BIOLOGICAL UNDERPINNINGS OF CRIMINAL BEHAVIOR: A COMPREHENSIVE REVIEW

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ABSTRACT

Background: Traditional criminological theories often emphasize social and environmental factors in criminal behavior. However, early biological research, which was initially reductionist and focused on physical traits, has evolved significantly with advancements in genetics and neuroimaging techniques. This evolution has led to a more nuanced understanding of the role of biological factors in criminal behavior.

Objective: This review aims to critically examine how genetic, neurobiological, and psychophysiological factors contribute to criminal behavior, and to explore the interplay between these biological predispositions and environmental influences.

Methods: We systematically analyzed empirical studies that investigate the impact of abnormalities in brain structures, neurotransmitter systems, and genetic predispositions on antisocial behaviors, integrating these findings with socio-environmental conditions.

Results: Findings from recent studies indicate significant contributions of abnormalities in brain areas such as the prefrontal cortex and amygdala, and dysregulation in neurotransmitter systems to antisocial behaviors. These biological factors, when combined with environmental influences, enhance our understanding of criminal tendencies.

Conclusion: The integration of biological perspectives into criminological theories marks a significant shift towards a more holistic approach in the study of criminal behavior. This review advocates for the development of targeted intervention strategies and ethical policy formulations, emphasizing the potential of biological research to improve the efficacy and humanity of the criminal justice system. Ongoing interdisciplinary research and collaboration are essential to continue advancing our understanding and management of criminal behavior.

Keywords: Biological Criminology, Neurobiology of Criminal Behavior, Genetic Predispositions, Psychophysiological Factors, Multidisciplinary Approach.

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FUNDAMENTOS BIOLÓGICOS DEL COMPORTAMIENTO CRIMINOSO: UNA REVISIÓN EXHAUSTIVA

RESUMEN

Antecedentes: Las teorías criminológicas tradicionales a menudo enfatizan los factores sociales y ambientales en el comportamiento criminal. Sin embargo, la investigación biológica temprana, que inicialmente era reduccionista y se centró en los rasgos físicos, ha evolucionado significativamente con los avances en la genética y las técnicas de neuroimagen. Esta evolución ha llevado a una comprensión más matizada del papel de los factores biológicos en el comportamiento criminal.

Objetivo: Esta revisión tiene como objetivo examinar críticamente cómo los factores genéticos, neurobiológicos y psicofisiológicos contribuyen al comportamiento criminal, y explorar la interacción entre estas predisposiciones biológicas e influencias ambientales.

Métodos: Se analizaron sistemáticamente los estudios empíricos que investigan el impacto de las anomalías en las estructuras cerebrales, los sistemas neurotransmisores y las predisposiciones genéticas en los comportamientos antisociales, integrando estos hallazgos con las condiciones socioambientales.

Resultados: Los resultados de estudios recientes indican contribuciones significativas de anomalías en áreas cerebrales como la corteza prefrontal y la amígdala, y desregulación en los sistemas neurotransmisores a comportamientos antisociales. Estos factores biológicos, cuando se combinan con influencias ambientales, mejoran nuestra comprensión de las tendencias criminales.

Conclusión: La integración de las perspectivas biológicas en las teorías criminológicas marca un cambio significativo hacia un enfoque más holístico en el estudio del comportamiento criminal. Este examen aboga por el...
INTRODUCTION

The exploration of biological factors in criminal behavior occupies a pivotal role in the field of criminology, offering insights into the complex interplay between genetic, neurological, and physiological elements and antisocial actions. This line of inquiry is significant because it holds the potential to unravel the underpinnings of predispositions towards criminality, thereby enhancing the effectiveness of prevention, intervention, and rehabilitation strategies. Biological perspectives on criminal behavior challenge the traditional focus on environmental and social factors, advocating for a more holistic approach that considers innate predispositions and their interaction with external influences. The significance of studying these biological factors lies in their capacity to provide a more nuanced understanding of the determinants of criminal behavior, which could lead to more targeted and effective treatments and policies (Raine 2013).

