The limbic system human brain function

The limbic system can arguably be stated as the parts of the brain responsible for those functions that make us all human. The structures of the limbic system are very much related to what is necessary for our survival. The limbic structures are involved in memory and emotions such as anger, fear, and pleasure, which include feelings experienced after eating or sexual behavior. The limbic system is credited as the " region of the cerebrum that acts as a link between higher cognitive functions, such as reasoning, and more primitive emotional responses, such as fear" (Silverthorn, et al). There are various components of the brain which make up the limbic system and each of its structures and functions will be described in order to attain a better understanding of the role of the system as a whole. These components include the amygdala, hippocampus, cingulate gyrus, thalamus, hypothalamus, fornix, and olfactory cortex. Also, potential diseases that affect the limbic system will be discussed.

The first structure of the limbic system that will be discussed is the amygdala, which is involved in emotion and memory. " The amygdala is an almond shaped mass of nuclei located deep within the temporal lobes, medial to the hypothalamus, and adjacent to the hippocampus." Its various functions include responses to emotion, hormonal secretions, arousal, and it controls autonomic responses associated with fear. The " fear network" in animals is centered in the amygdala and projects toward the hypothalamus and brainstem. This would explain why fear responses can be observed. It has been hypothesized that medications which involve an increase in serotonin would " desensitize the fear network." Tracing the pathways for emotion can be complex. When one perceives the world around them, sensory stimuli are fed into the cerebral cortex. In the association areas of the brain, this information is then integrated. It is then passed on to the limbic system. The limbic system gives feedback to the cerebral cortex, which creates an awareness of the emotion. Meanwhile, " descending pathways to the hypothalamus and brain stem initiate voluntary behaviors and unconscious responses mediated by autonomic, endocrine, immune, and somatic motor systems" (Silverthorn et al). Patients have reported feeling anxious and fearful when scientists artificially stimulated the amygdala in humans, and when lesions were performed to destroy the amygdala in animals, it caused " the animals to become tamer and to display hypersexuality. As a result, neurobiologists believe that the amygdala is the center for basic instincts such as fear and aggression" (Silverthorn et al). Feelings of pleasure can be attributed to increased activity of the neurotransmitter dopamine in different areas of the brain. Pleasurable sensations in the brain are increased when drugs such as nicotine and cocaine are abused by the individual. These drugs enhance the effects of dopamine, which increases the pleasure sensation perceived by the brain.

The hippocampus, another structure that acts as a part of the limbic system, is important in both learning and memory. The hippocampus can be attributed as what is responsible for our spatial orientation, navigation, emotions, and our fusion of new memories. When patients with epilepsy had a part of their hippocampus destroyed, they had trouble remembering new information. If given a list of words to repeat, they could remember the words so long as their attention was focused on the list and nothing else. However, as soon as their attention was diverted from the list and onto something else, their memory of the words would disappear. The hippocampus allows us to convert short term memory into long term memory and also plays an important role in our ability to recall the spatial relationships in the world around us. One example of spatial relationships is our ability of depth perception. The hippocampus tells us that it certainly would not be sensible to walk straight over the edge of the Grand Canyon.

The cingulated gyrus also plays a role in emotion. Its functions include emotional responses to pain, it coordinates sensory input with emotions, and it regulates aggressive behavior. The cingulated gyrus is a ridge of infolded cerebral cortex found above the corpus callosum, and can be associated with mood as well.

The thalamus, another structure of the brain which is a component of the limbic system, gives us our motor control ability, relays sensory signals to the cerebral cortex, and receives auditory, somatosensory and visual sensory signals. It " serves as an integrating center and relay station for information going to and from higher brain centers, including sensory and motor information" (Silverthorn et al). Sensory fibers are received by the thalamus from the spinal cord, ears, optic tract, and motor information is received from the cerebellum. Almost all sensory information that comes in from the spinal cord passes through the thalamus, and, similar to the spinal cord, " the thalamus can modify information passing through it, making it an integrating center as well as a relay station" (Silverthorn et al). All sensory information passes through the thalamus (one example is visual information moves from the eyes, down the optic nerve and optic tract, through the thalamus, and then to the visual cortex for perception) with the exception of olfactory information.

