Brain Mechanisms of Emotion

Introduction

It is difficult to study the neural basis of emotion. What we know has been derived from a synthesis of animal and human studies. Animal studies have focused on emotional expression. Human studies have focused on emotional experience

What is Emotion

Is emotion a sensory signal from our body, a diffuse pattern of activity in our cortex, or something else?

Theories of Emotion

The James-Lange Theory

This theory, first suggested in 1884, proposed that emotional experience is a response to physiological changes in our body.

- Emotional expression causes the emotional experience.

The Cannon-Bard Theory

This theory, suggested in 1927, proposed that emotional experience can occur independently of physiological changes in our body.

- Emotional experience causes the emotional expression.

The Limbic System Concept

Broca's Limbic Lobe

Paul Broca noted in 1878 that there were a group of structures in the medial brain that appeared different from the surrounding cortex.

- These structures were grouped together as the limbic lobe and included the
    - Cingulate gyrus
    - Medial temporal lobe
    - Hippocampus

The Papez Circuit

James Papez proposed in the 1930s that there was an "emotion system" lying in the medial brain that links the cortex with the hypothalamus.

- The Neocortex is interconnected with the cingulate gyrus.
    - The cingulate gyrus sends signals to the hippocampus
    - The hippocampus sends signals to the hypothalamus
    - The hypothalamus sends signals to the anterior nuclei of the thalamus.
    - The anterior thalamus sends signals to the cingulate cortex.

- During this era it was known that damage to certain cortical areas were associated with profound emotional changes.
- Tumors of the cingulate gyrus were often accompanied by fear, irritability, and depression.
- The hypothalamus integrates the actions of the autonomic nervous system.
- The hippocampus is affected (and infected) by the rabies virus.

Problems with the Single Emotion System Concept

- Current data support the role of some of the structures of the limbic lobe and Papez circuit in emotion.
- Current data do not support a role for the hippocampus in emotion.
- Many of the limbic structures are involved in other functions.
- Emotional processing probably involves other structures.

The Klüver-Bucy Syndrome

Heinrich Klüver and Paul Bucy found that bilateral removal of the temporal lobes in rhesus monkeys had a dramatic effect on aggressive tendencies and responses to fearful situations. Temporal lobectomy is associated with:

- Good visual perception, but poor visual recognition.
- Increased interest in sex.
- Decreased fear and aggression.
- Flattened emotions in humans.

The Amygdala and Associated Brain Circuits

Anatomy of the Amygdala

The amygdala is located in the anterior medial pole of the temporal lobe.

- The amygdala receives signals from all cortical lobes, the hippocampus, an dhte cingulate gyrus.
- Sensory specific signals from all sensory systems feed into the basolateral nuclei of the amygdala.
- The amygdala sends signals to the hypothalamus via the amygadofugal pathway and stria terminalis.

The Amygdala and Fear

- Lesions of the amygdala flatten emotional behavior in animals and impair recognition of emotional expression (fearful facial expressions) in humans.
- Electrical stimulation of the amygdala elicits fear and aggression in animals and fear and anxiety in humans.
- In humans fMRI shows more activity in the amygdala in response to pictures of faces with fearful expressions.

A Neural Circuit for Learned Fear

Memories of emotional events are particularly vivid and long lasting.

- A conditioned auditory stimulus (previously paired with a painful stimulus) activates neurons in the central nucleus of the amygdala in rabbits. Prior to conditioning the auditory stimulus did not evoke a response.
- In humans fMRI shows increased activity in the amygdala in response to a conditioned visual stimulus (previously paired with a painful stimulus). Prior to conditioning the visual stimulus did not evoke a response.
- Sensory signals feed into the basolateral nucleus of the amygdala
    - The basolateral nucleus sends signals to the cerebral cortex and to the central nucleus of the amygdala
    - The central nucleus of the amygdala sends signals to the hypothalamus and to the periaqueductal gray of the midbrain.

The Amygdala and Aggression

Predatory aggression is used for obtaining food. Affective aggression is used for show.

- Lesions of the amygdala in rhesus monkeys cause a considerable lowering of their social hierarchy.
- Stimulation of the amygdala in rhesus monkeys induces agitation and affective aggression.

Surgery to Reduce Human Aggression

- Lesions of the amygdala in humans reduces aggressive behavior and anxiety

Neural Components of Aggression beyond the Amygdala

In a series of experiments performed in the 1920s:

- Removal of the cerebral cortex induces sham rage.
- Removal of the cerebral cortex and the anterior hypothalamus induces sham rage.
- Removal of the cerebral cortex, the anterior hypothalamus, and the posterior hypothalamus does not induce sham rage.
- The implication is that the posterior hypothalamus is involved in aggression.

The Hypothalamus and Aggression

In a later series of experiments performed in the 1960s by john Flynn:

- Stimulation of the medial posterior hypothalamus induces affective aggression.
- Stimulation of the lateral posterior hypothalamus induces predatory aggression.

The Midbrain and Aggression

- Neurons in the lateral hypothalamus send axons through the medial forebrain bundle and into the ventral tegmental area of the midbrain.
- Neurons of the medial hypothalamus send axons through the dorsal longitudinal fasciculus and into the periaqueductal gray of the midbrain.

Serotonin and Aggression

- 5HT-1A and 5HT-1B receptors are presynaptic autoreceptors.
- Agonists of these receptors decrease anxiety and aggressiveness.