Furthermore, the incorporation of biological factors into criminological research reflects an interdisciplinary approach, merging insights from psychology, neuroscience, and genetics with traditional criminological theories to offer a comprehensive framework for understanding the complexities of criminal behavior (Ling, Umbach, and Raine 2019).

The historical trajectory of biological explanations in criminology reveals a dynamic evolution, marked by initial enthusiasm, subsequent skepticism, and a modern resurgence underpinned by advanced scientific methodologies. In the late 19th and early 20th centuries, figures like Cesare Lombroso in Italy pioneered the biological approach to understanding criminal behavior, proposing that criminals could be identified by certain physical anomalies, which he termed ‘atavistic’ traits. This period was characterized by deterministic views that linked physical characteristics to criminal propensity, a perspective that eventually waned due to its reductionist approach and the lack of empirical support (Anon 2006). However, the mid-20th century saw a decline in the popularity of biological explanations as sociological theories...
gained prominence, emphasizing environmental and social factors over innate biological predispositions (Sutherland 1947).

The revival of interest in biological factors began in the late 20th and early 21st centuries, fueled by advances in genetics, neurobiology, and psychophysiology. This resurgence was characterized by a shift from simplistic, deterministic models to more sophisticated approaches that recognize the interaction between biology and environment. Modern bio-criminology incorporates techniques such as neuroimaging, twin studies, and molecular genetics to investigate the complex interplay between genetic and environmental influences on criminal behavior. This contemporary perspective acknowledges the multifaceted nature of criminality, emphasizing the importance of an interdisciplinary approach that integrates biological insights with psychological and sociological perspectives (Moffitt 2005; Raine 2002).

The primary aim of this literature review is to systematically explore and synthesize existing research on the biological determinants of criminal behavior, with a particular focus on psychophysiology, brain mechanisms, genetics, and the integration of these biological factors with environmental influences. This endeavor seeks to elucidate the complex interplay between an individual's biological constitution and their propensity for criminal behavior, thereby contributing to a more comprehensive understanding of the roots of criminality. By examining these dimensions, the review aims to highlight potential avenues for prevention and intervention, and to suggest a framework for future research that could bridge the gaps in current knowledge (Anon n.d.-b). The scope of this review encompasses a wide range of studies, from experimental and longitudinal research to meta-analyses and review articles, thereby ensuring a thorough examination of the multifaceted relationship between biology and criminal behavior.

The selection criteria for studies included in this review were meticulously defined to ensure the inclusion of high-quality, relevant research. Studies were selected based on their focus on the biological aspects of criminal behavior, including works on psychophysiology, neurobiology, genetics, and their interactions with environmental factors. The time frame for literature considered spanned the past two decades, allowing for the inclusion of both foundational studies and cutting-edge research. Only studies published in peer-reviewed journals were considered, ensuring the reliability and academic rigor of the included research. Furthermore, the review prioritized studies that employed robust methodological designs, including experimental, longitudinal, and comprehensive review articles, to provide a solid empirical foundation for the conclusions drawn (Moffitt and Caspi 2001; Uher and McGuffin 2008).
2 METHOD

The methodology for conducting the literature search and selection process was meticulously designed to ensure a comprehensive and systematic review of studies pertaining to biological factors in criminal behavior. The literature search was conducted across several scientific databases, including PubMed, PsycINFO, Scopus, and Web of Science, to capture a wide array of research articles, reviews, and meta-analyses published in this domain. Keywords used in the search strategy encompassed a combination of terms related to biological aspects ("genetics", "neurobiology", "psychophysiology") and criminal behavior ("criminality", "antisocial behavior", "aggression"). The time frame for literature considered was deliberately set from January 2000 to December 2023, aiming to focus on the most recent two decades of research to capture contemporary findings and methodologies in the field (Page et al. 2021).

The criteria for including studies in the review were rigorously defined to ensure relevance and quality. Inclusion criteria specified that studies must (i) be peer-reviewed articles or book chapters, (ii) present empirical findings related to biological factors of criminal behavior, (iii) utilize well-defined methodologies in genetics, neurobiology, or psychophysiology, and (iv) include samples with clear definitions of criminal or antisocial behavior. Exclusion criteria were applied to studies that (i) focused solely on environmental or socio-economic determinants without integrating biological perspectives, (ii) were case studies or anecdotal reports lacking empirical data, and (iii) were published outside the defined time frame or in languages other than English. This selection process aimed to ensure that the review was grounded in empirical evidence and reflective of current scientific understanding in the field (Anon n.d.-c; Moher et al. 2009).