Though it only occupies a small fraction of the brain's total volume (1%), the hypothalamus, which lies beneath the thalamus, is the center for homeostasis. It receives input from various sensory receptors, the cerebrum, and the reticular formation. The hypothalamus " activates the sympathetic nervous system, maintains body temperature, controls body osmolarity, controls reproductive functions, controls food intake, interacts with the limbic system to influence behavior and emotions, influences the cardiovascular control center in the medulla oblongata, and secretes trophic hormones that control release of hormones from the anterior pituitary gland" (Silverthorn et al).

The exact functional importance of the fornix is unclear. The fornix connects the hippocampus to the hypothalamus. It is made up of a bundle of axons that extend from the hippocampus to the mammillary body of the hypothalamus and forms an arch over the thalamus. In an experiment performed with rats, " activity levels were measured following selective knife-cuts of the fornix, medial forebrain bundle or diagonal band. Each of these manipulations increased running-wheel activity, but only fornix transection increased activity in the stabilimeter" (Hamilton).

Olfactory cortex, located in the temporal lobe, receives input from chemoreceptors in the nose. As stated earlier, olfactory information is the only sensory information that is not routed through the thalamus. Odors travel from the nose to the olfactory nerve (cranial nerve I) and olfactory bulb. It is then sent to the olfactory bulb in the cerebrum. It has been presumed, because of this direct input from the olfactory bulb to the cerebrum, that memories and emotions are closely linked to emotion. One might be able to pinpoint the exact day, time, location, and occasion of a significant event in their lives simply by smelling the same fragrance or odor that was present at the time. Just by a smell, a person could be led down a path of nostalgia.

When the nervous system is stimulated by an emotional response, neurotransmitters pass along nerve cell networks known as pathways. The brain produces these neurotransmitters naturally. Therefore, it is important that these neurotransmitters remain in balance so that pathways can operate efficiently.

In the limbic system, there are two basic pathways, excitatory (" gets our juices flowing") and inhibitory (calming effect). The neurotransmitters critical to the excitatory pathways include dopamine, epinephrine and norepinephrine. These are made and released in the beginning of the day and allow us to be motivated and alert. The neurotransmitters involved in the inhibitory pathways are serotonin and GABA (gamma amino butyric acid), which are made and released in the afternoon or evening, when people relax and go to sleep.

If an individual suffers from low neurotransmitter production, they are more susceptible to depression. When one has low excitatory neurotransmitters, they are more vulnerable to dependence on stimulant drugs. While, if one has low inhibitory neurotransmitters, the person may suffer from anxiety disorders. Disorders that are found to have a high occurrence in people with a low number of these limbic system neurotransmitters usually show to have eating disorders, sleep disorders, and obsessive/compulsive disorders, along with ADD or ADHD.

Other potential damage could be done to the limbic system after one suffers from a heart attack. In a study done with rats, " apoptosis of the limbic system was found to occur after the rat suffered from a myocardial infarction (heart attack)" (B. P. Wann et al).

Huntington's disease causes damage to the caudate nucleus, which affects communication of the limbic system with the frontal lobes. The caudate nucleus acts as a relay station in between. " As the connections degenerate, the activity-initiating frontal lobes are disconnected from the emotion processing center of the brain, producing apathy, a common symptom of Huntington's disease."

As we have seen, the structures of the limbic system are vital to what sets us apart from other organisms in the animal kingdom. It was stated by researchers that " the nucleus accumbens is a major anatomical link between the limbic system and the motor system, providing a means by which 'motivational-emotional determinants of behavior become transformed into actions'" (Vanderwolf et al). Because this system is responsible for the sexual drives, emotions, memories, and hormonal body regulations we experience, it can collectively be held responsible for those characteristics which make us all human beings.