

Psychoneuropsychiatricity on Adolescent Emotions and Behavior

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Abstrak

Adolescence was a critical transitional period marked by profound neural circuit transformation, where brain maturation occurred asynchronously. This literature review aimed to examine the relationship between neurobiological brain structure and function and adolescent emotional and behavioral manifestations from a psychoneuropsychiatric perspective. A comprehensive literature search was conducted across Google Scholar, PubMed, and NCBI databases, selecting publications from 2008 to 2026. Synthesized findings revealed that a maturational imbalance between the early-developing limbic system and the immature prefrontal cortex underlay the dominance of emotional responses over cognitive control. Consequently, heightened dopaminergic activity driven elevated sensation-seeking and risk-taking behaviors. This neurobiological vulnerability interacted dynamically with psychosocial factors, escalating susceptibility to psychoneuropsychiatric conditions including anxiety, depression, post-traumatic stress disorder, substance abuse, and psychosis. Ultimately, implementing a biopsychosocial approach that integrated early screening via standardized instruments with combined psychotherapy and pharmacotherapy was imperative for comprehensive adolescent mental health management.

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1. INTRODUCTION

Adolescence is a complex transitional phase, connecting childhood to adulthood. During this phase, individuals experience significant changes, both physically, cognitively, emotionally, and socially [1]. Until now, behavioral changes in adolescents have often been explained solely from a social or psychological perspective. However, a psychoneuropsychiatric approach provides a more comprehensive perspective by linking behavioral aspects to the neurobiological basis of the brain [2].

In general, adolescents are often associated with unstable emotions, impulsive tendencies, and risky behavior. This phenomenon is not simply unfounded, but rather related to an unbalanced brain development process. The limbic system, which plays a role in emotional regulation, develops more rapidly than the prefrontal cortex, which is responsible for executive functions such as decision-making and impulse control [1], [3]. This imbalance is known as the *dual systems model* or *mismatch model*, which peaks in adolescence and has a direct impact on individual behavioral patterns [4].

Along with the development of technology, research in *neuroimaging* has provided a clearer picture of the changes that occur in the adolescent brain. Studies show that there is a process of *synaptic pruning* and myelination that occurs unevenly across various brain

areas. The prefrontal cortex is one of the areas that matures most slowly [1]. In addition, changes in the neurotransmitter system, particularly dopamine, also play a role in increasing sensitivity to rewards and social influences in adolescents [1], [4].

Understanding the neurobiological mechanisms of the adolescent brain is becoming increasingly important, particularly in the context of mental health. This imbalance in nervous system development makes adolescents a vulnerable group for psychiatric disorders. Furthermore, this phase is also a critical period associated with increased risk of behavioral issues such as substance abuse, aggression, and other behavioral problems related to suboptimal emotional regulation [3].

Based on this, this literature review was prepared to examine in more depth the relationship between brain structure and function with the manifestation of emotional behavior in adolescents from a psychoneuropsychiatric perspective, including how the structural and functional development of the brain occurs during adolescence, the neurobiological mechanisms underlying emotion regulation, the relationship between brain development patterns and manifestations of risky behavior, and their clinical implications for the management of emotional and behavioral disorders in adolescents. Specifically, this review aims to describe the structural and functional development of the adolescent brain based on current evidence, describe the neurobiological mechanisms of emotion regulation, especially the interaction of the limbic system and the prefrontal cortex, analyze the relationship between brain development patterns and manifestations of risky behavior, and identify the clinical implications of psychoneuropsychiatry as a basis for developing management strategies. By understanding these relationships, this review is expected to enrich the developmental neuropsychiatric literature, provide a neurobiologically based theoretical framework for medical personnel and mental health practitioners, and serve as a framework that can be integrated into adolescent health education programs in schools and families, to support the development of more empathetic and evidence-based intervention strategies.