The literature review encompasses a diverse array of studies, including experimental research, longitudinal investigations, and review articles, each employing distinct methodologies to explore the biological underpinnings of criminal behavior. Experimental studies within this corpus frequently utilize psychophysiological measures, such as skin conductance, heart rate variability, and electroencephalography (EEG), to assess the physiological responses associated with aggression and impulsivity. These studies aim to elucidate the immediate biological reactions that may predispose individuals to criminal behaviors, highlighting the role of autonomic nervous system (ANS) reactivity and neuroendocrine responses in modulating aggression and emotional regulation (Gao et al. 2009).

Longitudinal research designs, another critical component of the reviewed literature, track individuals over extended periods to examine the developmental trajectories of antisocial
behavior in relation to genetic and neurobiological factors. Such studies often incorporate neuroimaging techniques, including functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), to identify structural and functional brain anomalies that correlate with persistent criminal behavior. By examining changes in the prefrontal cortex, amygdala, and associated neural circuits over time, these studies contribute to understanding how brain mechanisms evolve in the context of antisocial and criminal behavior (Raine and Yang 2006).

Review articles included in the literature synthesis offer comprehensive analyses of existing research on genetics and criminal behavior, summarizing findings from twin and adoption studies that investigate the heritability of antisocial traits. These reviews also delve into gene-environment interactions, exploring how specific genetic predispositions may be expressed or moderated in different environmental contexts. Such articles are pivotal in integrating biological and environmental factors, presenting a nuanced view of the biopsychosocial models that account for the multifactorial nature of criminal behavior. Through the synthesis of genetic markers, environmental influences, and psychosocial factors, these reviews emphasize the complexity of criminal behavior and the need for multidisciplinary approaches to fully understand its biological roots (Anon n.d.-d; Moffitt 2005).

3 RESULTS

The investigation into the psychophysiology of criminal behavior has significantly advanced our understanding of the biological underpinnings associated with aggression and impulsivity. Research focusing on the autonomic nervous system (ANS) reactivity provides compelling evidence of its role in modulating emotional and behavioral responses to stress, with particular relevance to aggressive and impulsive behaviors. Studies utilizing measures of skin conductance and heart rate variability have demonstrated that individuals with a predisposition to criminal behavior often exhibit lower baseline levels of ANS arousal. This hypoarousal is theorized to contribute to a decreased sensitivity to social cues and a reduced ability to learn from negative experiences, thereby increasing the likelihood of engaging in antisocial behavior (Ortiz and Raine 2004).

Furthermore, neuroendocrine factors, specifically the role of cortisol and testosterone, have been closely examined for their influence on aggression and impulsivity. Cortisol, a stress hormone, has been associated with behavioral regulation, where atypically low levels have been observed in individuals exhibiting high levels of aggression and impulsivity. Conversely,
elevated levels of testosterone have been linked to increased aggression, suggesting a hormonal basis for some forms of criminal behavior. These findings underscore the complex interaction between neuroendocrine regulation and psychophysiological responses, highlighting the importance of considering these biological markers when examining the predispositions towards criminal behavior (Popma et al. 2007).

Neuroimaging studies have significantly advanced our understanding of brain mechanisms underlying criminal behavior, with a particular focus on the prefrontal cortex and amygdala. Abnormalities in these areas have been strongly linked to impulsivity, aggression, and a lack of empathy—traits often observed in individuals displaying antisocial behavior. The prefrontal cortex, responsible for decision-making, impulse control, and social behavior, has been found to exhibit reduced activity and structural abnormalities in criminal populations. Such findings suggest a compromised ability to regulate emotions and inhibit aggressive impulses. Similarly, alterations in amygdala functioning, a region critical for emotional processing and fear response, have been associated with increased aggression and a diminished fear of consequences, further predisposing individuals to criminal activities (Anderson and Kiehl 2012).

