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AGE-RELATED FEATURES OF THE LIMBIC SYSTEM IN THE FORMATION OF BEHAVIOR

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Abstract
The limbic system is a complex of structures within the central nervous system that plays a crucial role in regulating emotion, motivation, memory, and behavior. It occupies a central position in the control of human behavior.
By integrating emotional states, memory, motivation, and instinctive reactions, the limbic system enables the organism to adapt to both external and internal conditions. This article analyzes scientific literature on the age-related development of behavior, the morphological and functional maturation of the limbic system, and the significance of maintaining balance between the limbic system and the prefrontal cortex in ensuring emotional stability and conscious behavioral regulation.

Keywords: Limbic system, prefrontal cortex, motivation, amygdala, aggression, hippocampus, amygdaloid body, hypothalamus, cingulate gyrus.

Introduction

Relevance of the Topic

The limbic system is one of the most important functional structures of the human brain, playing a key role in forming emotional states, motivation, memory processes, and behavioral dynamics. It acts as a central mechanism regulating responses to external stimuli and mediating adaptation to internal needs and the social environment. Understanding the physiological and psychological mechanisms of the limbic system is essential for analyzing behavioral models, decision-making processes, and interpersonal interactions.
The term limbic system was first introduced by Paul Broca in 1878, who described it as the “limbic lobe.” Later, James Papez and Paul MacLean expanded the concept and provided theoretical justification for its role as the “emotional brain.” [1]
The limbic system includes the amygdala, hippocampus, hypothalamus, cingulate gyrus, fornix, and mammillary bodies. Through neuronal interconnections, these structures integrate emotional responses, memory, and sensory signals into a unified functional system. [2]
The amygdala regulates key affective states such as fear, anxiety, and aggression. It rapidly evaluates external threats and prepares the organism for defensive reactions. For example, in dangerous situations the amygdala activates the sympathetic nervous system, increasing heart rate,

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enhancing muscle blood flow, and preparing the body for a "fight-or-flight" response. The amygdala also participates in positive emotional reactions, contributing to motivational aspects of behavior.

The hippocampus plays a major role in converting short-term memories into long-term memories. Through learning and experience, it shapes future behavioral responses. For instance, if a particular action yields a positive outcome, the hippocampus stores this information and promotes repetition of the behavior in the future. The hippocampus is also involved in stress responses; chronic stress may impair hippocampal neurons, leading to memory deficits.

The hypothalamus regulates essential physiological needs such as hunger, thirst, sleep, sexual drive, and pain avoidance. It is connected to the endocrine system and regulates hormone production, integrating emotional states with physiological responses. [3]

The limbic system and the prefrontal cortex together form the center responsible for conscious control, planning, and rational decision-making. The balance between the prefrontal cortex and the limbic system determines behavioral responses. Excessive limbic activity leads to irritability, impulsiveness, and emotional vulnerability. Well-developed prefrontal–limbic connections support appropriate decision-making, emotional regulation, and socially adaptive behavior. [3]

Limbic system functioning is strongly age-dependent. In children, the amygdala and hippocampus develop rapidly, while the prefrontal cortex remains immature. Consequently, children exhibit high emotional reactivity and limited ability to regulate their feelings. Early in life, the limbic system is extremely sensitive to environmental influences, shaping behavioral patterns through social learning and repeated emotional experiences. These experiences leave neural traces in limbic structures, stabilizing future behavior. [3]

The limbic system develops actively from around 15 months to 4.5 years of age, shaping the child's behavior, emotional understanding, and motivation. Age-specific features include the development of emotional reactions, formation of attachments, and acquisition of basic social skills. As the cerebral cortex matures, more refined behavioral regulation emerges. During this period, the limbic system serves as the primary structural unit driving emotional development. Foundations of emotional reactivity, attachment, and early social behavior are formed during this stage. Children's behavior is predominantly limbic-driven, making them highly sensitive and emotionally expressive. [4]

Successful limbic development in early childhood provides the foundation for healthy emotional and social functioning later in life. As the prefrontal cortex matures, emotional responses and behavioral control become more conscious and refined. Age-related developmental features of the limbic system are crucial for establishing emotional patterns and primary behavioral models. Negative factors during these periods can negatively influence later development, underscoring the importance of a supportive environment for the child. [5]

Adolescence is characterized by intense emotional fluctuations, impulsive decision-making, and a drive for independence. During this period, limbic system activity is heightened, while the prefrontal cortex is not yet fully matured. As a result, emotional reactions are triggered rapidly by the limbic system, but cognitive control mechanisms remain relatively weak. This explains adolescents' increased tendency toward risk-taking, conflict, and emotional outbursts. This pattern reflects normal neurobiological development (Table 1).

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Age-Related Characteristics of the Limbic System

Table 1.

Age Period	Amygdala Reactivity	Prefrontal Control	Behavioral Features
Childhood	High	Low	Rapid emotional reactivity
Adolescence	Very high	Moderate	Impulsivity, risk-taking
Adulthood	Regulated	High	Stable emotional regulation

In adulthood, the prefrontal cortex fully matures and strengthens its modulatory control over limbic activity. Based on incoming signals from the amygdala, the prefrontal cortex ensures emotional analysis, decision-making, and self-regulation. Life experience, social roles, and cognitive strategies all contribute to emotional stability. In adults, emotional reactions generated by the limbic system do not directly translate into behavior; instead, they undergo rational evaluation.

Conclusion

The activity of the limbic system and its role in behavioral formation are closely related to age. Emotional dominance characterizes childhood, impulsivity marks adolescence, and stable emotional control emerges in adulthood. Understanding these age-related differences is crucial for pedagogical, clinical, and psychocorrectional practice.

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