2002). Differences in the brain

developmental stages create the learning transformations seen between first, third, and seventh grade.

The first grade cerebral cortex is a tangled weave of neurons. At first grade, children have approximately 50% more synapses than a typical adult (Lenroot & Giedd, 2006, p. 722). MRI scanning of six to seven year olds shows high concentrations of gray matter (Nash, 1997). Gray matter is the area of the brain that consists of tightly packed neurons. The percentage of gray matter (neural connections) in the brain peaks between the ages of five and seven years old (Giedd, et al, 1996, p. 558). After this time, neural connections are rapidly lost to make room for efficient connections between synapses. Along with the high percentage of gray matter in the cerebral cortex, MRI technology shows little to no development of the limbic system (Hariri, Bookheimer, & Mazziotta, 2000, p. 45). These biological evolutions have many implications for classroom instruction.

MRI picture of six year old brain.



The dark patches (gray matter) are areas of densely connected brain cells.

Erickson's Theory of Development describes first graders as having an exploratory attitude. This theory is directly supported by brain development. The brain is beginning to transition from growth of synapses to pruning. There is a desire driven by the brain to define one's interests, so that specific neural connections are possible (Woolfolk, 2012, p. 33). A classroom can be designed to specifically support the developmental stage that students are experiencing. Classroom activities should be diverse to give students the opportunity to explore areas that they have not yet discovered. Also in first grade, students are beginning to interact symbolically and form language skills. Students' vocabulary is increasing substantially; they

begin to develop the ability to express themselves in written words using basic grammar in their sentence construction (Temple, et al, 2011, p. 158). This is due to increased activity in the cerebral cortex.

Piaget's Theory of Development emphasizes the egocentric behavior of six to seven year olds. First graders struggle to empathize with others because the limbic system of the brain is minimally developed (Hariri, Bookheimer, & Mazziotta, 2000, p. 43). Students are only beginning to decipher their own emotions, making it difficult for them to understand other people's feelings. At this age, classroom management that teaches students about empathy is essential. Through repetition of *I feel, they feel* activities, the brain will form synaptic connections that help the student relate to other people and lay the framework for the limbic system development. Providing concrete examples and learning through experience enables students to make these connections.

Finally, Kohlberg's Theory of Morality describes first graders ability for moral reasoning as that of punishment and obedience standards. A child's occipital circuits are far more developed than the cerebral cortex. Six year olds still comprehend much of the world through perceptual centration (Snowman, McCown, & Biehler, 2012). Behavior is established as right and wrong through direct consequences. In order for students to gain a concrete understanding of moral reasoning, discipline and expectations should be consistent. Again, this enables the brain to create specific synapse connections of moral behavior.

In just two years the development of a child's brain has transformed. The gray matter (synaptic connections) in the brain is rapidly being pruned back. Pruning gives way to glial cells or white matter. Essentially, white matter is myelin coating that begins to develop when students are about eight years old (Woolfolk, 2012, p. 35). This fatty sheath is formed around the axon to

Above is an MRI image of an eight year olds brain when shown an emotional picture. Notice the activity near the limbic cavity.

increase the speed of connections. Also during this time, there is an increase in limbic system activity. One study completed in 2006, showed increased brain waves within the limbic system of eight and nine year olds. Children were shown pictures of an emotional event (such as a car crash or a fight) and then MRI scanning took pictures of their brain activity. The results showed a definite limbic system response (Lenroot & Giedd, 2006, p. 723).

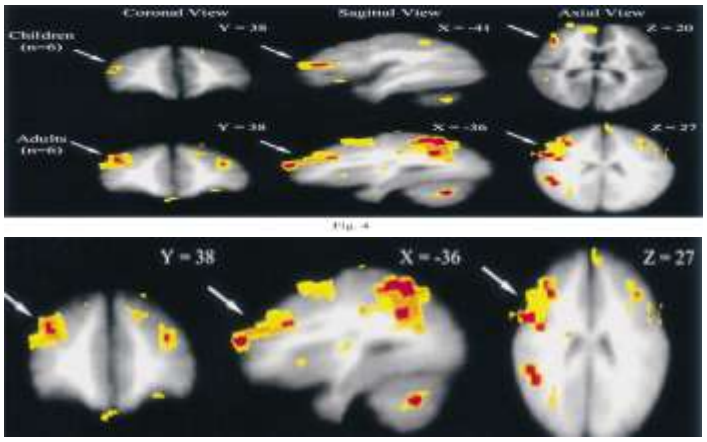
Just as the psychological theories of a first grader are supported by brain developmental phases, so are the psychological theories of a third grader. Erickson's Theory of Development describes third graders as, developing enjoyment out of mastering a task. Through experience, students shape the way their brain is pruned. Neural circuits are improved with myelination when the synapse connection is often utilized. As the signals between neurons become more efficient, the person's ability improves (Coyle, 2009, p. 19). Myelination increases through targeted practice. Pushing students to work at the edge of their ability, and encouraging students to make mistakes are two ways teachers can increase their students potential to gain mastery in an area.