Moreover, the role of neurotransmitter systems in modulating criminal behavior has garnered considerable attention. Dysregulation in neurotransmitters such as serotonin, dopamine, and norepinephrine has been implicated in heightened aggression and impulsivity. Specifically, low serotonin levels have been correlated with increased impulsiveness and aggression, while dopamine dysregulation is linked to reward-seeking behavior and substance abuse, factors often associated with criminality. Additionally, alterations in norepinephrine levels have been observed in individuals with aggressive behaviors, underscoring the complex interplay between neurotransmitter systems and the neural circuits governing social and emotional behaviors. These insights highlight the multifaceted nature of brain mechanisms in criminality, emphasizing the need for integrative approaches to address the neurobiological roots of antisocial behavior (Raine 2002).

The integration of biological and environmental factors in explaining criminal behavior has led to the development and support of biopsychosocial models, which emphasize the intricate interplay between genetics, brain function, and socio-environmental influences. These models propose that while biological predispositions may increase the risk of engaging in criminal activities, environmental factors such as family dynamics, peer associations, and socio-economic status significantly modulate these risks. Evidence supporting this approach comes from studies demonstrating how adverse early life experiences, including neglect, abuse,
and exposure to violence, can alter brain development and function, particularly in areas associated with emotional regulation and impulse control. Such modifications can exacerbate the effects of biological vulnerabilities, thereby increasing the propensity for criminal behavior (Moffitt and Caspi 2003).

Further supporting the biopsychosocial perspective, research on gene-environment interactions highlights how specific genetic configurations can make individuals more susceptible to the influence of environmental stressors. For instance, individuals with certain variations in the monoamine oxidase A (MAOA) gene, when exposed to early life stress, have been shown to have a higher likelihood of developing antisocial behavior. This body of work underscores the importance of considering both biological and environmental factors in the assessment, prevention, and treatment of criminal behavior. It suggests that interventions aimed at mitigating environmental risks and enhancing protective factors could be particularly effective for individuals with biological susceptibilities to antisocial behavior (Kim-Cohen et al. 2006).

4 DISCUSSION

The integration of the results from studies on biological factors in criminal behavior within the broader landscape of criminological theory and research marks a pivotal advancement towards a more nuanced understanding of criminality. This synthesis underscores the transition from traditional criminological perspectives, which predominantly focused on social and environmental determinants, to a more comprehensive approach that also considers biological predispositions. The findings from neuroimaging studies, genetic research, and psychophysiological investigations enrich our comprehension of the multifaceted nature of criminal behavior, challenging the reductionist views of earlier biological theories, such as those proposed by Lombroso in the late 19th century. Contemporary research, demonstrating the significant roles of the prefrontal cortex, amygdala, and neurotransmitter systems, as well as genetic and environmental interactions, aligns with the bio-psycho-social model of criminality. This model posits that criminal behavior emerges from the complex interplay between biological vulnerabilities, psychological traits, and socio-environmental influences (Moffitt 1993).

Furthermore, the integration of biological insights with criminological theories, such as the social learning theory and strain theory, provides a more robust framework for understanding the pathways to criminal behavior. The evidence supporting the impact of early
life experiences, including trauma, abuse, and neglect, on brain development and subsequent behavioral outcomes illustrates the critical intersection of biological and environmental factors. This holistic view encourages a reconsideration of intervention strategies, emphasizing the importance of early prevention and tailored rehabilitation programs that address both the biological underpinnings and environmental contexts of criminal behavior. Thus, the discussion within the current criminological research landscape advocates for a multidisciplinary approach, incorporating insights from psychology, neuroscience, and genetics, to foster a deeper and more effective understanding of the mechanisms driving criminal behavior (Raine 2013).