2. RESEARCH METHODS

This literature review was compiled through a search of scientific articles from various databases, namely Google Scholar, PubMed, and NCBI. The selected articles were publications relevant to the topic of adolescent brain development and adolescent emotions and behavior from a psychoneuropsychiatric perspective, using key keywords such as adolescent brain development, teenage brain, emotion regulation adolescent, neurobiological basis, risk-taking behavior adolescent, dopamine reward system, prefrontal cortex maturation, and psychoneuropsychiatry. Based on the search results, several journal articles, academic textbooks, and other sources were obtained, which were then further selected according to predetermined inclusion and exclusion criteria.

Inclusion criteria included: (1) articles and books relevant to the topics of adolescent brain neurobiological development, emotion regulation, risk behavior, and psychoneuropsychiatric disorders; (2) available in full text or informative abstracts; (3) of good methodological quality, especially for peer-reviewed articles; and (4) published within the last 18 years (2008–2026) to ensure relevance to the latest developments in neuroscience. Publications older than these limits were still considered if they had fundamental theoretical contributions and were still relevant to the topic. Exclusion criteria included: (1) articles irrelevant to the topic of adolescent brain development and psychoneuropsychiatric aspects; (2) duplications or different versions of the same publication; (3) having significant data limitations; (4) focusing only on populations of children under 10 years or adults over 25 years; and (5) sources that could not be verified or lacked clear academic credibility.

In the selection process, most of the sources were prioritized from the last 10 years, especially neuroimaging literature and contemporary brain development research. However, some literature exceeds this limit because they are landmark studies or fundamental theories that are still very relevant in understanding the dual systems model and adolescent brain development, such as the work of Steinberg [1], [5], Giedd [6], and Casey & Jones [7]. In addition to journal articles from academic databases, this review also uses book sources in the form of literature synthesis and academic textbooks such as the work of Crone & Dahl [4], as well as publications from the American Psychological Association, as additional references to strengthen the theoretical foundation and provide a more comprehensive perspective.

The selection process was carried out in stages, starting with screening titles and abstracts to ensure relevance to the topic, followed by a full-text review to evaluate methodological quality and analytical depth, and finally a critical analysis of each publication to verify the consistency of the findings with other studies in the same field. All selected sources were then analyzed and synthesized using a thematic approach to gain a comprehensive understanding of the structural and functional development of the adolescent brain, the neurobiological mechanisms of emotion regulation, the manifestations of risky behavior, and the clinical implications of psychoneuropsychiatry in treating emotional and behavioral disorders in the adolescent population.

3. RESEARCH RESULTS AND DISCUSSION

3.1 Definition and Stages of Adolescence

Adolescence is a stage of individual development that begins with puberty and continues into adulthood. During this phase, individuals experience various changes and begin to achieve independence, such as completing education, working, and starting a family, which generally occurs around the ages of 10–20. Adolescence is also marked by changes in biological, psychological, and social aspects that occur simultaneously and are influenced by various environmental factors [8].

Adolescence is divided into three main stages: early adolescence, middle adolescence, and late adolescence. Early adolescence (10–13 years) is characterized by the onset of puberty, which causes rapid physical changes, including the emergence of secondary sexual characteristics. In addition, adolescents begin to form a self-identity, become more interested in relationships with peers, and exhibit emotional instability. In middle adolescence (14–15 years), social relationships expand, including the emergence of interest in the opposite sex; adolescents begin to experience a deeper process of self-discovery and the development of more complex thinking skills, although they often still experience confusion in decision-making. Meanwhile, late adolescence (16–21 years) is characterized by increasing emotional, social, and cognitive maturity; adolescents begin to develop a clearer self-identity, are able to think logically and realistically, and demonstrate independence in decision-making and planning for the future [8].

3.2 Adolescent Brain Development

Brain development in adolescents is a crucial part of physical development because the brain functions as the control center for all human activity. The brain consists of approximately 100 billion interconnected neurons, enabling complex communication within the nervous system. Structurally, the brain consists of several main parts, such as the brainstem, midbrain, cerebellum, and cerebral cortex, which play a role in thinking, language, and perception, with a division of functions between the more logical and analytical left brain and the more intuitive and imaginative right brain. The brain

development process occurs through three main stages: cell production (*cell production*), cell migration (*cell migration*), and cell elaboration (*cell elaboration*), which allows the formation of connections between neurons through synapses. This development greatly influences the cognitive, emotional, social, and motor abilities of adolescents, so that the more mature the nervous system, the better the individual's thinking ability, emotional control, and behavior [8].

