Neurobiological underpinnings of emotions

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Emotion is a stirred-up state caused by physiological changes occurring as a response to some event and which tends to maintain or abolish the causative event. Understanding the neuroanatomical basis of the genesis and control of emotions is quintessential in understanding how biology affects the mind and in turn, helps in understanding our own nature. We present a short communication explaining the neurological basis of emotions.

ROLE OF HYPOTHALAMUS

Stimulation of the lateral hypothalamus produces thirst, hunger and increases the general level of activity of the animal, sometimes leading to fury, and/or fighting. When the ventromedial nucleus of the hypothalamus is stimulated, it causes a sensation of satiety, reduction of food intake, and tranquility. Stimulation of periventricular nuclei produces fear and punishment reactions. Stimulation of the anterior and posterior portions of the hypothalamus leads to accentuated sex drive. Connections from the amygdala to the hypothalamus can modulate reflex responses to emotional stimuli.

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ROLE OF THE PREFRONTAL CORTEX

The prefrontal area is the seat of human personality. Studies have revealed that the prefrontal cortex (PFC) takes part in decision-making and in adopting behavioral strategies more appropriate to the physical and social situation. The PFC also helps in the regulation of emotions through reappraisal. Reappraisal is a cognitive-linguistic strategy that changes the path of emotional responses by reformulating the meaning of a situation. Medial, dorsolateral, and ventrolateral PFC, and dorsal anterior cingulate cortex (ACC) play an important role in reappraisal. Reappraisal long term and frequent use of reappraisal lead to better control of emotion, interpersonal functioning, and psychological and physical well-being.

ROLE OF CINGULATE CORTEX

Reduction of \( \mu \) receptors in rostral ACC has been observed in self-induced state of sadness, which is also associated with negative affect. The ACC has also been associated with the representation of pain affect which is also mediated by \( \mu \) receptors. Reduced metabolism of rostral ACC is seen in depressive illnesses and is associated with poor response to antidepressants. It also helps in ascertaining the contents of memory, and its activity is increased when people lie.

ROLE OF HIPPOCAMPUS

Hippocampus plays an important role in behavior and memory. Bilateral removal of hippocampus leads to the ability to access learned memory, but the inability to learn any new information. It plays a crucial role in decision-making because when the hippocampus interprets a neuronal signal as important, it is probably stored in memory.

ROLE OF AMYGDALA

Amygdala and anterior insula are involved in experiencing both positive and negative emotions. In patients with depression, an exaggerated amygdala response to negative stimuli and an attenuated amygdala response to positive stimuli is observed. Symptoms of depression have been reduced in research by upregulating the amygdala. The thalamus, amygdala, and hippocampus are the key regions of the limbic system that are closely related to emotional memory.

Table 1: Role of monoamine neurotransmitters in basic emotions

| Basic emotions   | Serotonin (5-HT) | DA  | NE |
|------------------|------------------|-----|----|
| Interest         | High             | High| High|
| Enjoyment/joy    | High             | High| Low |
| Surprise         | High             | Low | High|
| Distress/anguish | Low              | Low | High|
| Fear/terror      | Low              | High| Low |
| Shame/humiliation| Low              | Low | Low |
| Contempt/disgust | High             | Low | Low |
| Anger/rage       | Low              | High| High|

DA – Dopamine; NE – Noradrenaline; Based on Lovheim.

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RECOGNITION OF EMOTIONS

The perception of emotions in humans occurs at three levels. Perception at subcortical level-visual processing can occur in the absence of striate cortex as well. The pathways that mediate this blindsight involve nerve fibers from the retina to the superior colliculus, then to the pulvinar nucleus of the thalamus, and hence to extrastriate visual cortices. It was initially considered that such processing can only encode very crude information about the stimulus, such as its spatial location, its direction of motion, and some spectral information. However, recent studies indicate that processing includes the ability to discriminate facial expressions of emotion.

Perception at critical level-early perceptual processing to categorize faces as distinct from other visual objects is done in the fusiform gyrus. Further categorization of faces along with discrimination of emotional facial expressions is done in the midline occipital cortex, followed by temporal cortical activity and fusiform gyrus. Postperceptual processing of faces, such as recognition of identity is done in the anterior temporal cortex.

Lateralized perceptions of the emotions-right hemisphere are more adapted to recognition of own face. Damage to the right cerebral hemisphere leads to facial agnosia and the inability to recognize, discriminate, and name emotions. Possible mechanisms to the lateralization of perception of emotions include the right cerebral hemisphere hypothesis and valence hypothesis.

There is still a long way to go to acquire a better understanding of the neurobiological mechanisms related to emotions, and ultimately making humans understand their own nature.

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