The findings from diverse research domains including psychophysiology, brain mechanisms, genetics, and their interactions with environmental factors, coalesce to furnish a comprehensive understanding of criminal behavior, transcending the boundaries of traditional criminological theories. The psychophysiological insights, particularly regarding ANS reactivity and neuroendocrine factors, reveal the foundational biological responses that may predispose individuals to aggression and impulsivity. Such physiological underpinnings, when considered alongside brain mechanism studies that highlight abnormalities in the prefrontal cortex and amygdala, offer a detailed picture of the neurobiological discrepancies that contribute to antisocial behaviors. These brain regions, crucial for emotion regulation, decision-making, and social behavior, exhibit functional and structural deviations in individuals prone to criminal activity, underscoring a biological substrate for behavioral tendencies (Blair 2003).

Genetic research further enriches this understanding by uncovering the heritable components of antisocial behavior, demonstrating not only the presence of specific genetic markers associated with criminality but also how these genetic predispositions interact with environmental stimuli. This gene-environment interplay is pivotal, as it elucidates the mechanism by which inherent biological susceptibilities can be expressed or mitigated by external factors, such as familial relationships, community support, or socio-economic status. The synthesis of these findings advocates for a biopsychosocial model, where the complex interrelation of biological, psychological, and social factors is acknowledged as contributing to the multifaceted nature of criminal behavior. Such an integrative perspective is instrumental in moving beyond the dichotomy of "nature versus nurture," highlighting instead how the dynamic interplay between genes, brain function, and environmental context shapes the trajectory towards criminality (Caspi et al. 2002).

The integration of biological insights into the understanding of criminal behavior has profound implications for policy and practice, particularly in the realms of risk assessment,
intervention strategies, and ethical considerations. The identification of specific biological markers associated with increased risk of criminal behavior, such as abnormalities in brain structure or function and genetic predispositions, offers a unique opportunity to refine risk assessment tools. These tools can be tailored to incorporate biological factors, enhancing their predictive accuracy and allowing for more targeted interventions. Such advancements in risk assessment necessitate a reevaluation of intervention strategies, shifting towards approaches that address not only the psychological and social dimensions of criminal behavior but also its biological underpinnings. This could involve the development of pharmacological treatments targeting specific neurotransmitter imbalances or therapeutic interventions aimed at mitigating the impact of early adverse experiences on brain development (Raine 2013).

However, the incorporation of biological factors into criminological practice also raises significant ethical concerns. The potential for stigmatization of individuals identified as biologically at risk for criminal behavior is a critical issue, as is the risk of infringing on personal privacy and autonomy. Ethical guidelines must therefore be established to govern the use of biological information in criminal justice settings, ensuring that such data is used responsibly and with the utmost regard for the rights and dignity of individuals. Moreover, policies must be developed to prevent the misuse of biological information in ways that could exacerbate social inequalities or justify discriminatory practices. The ethical implementation of biologically informed policies and practices in criminology requires a delicate balance between leveraging the potential benefits of this knowledge and safeguarding against its potential harms (Farah 2012).

Despite significant advancements in understanding the biological underpinnings of criminal behavior, several research gaps remain, underscoring the need for future investigations to adopt multidisciplinary approaches. One notable area necessitating further exploration is the interaction between genetic predispositions and specific environmental contexts, particularly in non-Western populations where such studies are scant. This gap highlights the importance of cultural diversity in research, suggesting that findings from one population may not be universally applicable. Additionally, the longitudinal effects of interventions targeting biological factors on criminal behavior warrant deeper investigation. There is a need to assess the long-term efficacy of such interventions, examining whether changes in biological markers correlate with sustained behavioral modifications (Moffitt and E-Risk Study Team 2002).

Future research should also focus on the ethical implications of integrating biological factors into criminological practice, a relatively underexplored area. This includes studying public perceptions of biologically based interventions and the potential societal impacts of
classifying individuals as biologically at risk for criminal behavior. Furthermore, the development of multidisciplinary approaches that incorporate insights from neuroscience, genetics, psychology, sociology, and ethics is crucial. Such approaches would enable a more holistic understanding of criminal behavior, fostering the development of more effective and ethically sound intervention strategies. Emphasizing collaborative research across disciplines, future studies could provide a more nuanced understanding of the complex interplay between biological and environmental factors in criminality, leading to more comprehensive and inclusive criminological models (Illes and Bird 2006).