3.3 Neurobiology of Emotion in Adolescents

The neurobiology of emotion in adolescence involves complex interactions between the limbic system, the *reward system*, and neurotransmitters that undergo significant changes during development. The main structures involved are the amygdala, hippocampus, and *nucleus accumbens* as part of the limbic system responsible for emotional processing, emotional learning, and responses to affectively meaningful stimuli. In adolescence, the amygdala shows increased reactivity to emotional stimuli, especially those of a social and threatening nature, resulting in more intense emotional responses than in adults [9], [10].

In addition, the *reward system* mediated by the mesolimbic dopaminergic pathway (ventral tegmental area leading to the *nucleus accumbens*) experiences increased sensitivity during adolescence. This condition causes an increased response to *reward*, *novelty*, and pleasant stimuli. This increase in dopamine activity is also related to the phenomenon of *sensation seeking* and the tendency for exploratory behavior in adolescents. Recent studies have shown that the maturation of the dopamine system, including the mesocortical pathway to the prefrontal cortex, is slower and plays a role in modulating cognitive control over emotions [11].

Besides dopamine, the system's other chemicals, such as serotonin, glutamate, and GABA, also play a role in emotional regulation. Serotonin functions in stabilizing *mood* and impulse control, while an imbalance between the excitatory (glutamate) and inhibitory (GABA) systems in the limbic-prefrontal circuit can lead to increased emotional reactivity. These neurochemical changes, along with neuroplasticity processes such as synaptic pruning (a natural process in which the brain removes weak and rarely used neural connections or synapses) and myelination (the biological process of forming myelin sheaths around nerve fibers), contribute to adolescent emotional patterns that tend to be fluctuating and reactive to the environment [12].

3.4 Emotional Regulation and Cognitive Function

Emotional regulation in adolescents is greatly influenced by the maturation of the prefrontal cortex (*prefrontal cortex/PFC*), particularly the dorsolateral and ventromedial regions, which play a role in executive function, decision-making, and impulse control. The PFC is one of the brain areas that undergoes the slowest development, with structural and functional maturation continuing until young adulthood. This process involves increased connectivity in *white matter* as well as synaptic reorganization, which is important for the efficiency of neural networks [6], [12].

The imbalance between the more rapidly developing limbic system and the still immature PFC results in a phenomenon known as the dual systems model, in which the emotional system (*bottom-up*) is more dominant than cognitive control (*top-down*). This causes teenagers to be more susceptible to impulsivity, difficulty in regulating emotions, and decision-making that is more influenced by emotions than rational considerations [5], [13].

Neurobiologically, emotional regulation involves connectivity between the PFC and the amygdala. In adults, the PFC can inhibit amygdala activity through a mechanism of

top-down control. However, in adolescents, this connection is not fully mature, so emotional regulation is less than optimal. Recent research has shown that increasing fronto-limbic network integration with age correlates with increased self-control and emotional stability [12]. In addition, the dopamine system in the PFC also plays a role in modulating executive functions and behavioral adaptation to the environment, making adolescence a highly plastic period but also vulnerable to neuropsychiatric disorders [11].

3.5 Adolescent Behavior from a Neuropsychiatric Perspective

Adolescent behavior is the result of a dynamic interaction between neurobiological development and the influence of the social environment. One of the main characteristics is increased *risk-taking behavior* and *sensation seeking*, which is closely related to hyperactivity of the nervous system *reward* brain, especially in the *nucleus accumbens*. Excessive activation of this system causes adolescents to be more sensitive to *reward* compared to punishment, so they are more likely to take risks even though they are aware of the consequences [5], [13].