The increased activity of the limbic system supports Piaget's Theory of Development. At eight years old, students understand empathy. A neuropsychologist would attribute this ability to empathize with increased activity of the limbic system. The limbic system controls primary emotions. Prior to third grade students have not yet developed strong emotional attachments, emotional responses before this point are generally copied (Snowman, McCown, & Biehler, 2012). As the limbic system develops, authentic emotional reactions are shown within the brain. Teachers can incorporate this increased ability to empathize with core curriculum lessons.

Students are gaining the capability to imagine how people might feel in abstract situations. An example of this is having the class imagine how slaves in the American South might have felt.

Finally, as the cerebral cortex is developing, students are gaining the ability to reason. Although most third graders still define morals based off of immediate consequences, some third graders may develop the ability to reason morality. Kohlberg's Theory of Morality defines this phase as, moral decisions based on reciprocity (Snowman, McCown, & Biehler, 2012). If the students gain something good for an action, that deed is determined to be moral and vice versa. In this stage, discipline and expectations should remain consistent.

After elementary school not only are their immense chemical changes within the brain, but the life of the student also changes dramatically. Seventh grade often marks the onset of puberty in many students. As children develop, their brain begins to transmit greater amounts of neurotransmitters (Woolfolk, 2012, p. 33). These chemical signals are sent throughout the brain with a high concentration transmitted to and from the limbic system. As functioning in the limbic system increases, so does the students ability to have complex emotions. In addition to the changes in the limbic system, continual maturation of the cerebral cortex occurs. Studies have shown that neural pruning is not complete until seventeen years of



The images above are from a brain development study that evaluated the cognitive development of the brain in relation to brain maturation. The top MRI is of a six year olds brain performing on a grade appropriate memory task. The scan below is of a thirteen year old working on a grade appropriate memory task. Much greater brain functioning is apparent in the seventh grader. The decrease in cortical density coincides with this greater cognitive capacity (Casey, Giedd, & Thomas, 2000, p. 250).

age (Reiss, Abrams, Singer, Ross, & Denckla, 1996, p. 1770). Throughout seventh grade, vigorous pruning is still taking place. This loss of cortical gray matter and extensive myelination correlates to higher brain functioning in academic tasks such as: selective attention, working memory, and inhibition. As the brain matures, not only are students able to make significant academic leaps, but myelination helps to differentiate their talents and interests.

Both Erikson's and Piaget's Theories of Development state that, students are struggling to find their personal, social, and occupational identity. The middle school years mark a time of great social change. Students are moving away from their parent's guidance and turning towards their peers. They are very concerned with how they are viewed by others. This adjustment can be partially attributed to the changes that are occurring in the limbic system and the higher levels of neurotransmitters sent throughout the brain. Students are striving to connect with people that are like them, therefore turning towards their peers. During this stage of life students are experimenting to find their identity. Teachers can support the brains greater ability to reason, as well as help the students to make healthy choices by teaching students about decision making. Being an advocate for the students also helps them to feel supported and protected (Snowman, McCown, & Biehler, 2012).

Piaget's Theory of Development also states that students are developing the ability to think abstractly. Maturation of the cerebral cortex allows for greater understanding of decision-making, higher level thinking, reasoning, and language. Classroom curriculum that focuses on student centered learning allows students to gain their independence, discover their interests, and increase their intrinsic motivation for learning. At this age students are able to grasp ideas such as scientific reasoning, inductive reasoning, and metacognition (Snowman, McCown, & Biehler, 2012).

As the limbic system is maturing and students move away from adult role models and towards their peers, their moral reasoning becomes linked with a concern of social reaction. Students are self-conscious and feel a large pressure to please those around them. Therefore, behavior tends to be what will please others (Snowman, McCown, & Biehler, 2012). Teachers play an important role in instilling students to make healthy decisions. Students who are surrounded by people who know how to make healthy decisions will generally act in this way.

Brain development correlates to learning differences between age groups. The brain of a seventh grader is not the same as that of a first greater, this creates the need for learning differentiation. Knowledge of brain development and how it connects with students emotional, social, and academic needs, allows teachers to design specific classroom structure that will help support the students current state. Areas in which this research had limitations were that this study only evaluated a specific age range (first, third, and seventh graders). An interesting opportunity for further research would be to look into whether brain maturation pairs with learning throughout life. Also, this study did not account for differences in individual developmental rates. All the data is based off of generalized brain developmental studies. The research did not account for exceptionalities, learning disabilities, or brain abnormalities that would affect a student's development both neurologically as well as academically. Finally this research was primarily biologically based and did not look into how a person's environment affects their brain development and learning needs. A study into how nurture affects brain developmental patterns would be a good addition to this research. As a prospective teacher this critical thinking assignment allowed me to focus on an area of interest—brain development in students—and correlate my research to how I will teach in my future classroom.

"On my honor"

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