5 CONCLUSION

The comprehensive review of literature on the biological factors influencing criminal behavior reveals key findings that significantly enhance our understanding and management of criminal tendencies. Notably, psychophysiological studies underscore the role of the autonomic nervous system (ANS) reactivity and neuroendocrine factors in predisposing individuals to aggression and impulsivity, suggesting a biological basis for emotional and behavioral regulation deficiencies observed in criminal populations (Ortiz and Raine 2004). Neuroimaging research further contributes to this understanding by highlighting structural and functional abnormalities in the prefrontal cortex and amygdala, areas of the brain crucial for decision-making, impulse control, and emotional processing, thereby establishing a neurobiological foundation for antisocial behaviors (Anderson and Kiehl 2012).

Genetic studies have identified specific markers associated with antisocial and criminal behaviors, emphasizing not only the heritability of such tendencies but also the complex interplay between genes and environmental factors. This gene-environment interaction underlines the importance of considering the broader socio-environmental context in which biological predispositions are expressed or mitigated (Anon n.d.-d). The integration of these findings supports a biopsychosocial model of criminal behavior, advocating for a holistic approach to understanding and managing criminality that encompasses biological vulnerabilities, psychological traits, and environmental influences.

The implications of these findings are far-reaching, suggesting that interventions aimed at mitigating criminal behavior must address the multifaceted nature of its determinants. This could involve the development of tailored therapeutic interventions targeting specific neurobiological and genetic vulnerabilities, as well as social and environmental interventions designed to alter the contexts that enable the expression of these biological predispositions.
Additionally, these insights underscore the need for ethical considerations in the application of biological knowledge in criminal justice settings, ensuring that such information is used to inform rehabilitative rather than punitive measures (Raine 2013).

The shift towards integrating biological perspectives within criminology marks a significant evolution in the field, reflecting a broader recognition of the complexity of criminal behavior. This multidisciplinary approach, which combines insights from biology, psychology, sociology, and even ethics, represents a paradigm shift from traditional models that predominantly focused on social and environmental factors. The inclusion of biological perspectives not only enriches our understanding of the underpinnings of criminal behavior but also opens new avenues for prevention, intervention, and rehabilitation strategies that are more nuanced and tailored to individual needs. This integrative approach acknowledges that effective management of criminal behavior requires addressing the interplay of biological vulnerabilities with environmental and social influences, thereby offering a more holistic perspective on crime prevention and rehabilitation (Moffitt 2005).

The culmination of insights from biological research into criminal behavior underscores a pivotal advancement in criminology, elucidating the intricate interplay between inherent biological factors and external environmental influences. This body of research not only deepens our understanding of the roots of criminal behavior but also paves the way for the development of more effective interventions and policies tailored to address these complex determinants. The significance of biological research in this context cannot be overstated; it provides a scientific foundation for identifying biological markers that could predict susceptibility to criminal behavior, thereby enabling early intervention and the implementation of preventative strategies aimed at those most at risk (Anon n.d.-a).

Moreover, the application of biological research in the development of intervention strategies offers a promising avenue for enhancing the effectiveness of rehabilitation programs. By integrating biological insights with psychological and social support mechanisms, it is possible to design comprehensive treatment plans that address the multifaceted nature of criminal behavior. Such approaches are likely to be more effective in reducing recidivism and facilitating successful reintegration into society. Furthermore, the integration of biological perspectives into policy-making processes holds the potential to transform the criminal justice system, moving it towards more humane and scientifically informed practices. This shift could lead to policies that not only aim to punish but also rehabilitate, ultimately contributing to the safety and well-being of society as a whole (Steel, Ellem, and Baxter 2015).
In conclusion, the incorporation of biological research into the study of criminal behavior represents a critical evolution in the field of criminology. It enriches our understanding of the biological underpinnings of criminality, encourages interdisciplinary collaboration, and fosters the development of interventions and policies that are both effective and ethically grounded. As this field continues to evolve, it holds the promise of revealing new insights that could further refine our approaches to preventing and managing criminal behavior, underscoring the enduring value of biological research in contributing to a more just and safe society.

REFERENCES


Biological Underpinnings of Criminal Behavior: A Comprehensive Review