Furthermore, immature frontostriatal circuit development leads to an imbalance between motivational drive and cognitive control. The ventral striatum, which plays a role in reward processing, develops more rapidly than the PFC, thus reinforcing impulsive behavior tendencies. This neurobiological model explains that adolescent behavior is not simply a psychological problem, but a reflection of the unbalanced development of brain systems [7].

Social factors, especially peer influence (*peer influence*), also have a significant impact on adolescent brain activity. Studies show that the presence of peers can increase activation in the brain *reward system*, thereby increasing the tendency for risky behavior. This suggests that social context can directly modulate neurobiological responses [5].

From a psychoneuropsychiatric perspective, this condition is also associated with increased vulnerability to mental disorders such as depression, anxiety disorders, and substance abuse. Adolescence is a critical period because the brain system is still in the process of reorganization, so exposure to stress or negative environmental factors can trigger long-term changes in neural circuits, especially in the dopamine pathway and PFC. Therefore, understanding the neurobiological basis of adolescent behavior is crucial in efforts to prevent and intervene in mental disorders in this age group [11], [12].

3.6 Factors Influencing Adolescent Emotions and Behavior

Parenting Patterns and Family Environment

The family is the first school for adolescents in recognizing emotions. The way parents educate greatly determines how adolescents behave. There are several conditions that can influence adolescents' emotions and behavior in the family environment. In permissive parenting, the prevalence of mental and emotional problems is quite high, often caused by poor parenting patterns, parents who are too indulgent or give freedom without control, making it difficult for adolescents to control their emotions when facing problems [14]. Psychological conditions of the family: adolescents who grow up in families with *broken homes* have a higher risk of experiencing anxiety, trauma (*Post-Traumatic Stress Disorder/PTSD*), to the point of falling into drug abuse [15]. Socioeconomic status, economic factors, and parental employment also influence children's stress levels and emotional stability at home [14].

Peer Influence (*Peer Group*)

During adolescence, bonds with friends are often stronger than those with family. Several conditions influence adolescents' emotions and behaviors, including those influenced by peers. Emotional support from friends who provide empathy and attention can increase self-confidence, so that adolescents feel loved and avoid bad behavior [14]. Peer pressure, a negative peer environment, can encourage adolescents to engage in deviant behavior. Conversely, positive groups will support each other to develop healthily [14].

School environment

Schools are not only places for academic learning, but also spaces for mental development. Several conditions influence adolescents' emotions and behavior in the school environment. Comfortable facilities, adequate school buildings, good air circulation, and a beautiful environment can create a sense of comfort and reduce stress levels during learning [14]. Less harmonious social relationships and interactions between school members can trigger symptoms of depression and anxiety in students [14].

Technology and Social Media

In the digital era, gadgets and social media have become new factors that are very dominant in influencing adolescent psychology. Several conditions that affect adolescent emotions and behavior are influenced by technology and social media. The duration of gadget use, the longer the time spent playing with gadgets, the greater the risk of mental health disorders [16]. Social media addiction: the high intensity of social media use is often triggered by the desire to seek entertainment or the fear of being left behind by trends (*Fear of Missing Out/FOMO*). The majority of teenagers (60.5%) are at the alert or wary stage due to the high intensity of social media use [17].

Quality of Life and Daily Habits

Physical health is closely linked to mental health. Sleep quality: Teenagers who have irregular sleep schedules or lack sleep are more likely to experience emotional problems than those with healthy sleep patterns [18]. A healthy lifestyle, the effort to openly discuss problems with trusted people, and limiting time spent online are highly recommended for teenagers to maintain mental resilience [14].

3.7 Psychoneuropsychiatric Disorders in Adolescents

Adolescence is a highly dynamic developmental phase that is also vulnerable to various psychological stresses. Psychoneuropsychiatric disorders during this period manifest not only as mental disorders but also involve interconnected neurological and emotional aspects. These disorders can be classified into several main categories, as follows:

Neurotic Disorders (Anxiety and Depression)

Neurotic disorders are the most common category of mental health problems found in adolescents, encompassing general anxiety and depressive symptoms. Adolescents experiencing these disorders typically exhibit clinical manifestations of feelings of unhappiness, crying easily, and loss of interest in daily activities [19]. In addition to emotional symptoms, neurotic disorders are often accompanied by physical or psychosomatic complaints, such as recurring headaches, sweaty palms, and sleep and appetite disturbances. If these conditions are not promptly identified through early detection, adolescents are at risk of experiencing decreased academic performance and difficulty in establishing healthy social interactions with their peers [20].

