

Adolescent Brain Development: An Overview

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In the adolescent brain some functions are fully developed; the five senses for instance: sight, hearing, taste, smell, and touch. So are capacities for language, balance and motor skills (to a large extent), reflexes, and the fundamental foundation for logical and consequential thinking.

Until the late 1900s, neuroscientists believed that the brain was fully developed by the time a child reached puberty, and that the total number of neurons (nerve cells) were in place. However, according to U.S. News and World Report - August 9, 1999 – “The neural circuitry, it turns out, is not completely installed in most people until their early 20’s!”

There are two specific areas of the adolescent brain that are particularly active: the Limbic System or Mid-Brain and the Pre-Frontal Cortex.

The Limbic System is a ring-shaped area deep within the center of the brain. It generates primal emotions such as fear and rage. During puberty, surging hormones cause a part of the Limbic System, the Amygdala, to swell in size. The Amygdala’s function is to determine emotional significance of experience. During adolescence the enlarged Amygdala intensifies all feelings, but especially aggression and the urge for high-risk behavior. This part of the brain evolved in primitive humans and served a basic survival function. For contemporary adolescents this hypersensitivity of the Amygdala helps the individual to begin to move from concrete, black-and-white thinking (*this is bad vs. this is good*) to more abstract thinking capable of distinguishing the “shades of gray” (*this is terrible, this is really bad, this is fairly bad, this is neutral, etc.*)

Left unchecked, the Limbic System can overpower the brain’s functioning, but it is modulated by the Pre-Frontal Cortex. This newer part of the brain (sometimes called the Neo-Cortex) acts as the brain’s traffic control officer. It coordinates processing among the brain’s component parts and modulates emotional responses. Unfortunately the adolescent cortex is not fully developed or functioning in this manner.

In fact, during adolescence, the cortex is undergoing a tremendous growth spurt, with neurons sprouting huge numbers of new connections. As it continues to develop and mature, the cortex prunes off unnecessary neurons, which allows the brain to function more effectively.

As this process is happening, the cortex is unable to respond to all its tasks at once. These excess neural connections mean that young minds cannot easily keep track of multiple thoughts. They also have trouble organizing multiple tasks. The cortex needs time to grow and learn to function fully. While that is happening, the over-developed, over-producing, thrill-seeking Limbic System can, at times, overpower the "higher" cortical functions.

During adolescence, the nervous system itself is physically altered as a result of experience, use of substances, amount of sleep, levels of stress, etc. These resulting changes contribute to the future operation of the brain and all its parts.

The neural circuitry in the amygdala has to do with, among other things, learning what is good or bad for us. Its neighbor, the Hippocampus, (which is Latin for "Seahorse," the relative shape of this brain part) holds short-term memory and sequences it for delivery to the cortex, where long-term memory is stored. This allows us to learn from experience.

Learning in the presence of strong emotion, however, is different from learning that is more neutral. When the Amygdala is over stimulated, by trauma or extreme stress, the Hippocampus shuts down, to prevent the cortex from becoming over-loaded.

In creating emotional memory, the nerve cell connections are physically altered. This is also true for the circuits that operate on the positive side, which set up what are called "reward circuits" within the brain. These positive emotional memory circuits help us learn what is good for us. (Incidentally, it is these positive reward circuits that are affected by recreational substances, in a manner that is most severe during adolescence.)

The Pre-Frontal Cortex, that part of the brain in charge of logical and consequential thinking, needs to balance thought AND emotion to allow us to make healthy decisions. In times of emergency (trauma, perceived threat or danger, etc.) the emotional circuits can bypass the Frontal Cortex. Again it is a matter of survival.

During adolescence the balance between emotion and thought is shaky, at best, and in fact, given its survival function, the emotional brain, the Limbic System, has the advantage and often has a greater say in setting priorities.

Given the increased functioning of the Amygdala, the ups and downs of adolescent feelings tend to be exaggerated, which often leads adults to think that the young person is just overreacting. However, what is in fact happening is that through this process of exaggerated feeling states, the adolescent is learning to discern between varying states of positive and negative feelings. It is an important step in the transition from the concrete (black & white) thinking of the child, to the abilities to discern between various levels of feeling, and to engage in abstract thought, appropriate to the adult brain.

The preceding information is a simplification of an extremely complex process, involving many, inter-connected and interdependent brain parts. For further information see the following references:

Badenoch, B. (2008). *Being a brain-wise therapist: A practical guide to interpersonal neurobiology*. New York, NY: Norton.

Cozolino, L. (2006). *The neuroscience of human relationships*. New York, NY: Norton

National Institute of Mental Health. (2011). *The teen brain: Still under construction*. <http://www.nimh.nih.gov>