Post-traumatic stress disorder

Post-traumatic stress disorder/PTSD in adolescents appears as a psychological response to life-threatening or self-integrity-threatening events, such as physical violence, abuse, or disasters [19]. Adolescents with PTSD are often trapped in bad memories that come suddenly, feel tense or hypervigilant (*hyperarousal*), and tend to withdraw from the social environment. The triggering factors for this trauma are very diverse, but are often related to disharmony in the family environment or experiences of severe bullying at school, which slowly erode the mental resilience of the teenager [15].

Psychoactive Substance Use Disorders

Psychoneuropsychiatric problems in adolescents also include behavioral disorders due to the abuse of psychoactive substances, including drugs and alcohol. In many cases, this substance use begins as a coping mechanism (*coping mechanism*) wrong, where teenagers try to self-medicate the anxiety or mental stress they feel. Dependence on psychoactive substances can neurologically damage the central nervous system of teenagers who are still developing, thus triggering drastic behavioral changes, decreased self-control, and the emergence of aggressive behavior that is dangerous to themselves and others around them [19].

Psychotic Disorders

Psychotic disorders are the most severe form of mental illness because they are characterized by a disconnection or loss of connection between the individual and reality. The most common symptoms are hallucinations, such as hearing voices that others do not hear, and delusions, or thoughts that are unreasonable and inconsistent with reality. Adolescents experiencing the early stages of psychosis may feel that others are talking about them or intending to harm them without any basis. Although their prevalence may be lower than that of anxiety disorders, psychotic disorders require immediate medical attention because they can cause permanent dysfunction if not treated with appropriate therapy early on [19].

3.8 Clinical Implications and Preventive Efforts

Understanding the complexity of mental disorders in adolescents demands concrete action, both in clinical and community settings. Integrated strategies are essential to reduce the currently high prevalence of mental health problems. These efforts must include early detection, extensive education, and appropriate medical intervention.

Early Detection of Mental Disorders

Early detection is a systematic effort to recognize the early signs or symptoms of mental health disorders before they develop into more severe or chronic conditions. The primary goal of early detection is not to provide a medical diagnosis, but rather to serve as a form of early alertness or an “early warning system” for adolescents, parents, and educators. Through early detection, adolescents who begin to exhibit unusual emotional or behavioral changes can be identified promptly, allowing them to receive appropriate assistance before their social, academic, and neurodevelopmental functioning is permanently impaired [19].

The process of early detection is called screening. Screening is a screening procedure using standardized instruments or measuring tools, usually in the form of a short, scientifically validated questionnaire, to distinguish between healthy and at-risk individuals [21]. In the context of adolescents, screening is often carried out en masse in schools or

community health centers due to its rapid and efficient method. The results of this screening provide an objective picture of the mental health status of adolescents, whether they are in the normal, borderline (*borderline*), or already showing symptoms of a disorder that requires further action.

Screening instruments that are often used in the world of health include: *Self-Reporting Questionnaire* (SRQ-29) and *Strengths and Difficulties Questionnaire* (SDQ). The SRQ-29 works by asking adolescents to report on their physical and psychological complaints through 29 simple questions, which can detect neurotic symptoms such as anxiety and depression, to more severe symptoms such as psychotic potential or trauma [19]. Meanwhile, the SDQ focuses more on mapping adolescents' strengths and difficulties in five main domains, namely emotional problems, behavioral problems, hyperactivity, peer relationship problems, and social behavior [21].

Once the screening process is complete, the next step is clinical follow-up. If the screening results indicate a teenager is in the "high-risk" category, they should be referred to a professional such as a psychologist or psychiatrist for an in-depth assessment. Thus, screening serves as a crucial first filter in the public health system to ensure that medical resources and psychological interventions can be channeled appropriately to those who need them most [20].

Parent Education and School Environment

Community-based preventive efforts, particularly in schools and families, have proven effective in improving mental health literacy. Schools act as protective environments through promotive approaches, such as interactive counseling on stress management and focus group discussions (*Focus Group Discussion*/FGD) to reduce the negative stigma against mental disorders [21]. On the other hand, the role of parents is crucial for the success of prevention through improved parenting patterns. Education for parents is needed so that they are able to create a stable and supportive home environment. Positive family support is a major protective factor (*protective factor*) which can prevent teenagers from falling into deviant behavior or emotional disorders due to domestic conflict [14].

Biopsychosocial Approach in Intervention

In a clinical setting, adolescent care cannot be viewed from a single perspective but must utilize a comprehensive biopsychosocial approach. Biologically, medical personnel must consider genetic factors and the highly dynamic neurological development of adolescents. Psychologically, the primary focus is on strengthening mental resilience *in* individuals through healthy emotional regulation and coping skills. Meanwhile, from a social perspective, interventions are aimed at improving the quality of adolescents' interactions with their peers and social environment to minimize external pressures that trigger stress [20]. The integration of these three aspects ensures that the treatment provided is holistic and addresses the root of the problem.

Interventions (Psychotherapy and Pharmacotherapy)

If the detection results indicate a significant disorder, professional intervention is required that combines psychotherapy and, if necessary, pharmacotherapy. Psychotherapy, such as Cognitive Behavioral Therapy (*Cognitive Behavioral Therapy*/CBT), is often the first line of help for adolescents to recognize and change negative thought patterns that trigger anxiety or depression [21]. In addition, stress management techniques such as progressive muscle relaxation can be taught as self-help skills for adolescents. However, in conditions where symptoms are already significantly interfering with daily life functioning

or there is a risk of self-harm, pharmacotherapy (such as the use of antidepressants or antipsychotics) can be provided by a specialist in mental health (psychiatrist) under very close supervision [19].

4. CONCLUSION

Adolescence is a developmental period neurobiologically characterized by massive transformations in brain structure and function. Adolescent brain development occurs asynchronously. The limbic system, particularly the amygdala, develops earlier than the prefrontal cortex, which only reaches full maturity at age 25. This maturational imbalance is the neurobiological foundation of the dual systems model and explains why adolescents tend to be more emotionally reactive and prone to risky behavior.

Neurotransmitter dynamics, particularly dopamine and serotonin, also play a central role in shaping typical adolescent emotional and behavioral patterns. Increased dopaminergic activity in the central nervous system contributes to the emergence of *sensation-seeking* and *risk-taking behavior*, which is further reinforced by the influence of peer groups. On the other hand, adolescent behavior cannot be understood in isolation, as biological, psychological, and environmental factors interact dynamically to shape the direction and pattern of each individual's development.

Dysfunction in this developing neurobiological system is a fundamental factor behind the emergence of various psychoneuropsychiatric disorders, including depression, anxiety disorders, ADHD, *conduct disorder*, and substance abuse. Therefore, a biopsychosocial approach that integrates neurological, psychological, and contextual understanding is the most comprehensive framework for early detection, diagnosis, and intervention in the adolescent population.

As a developmental perspective, medical personnel and mental health practitioners need to equip themselves with a sound understanding of the neurobiology of adolescent development, as understanding the biological roots of adolescent emotions and behavior will help clinicians design more targeted therapeutic approaches, both psychotherapeutic and pharmacological. For families and schools, understanding that adolescent impulsivity and emotional turmoil largely stem from an immature brain, rather than from poor character, is an important starting point so that parents and educators can respond to changes in adolescent behavior with greater patience, empathy, and a less stigmatizing approach. Further research remains crucial, particularly regarding how genetic, hormonal, and social factors interact to shape adolescent brain development. Longitudinal studies supported by the latest neuroimaging technology, including exploration of the impact of social media on developing brain circuits, are urgent and relevant areas of research.

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